Role of Professional Societies on Increasing Indigenous Peoples' Participation and Leadership in STEMM

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Indigenous people are the most underrepresented racial/ethnic group in Science, Technology, Engineering, Mathematics, and Medicine (STEMM) in the United States. Most prior research suggests this trend is the result broadly of settler colonialism, and more specifically of cultural differences between students and school/university environments; poor academic preparation in K-12 schools; vague constructs of educational or vocational goals; insufficient financial aid; unwelcoming school and university environments; prejudice and racism; and social isolation. There is also a vast body of published work on the unique epistemologies and knowledge systems held by Indigenous peoples, which are only recently being acknowledged within mainstream STEMM communities. One potential reason for lower participation in STEMM programs and professions by Indigenous people that has generally gone unexplored relates to unique cultural and spiritual factors that could deter Indigenous people from STEMM fields. Our research investigates the range and variation of cultural/spiritual/ethical practical issues that may be affecting Indigenous people's success in STEMM. Our research provides valuable insights for policy and practices within higher education institutions and industry to provide flexible pathways for Indigenous people to reduce or eliminate barriers related to culturally- and spiritually-informed issues. In this paper, we explore how our findings can be used by professional societies to provide leadership to higher education institutions and industry in the area of changing some standard practices to be more inclusive of Indigenous people. An important mode of systemic change in STEMM fields is through professional societies that guide future practices in various STEMM disciplines.

Keywords: Indigenous, STEMM, professional society, culture, spiritual, barriers

INTRODUCTION

Although diversity, equity, and inclusion (DEI) have become a higher priority across STEMM fields, there is still much work to be done. This paper begins with the assumption that professional societies in STEMM fields have a critical role to play in this arena. While advances have certainly been made in the diversification of STEMM and the awareness of DEI among STEMM practitioners, teachers, and leaders, our research points to a generally unexplored phenomenon that impacts the participation of

FIGURE 1 | The percent of AI/AN students in the United States earning STEM degrees compared to the total population between 2008 and 2014 (National Center for Education Statistics, 2016).
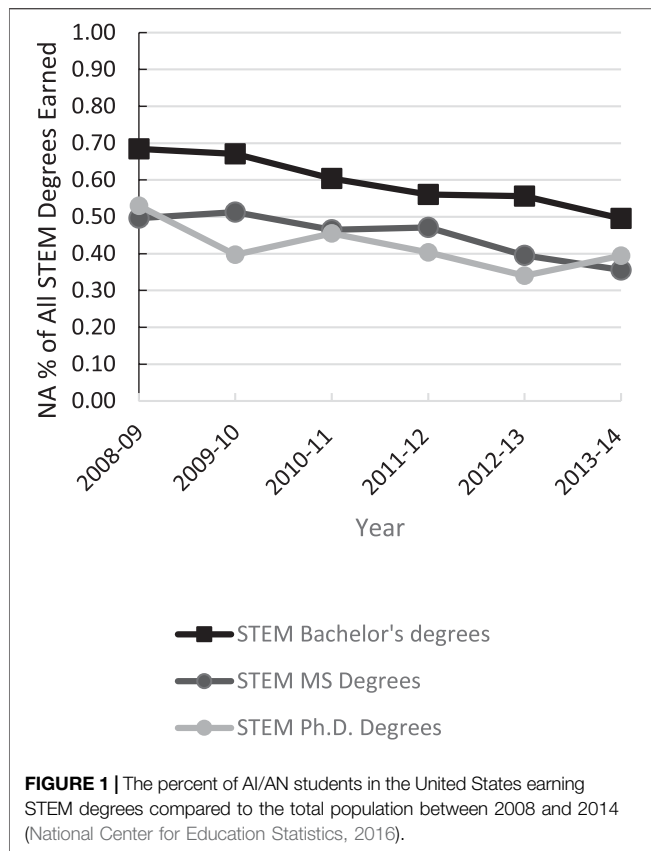
Indigenous people in STEMM pathways. In this paper, we explore how our research findings can be used by professional societies to provide leadership to higher education institutions and industry in the area of changing some standard practices to be more inclusive of Indigenous people.

Documented challenges for Indigenous students in higher education, as well as more specifically in science, technology, engineering, mathematics, and medicine (STEMM) fields are diverse. Indigenous people are the *most* underrepresented ethnic group in biomedical and health sciences (Diverse Issues in Higher Education, 2010). According to the National Center for Education Statistics (NCES), the overall percentage of baccalaureate degrees obtained by American Indian/Alaska Native (AI/AN)[1] undergraduates has decreased from 0.8 percent of the entire U.S. population in 2012 to 0.6% in 2015 (National Center for Education Statistics, 2016). There has been a similar decrease in STEM degrees awarded to Indigenous students since 2008, as shown in **Figure 1**.

Further, only 0.3% of all biology/biomedical degrees were conferred to AI/AN in 2015. This is compared to 1.6% of the entire U.S. population of AI/AN in 2015 (U.S. Census, 2016). Similarly, in 2015 the percentage of AI/AN receiving medical professional degrees (including MD, DDS, OD, PharmD, DO,

DP, DVM, DC) in the United States was only 0.5% (National Center for Education Statistics, 2016). These statistics are significant because health care for many Indigenous people is received through clinics staffed mainly by the Indian Health Services (IHS). These clinics often have medical staff who are not from the local Indigenous community and are only located at these clinics for a short period of time, often to relieve debt associated with medical or other health school expenses (U.S. Government Accountability Office, 2020). These "short-timers," although well-intentioned, do not build sustainable health care capacity within the Indigenous communities. Thus, it is critical to increase the number of Indigenous students pursuing degrees in biomedical and behavioral sciences to fill this need to return to their communities and advocate for their people. The same is true for other STEMM fields as well: Indigenous communities need engineers, field researchers, and environmental scientists who are members of their community, understand the local needs and assets, and can leverage their expertise in ways that build capacity now and into the future.

The under-representation of AI/AN among those earning STEMM degrees reflects both extremely low participation rates and generally poor retention rates for Indigenous college students (Brayboy, et al., 2012; McClellan, 2005). These trends can be linked to settler colonialism and the concomitant marginalization, assimilation, and attempted genocide of Indigenous peoples–all of which manifest currently patterned systemic barriers such as cultural differences between students and school/university environments; poor academic preparation in K-12 schools; vague constructs of educational or vocational goals; insufficient financial aid; unwelcoming school and university environments; prejudice and racism; and social isolation. The body of work investigating challenges for Indigenous students and STEM disciplines has mainly focused on differences in the way Indigenous people interact with each other and their surroundings compared to non-Indigenous students, as well as the lack of culturally responsive educational practices in schools serving Indigenous youth (Castagno and Brayboy, 2008; Ingram 2009; Smith et al., 2014; Hadfield et al., 2016). Under-studied barriers in AI/AN education, particularly with respect to STEMM programs, include cultural and spiritual factors that could exclude AI/AN people from STEMM-related 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 (Williams and Shipley, 2018). In our study, we also postulate that some standard practices in STEMM may be considered 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 STEMM educators and professionals (Weldon, 2007). 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 fieldwork of suspected Indigenous burial grounds, surveillance or dissection of

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[1]The terms Indigenous, Native American, and AI/AN are used interchangeably in this paper.

specific animals, examination of human cadavers, genetics research, investigation of weather events such as lightning strikes, and assigning monetary worth to natural resources (Dorson, 1955; Bulow, 1991; Mathiasen, 2006). These cultural and spiritual taboos vary with respect to the tribe as well as the extent that AI/AN people engage in traditional practices. One goal of our research was to investigate if cultural and spiritual taboos constrain the recruitment and/or retention of Indigenous people in STEMM. Another goal of our research was to determine, if there are cultural and spiritual barriers for Indigenous people pursuing STEMM degrees and professions, how can these barriers be reduced to allow higher participation of Indigenous people in STEMM fields. It is this second goal that has direct relevance for STEMM professional societies.

An important mode of systemic and sustainable change in STEMM fields is through professional societies. Indeed, these societies have a broad scope and can leverage influence across STEMM fields in ways that other institutions may not be able. Professional societies provide a means for articulating codes of conduct and ethics within their membership (Perlis and Shannon, 2012). These codes serve to set standards, educate members on their professional obligations, and communicate standards to the public. In their discussion of the role of professional societies in STEM Diversity, Morris and Washington (2017) provide a list of strategies that professional organizations can take to improve diversity and inclusion in the STEM workforce. These include acknowledging racism within their society, developing partnerships with minority serving STEM professional societies, and facilitating leadership opportunities for underrepresented members. Given the focus of this special issue, we consider the implications of our research on leadership, policy, and practice within STEMM professional societies. More specifically, our purpose in this paper is to provide recommendations to professional societies on how our findings can be used to provide guidance to higher education institutions and industry leaders in the area of changing some standard STEMM practices to be more inclusive of Indigenous people.

METHODS

Although the purpose of this paper is not to present the results of our study per se, we provide a brief overview of our methodology and key finds in order to contextualize our recommendations for professional societies. Our project was guided by the following research objectives: 1) develop a culturally responsive theory about the ethical considerations faced by Indigenous students and professionals in STEMM fields, 2) develop a set of recommended best practices related to ethical challenges for Indigenous students and professionals in STEMM fields, and 3) develop a set of future research and policy issues related to culturally-informed ethical issues in STEMM for those working with Indigenous individuals and communities. We employed a blend of Grounded Theory and Critical Indigenous Research Methodologies to investigate the ethical considerations faced by Indigenous STEMM students and professionals in the western

United States. Grounded Theory (Glaser and Strauss, 1967; Charmaz, 2006; Corbin and Strauss, 2008) is an inductive, iterative, and comparative methodology aimed at theory development. Critical Indigenous Research Methodologies suggest a set of guiding principles for researchers, including 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 (Smith 1999; Brayboy et al., 2012). This project was developed with these principles in mind, and we continue to center them as we analyze and disseminate the results of the research.

Data collection was initiated with an online survey sent to two distinct participant groups: Indigenous post-secondary (undergraduate and graduate) students, and Indigenous professionals. The study was limited to the western U.S. in order to minimize the impact of the vast diversity of tribal nations in the U.S., as well as to leverage the connections the authors had in this particular geographic region. Using purposive sampling, Indigenous students and professionals were recruited through student and professional listservs, professional connections, and snowball sampling. A total of 408 participants met inclusion criteria and completed the survey (206 Indigenous professionals and 202 Indigenous students). Twenty-three Likert scale questions were asked on topics related to cultural identity. The scale used was 1–5, with 1 begin strongly disagree and 5 being strongly agree. The survey also asked questions about involvement with activities or tasks in their STEMM field that may be of concern to Indigenous people. The response to the questions probed how concerned the participants were participating in specific activities or tasks. Descriptive statistics, including frequencies, relative frequencies, means, and standard deviations (SD) were used to summarize descriptive characteristics, cultural characteristics agreement, and level of concern regarding STEMM activities among STEMM students and professionals, separately. Ordinal logistic regression was used to estimate the associations of cultural characteristic scores with level of concern about particular STEMM activities, influence of cultural identity and tribal affiliation on college and career decisions, and perspectives on Indigenous conflicts. All analyses were conducted using SAS V9.4 (SAS Inc., Cary, North Carolina). 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 (Corbin and Strauss, 2008; Glesne, 2010; Denzin and Lincoln, 2017).

A total of 203 students representing 78 tribes participated in the survey. **Table 1** shows that 27% were affiliated with health sciences, with lower proportions of participants in life sciences (22%), engineering (16%), mathematics (15%), physical sciences (11%), and computer sciences (6%). Almost 90% of student participants were younger than 30 years while most were female (57%), had completed some college (50%), grew up in a rural area (35%), and currently live in an urban area (20%). Over 60% of student respondents scored high (mostly agreed or

TABLE 1 | Descriptive characteristics among STEM students and professionals.

	Students (n = 203)		Professionals (n = 206)	
	N	%	N	%
STEM Discipline/Field				
Life sciences	45	22.2	47	22.8
Physical sciences	22	10.8	24	11.7
Engineering	33	16.3	45	21.8
Mathematics	31	15.3	21	10.2
Computer sciences	12	5.9	21	10.2
Health sciences	55	27.1	36	17.5
Other	5	2.5	12	5.8
Age				
18–22 years	97	47.8	7	3.4
23–29 years	82	40.4	44	21.4
30–40 years	22	10.8	103	50.0
41–50 years	2	1.0	41	19.9
>50 years	0	—	11	5.3
Gender				
Male	82	40.4	116	56.3
Female	116	57.1	90	43.7
Other	5	2.5	0	—
Education level				
Some college, no degree completed yet	102	50.3	11	5.3
Associate degree	20	9.8	18	8.7
Bachelor's degree	55	27.1	112	54.4
Master's degree	22	10.8	53	25.7
Professional or terminal degree	4	2.0	11	5.3
Other	0	—	1	0.5
Where participants grew up				
Urban	39	19.2	47	22.8
Suburban	44	21.7	34	16.5
Rural	70	34.5	67	32.5
Reservation	49	24.1	57	27.7
Missing	1	0.5	1	0.5
Where participants currently live				
Urban	102	50.3	110	53.4
Suburban	53	26.1	63	30.6
Rural	25	12.3	13	6.3
Reservation	22	10.8	18	8.7
Missing	1	0.5	2	1.0
Grew up on reservation and still live there	21	10.3	14	6.8
Grew up on reservation and live in a rural area	5	2.5	1	0.5
Grew up on reservation and currently live in an urban/suburban area	22	10.8	41	19.9
Grew up in a rural area and still live there	18	8.9	10	4.9
Grew up in a rural area and live on the reservation	0	0	2	1.0
Grew up in a rural area and live in an urban/suburban area	52	25.6	55	26.7
Cultural Characteristics Scale				
Low (disagree; 10–29)	26	12.8	41	19.9
Medium (neither agree nor disagree; 30–39)	48	23.7	88	42.7
High (agree; ≥40)	129	63.5	77	37.4
Cultural Characteristics Scale Components (proportion agree or strongly agree)				
I value the cultural practices of my tribe and/or Native community	167	82.7	141	68.8
I participate in cultural events within my tribal community when possible	154	76.2	130	63.4
I know some of my tribe's history	171	84.7	156	76.1
I can identify important leaders for my tribe	147	72.8	128	62.4
I can identify important social, health, political, or economic issues for my tribe	151	74.8	135	65.9
I believe it is important to maintain and/or revitalize our indigenous language(s)	163	80.7	128	62.4
I believe it is important to share information about my tribe with the children who are tribal members	168	83.2	127	62.0
My cultural identity is important to me	161	79.7	127	62.0
I learn from Native community elders	151	74.8	111	54.1
I consider myself a traditional tribal member	111	55.0	88	42.9

strongly agreed) on the cultural characteristics scale. A total of 206 professionals representing 76 tribes participated in the survey. **Table 1** shows that 23% were affiliated with life sciences, with lower proportions of participants in engineering (22%), health sciences (18%), physical sciences (12%), mathematics (10%), and computer sciences (10%). Almost 70% of professional participants were 30 years or older while most were male (56%), had a bachelor's degree or higher (86%), grew up in a rural area (35%), and currently live in an urban area (20%). As compared to students, fewer professionals scored high on the cultural characteristics scale (37%), with the majority (43%) scoring in the medium range. We acknowledge that participants represent a number of different tribes with different cultural and spiritual beliefs. We do not aim for broad generalizability; the project is designed to uncover themes, issues, and trends in the ethical considerations faced by Indigenous students and professionals in STEMM fields in the western United States.

RESULTS

Overall, our research found that Indigenous students and professionals face unique cultural, spiritual, and ethical conflicts in STEMM and they engage in thoughtful and intentional strategies to navigate those conflicts. Our data indicate that STEMM disciplines and work that involves human remains, genetics, tribal lands, or Indigenous sacred sites is often viewed as more ethically concerning for many Indigenous students and professionals compared to activities outside this scope. The navigational strategies used by both students and professionals include teaching others and leveraging their support, engaging in ceremonial practices to provide protection and correction when needed, being in the right mindset and/or acting in the right ways, and–for some–changing pathways altogether (Castagno et al., in press). By centering Indigenous students and professionals' voices and experiences, we can better understand how intentional, complex, and thoughtful their strategies must be. As one professional shared, "all people make choices dependent on their survival, we honor our ancestors by making choices that are based on our culture and spiritual journey." These journeys have much to teach STEMM leaders, faculty, teachers, staff, and employers, but the perhaps most important is the message from this experienced Indigenous STEMM professional: "I believe Indigenous people can do what is expected of them in their profession, but it may not be the in the same way." Since a full discussion of our findings is beyond the scope of this paper, we focus on a few results that have particular relevance for informing professional societies about how they can be leaders in the effort to broaden participation among Indigenous peoples in STEMM.

The first relevant result relates to the cultural characteristics scale we developed by summing Likert scale responses for the ten cultural characteristics questions shown in **Table 1** (listed as Cultural Characteristics Scale Components). The scale scores ranged from 10 to 50 where a score from 10 to 29 indicated generally low/disagreement, 30–39 indicated medium/neither

agree nor disagree, and ≥40 indicated high/agreement. Importantly, this cultural characteristics scale is not meant to suggest an evaluative judgment or ranking of one's cultural identity; nor is it meant to suggest there are better or worse ways to be Indigenous. Instead, the cultural characteristics scale is intended as a way to capture a particular set of factors that may or may not collectively describe how one characterizes their Indigenous identity. This scale was not a feature of the research that we initially anticipated exploring, but after exploratory analyses of the survey, it evolved into a potentially important part of the narrative. As noted above, this scale is not intended to indicate any judgment about how individuals engage their cultural identities. But what it does provide is an important set of characteristics for universities and employers to better understand the importance of cultural identity for Indigenous individuals. The employment of cultural impact assessment, which has similarities to the cultural characteristics scale reported here, is used to understand the impact of culture and cultural activities with regard to interventions in economics, ecology, and society (Partal and Dunphy 2016). The cultural characteristics scale that we report provides context for the cultural identity of the survey participants allowing for improved interpretation of the results. Since many more students scored high on this scale (63.5 vs. 37.4 professionals scoring high, **Table 1**), it may be that employers will see more applicants and employees in the coming years who report higher levels of affiliation to their Indigeneity. Further, since a higher score on this scale correlates to higher odds of experiencing culturally-informed ethical conflicts in STEMM, we hope that the pathways to advanced degrees and desirable careers will evolve to be more culturally responsive with fewer conflicts for Indigenous people.

Another result of interest is that the particular field or subdiscipline of the participant does appear to make a difference in their reported experiences and perceptions. In one section of the survey, the participants were asked about concerns related to specific tasks associated with the STEMM fields (ranging from not concerned, somewhat concerned, and very concerned). **Table 2** lists the STEM tasks along with the percentages of the students and professionals who indicated that the task was very concerning. The percentages were determined by summing the very concerning responses and dividing by the total number of responses. The results indicated that among all participants, between 20 and 50% report being very concerned about every STEMM task listed in the survey that was part of their specific STEMM field. These are noteworthy numbers, even those at the lower end of the range. These results illustrate how some (non-Indigenous) individuals may consider these tasks to be part of the education process or tasks necessary for a particular discipline. However, an Indigenous individual may consider these tasks as a counter to their cultural or spiritual beliefs; thus, the individual must ignore their cultural or spiritual belief, navigate the task in light of their concern, or simply refuse to participate in the task. In a recent publication (Ingram 2021), we investigated the culturally-based barriers for Indigenous students and professionals in engineering fields. Many of the engineering participants identified difficulties being

TABLE 2 | STEMM task–percentages of very concerning responses.

	Students	Professional
Archaeological Field Work	21.1	18.6
Assessing Monetary Worth of Natural Resources on Tribal Lands	42.9	23.7
Being Near Human Remains	25.0	37.5
Commercial or Economic Development Efforts on Sacred Sites	38.5	37.8
Commercial or Economic Development Efforts on Tribal Lands	30.8	36.0
Designing Infrastructure on Tribal Lands	25.8	35.7
Discussion of Sacred or Ceremonial Knowledge	20.8	22.9
Dissection of Animals	29.0	20.5
Examining Human Cadavers	42.5	54.2
Genetics Research	33.3	34.0
Investigating Environmental Hazards on Sacred Sites	33.3	41.2
Investigating Environmental Hazards on Tribal Lands	44.8	41.0
Investigating Weather	30.0	28.6
Observing Animals in Clinical or Experimental Settings	26.2	18.9
Observing Animals in Natural Setting	22.4	19.7
Observing Medical Procedures on Animals	31.8	28.6
Observing Medical Procedures on Humans	6.8	20.7
Research on Indigenous Sacred Sites	31.3	40.6
Research on Tribal Lands	29.8	27.1
Research with Human Tissue Samples	36.7	32.6
Testing Infrastructure on Tribal Lands	31.3	22.6
Visiting Indigenous Ruins	25.9	25.0

Note: values provided as a percentage of very concerned responses divided by the total responses.

TABLE 3 | Association between cultural characteristics and perspectives on ethical concern for STEM activities among STEM students and professionals.

STEM activity	Students			STEM activity	Professionals		
	OR	95%	CI		OR	95%	CI
Archaeological field work of suspected Indigenous burial ground (n = 23)	**6.6**	**1.2**	**36.2**	Archaeological field work of suspected Indigenous burial ground (n = 43)	2.0	0.8	4.9
Visiting Indigenous ruins (n = 32)	**7.8**	**1.9**	**31.6**	Visiting Indigenous ruins (n = 52)	**3.4**	**1.6**	**7.3**
Designing infrastructure on tribal lands (n = 34)	**4.1**	**1.5**	**11.3**	Designing infrastructure on tribal lands (n = 60)	**5.0**	**2.4**	**10.3**
Testing infrastructure on tribal lands (n = 60)	1.8	0.9	3.5	Testing infrastructure on tribal lands (n = 68)	**3.7**	**1.9**	**7.1**
Assessing monetary worth of natural resources on tribal lands (n = 26)	1.8	0.7	4.6	Assessing monetary worth of natural resources on tribal lands (n = 40)	**3.3**	**1.3**	**8.1**
Commercial or economic development efforts on tribal lands (n = 27)	**3.3**	**1.0**	**10.8**	Commercial or economic development efforts on tribal lands (n = 51)	**2.5**	**1.2**	**5.0**
Commercial or economic development efforts on Indigenous sacred sites (n = 27)	**2.6**	**1.0**	**6.8**	Commercial or economic development efforts on Indigenous sacred sites (n = 45)	**2.2**	**1.0**	**4.5**
Research on tribal lands (n = 51)	1.6	0.8	3.3	Research on tribal lands (n = 60)	**2.1**	**1.1**	**4.0**
Research on Indigenous sacred sites (n = 17)	3.1	0.6	17.7	Research on Indigenous sacred sites (n = 34)	1.8	0.7	4.5
Investigating environmental hazards on tribal lands (n = 30)	**2.8**	**1.2**	**6.8**	Investigating environmental hazards on tribal lands (n = 40)	2.0	0.9	4.3
Investigating environmental hazards on Indigenous sacred sites (n = 26)	1.5	0.6	4.2	Investigating environmental hazards on Indigenous sacred sites (n = 36)	**3.0**	**1.2**	**7.9**
Hearing or discussing sacred or ceremonial knowledge outside of traditionally approved contexts (n = 30)	3.1	0.9	10.5	Hearing or discussing sacred or ceremonial knowledge outside of traditionally approved contexts (n = 40)	**3.8**	**1.3**	**11.3**
Dissection of animals (n = 74)	**2.4**	**1.2**	**4.7**	Dissection of animals (n = 46)	1.9	0.8	4.5
Observing animals in clinical or experimental settings (n = 64)	**2.2**	**1.1**	**4.5**	Observing animals in clinical or experimental settings (n = 54)	1.6	0.7	3.6
Observing animals in natural settings (n = 64)	1.3	0.7	2.6	Observing animals in natural settings (n = 70)	**1.9**	**1.0**	**3.3**
Observing medical procedures on animals (n = 48)	**2.9**	**1.3**	**6.5**	Observing medical procedures on animals (n = 28)	2.3	0.9	5.6
Examining human cadavers (n = 44)	1.3	0.7	2.7	Examining human cadavers (n = 27)	1.1	0.5	2.6
Being near human remains (n = 45)	1.6	0.7	3.4	Being near human remains (n = 24)	**5.2**	**1.1**	**24.1**
Research with human tissue samples (n = 53)	1.7	0.9	3.5	Research with human tissue samples (n = 48)	**5.7**	**1.8**	**17.7**
Genetics research (n = 53)	**4.0**	**1.8**	**8.9**	Genetics research (n = 51)	**2.7**	**1.3**	**5.5**
Medical procedures (n = 64)	1.3	0.6	3.0	Medical procedures (n = 59)	**2.2**	**1.1**	**4.3**
Investigating weather events (n = 32)	**0.3**	**0.12**	**0.9**	Investigating weather events (n = 42)	0.6	0.3	1.4

Abbreviations: Odds Ratio (OR); 95% Confidence Interval (95% CI).
Items in **Table 3** *that are in bold font are statistically significant.*

Indigenous in engineering fields that can be linked to cultural, ethical, and/or spiritual values that conflict with the U.S. majority population. The results suggested that engineering students have stronger concerns than the engineering professionals with participating in activities within the engineering field that they perceive to be in conflict with their cultural, ethical, and/or spiritual identities. These results could be interpreted in a few ways. One possible explanation is that more years of experience guide Indigenous professionals 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.

And finally, we also found that when assessing the association between the cultural characteristics scale and perspectives on ethical concern for STEMM activities among students and professionals, a higher score on the cultural characteristics scale was associated with higher odds of concern regarding performing STEMM activities that are part of an individual's particular field (Castagno et al., under review). This correlation was true for all STEMM activities in our survey, with the exception of investigating weather events; although not all associations were statistically significant (**Table 3**). For example, the odds of finding visiting Indigenous ruins very concerning were 7.8 times (95% CI: 1.9, 31.6) among students with higher cultural characteristics scores compared to students with lower scores. Similarly, the odds of finding research with human tissue samples very concerning were 5.7 times (95% CI: 1.8, 17.7) among professionals with higher cultural characteristics scores compared to professionals with lower scores.

These findings of the cultural characteristics scale and the reported concerns in STEMM activities are particularly important given the need to open up science, scientific inquiry, and scientific innovation to additional and alternative ways of thinking and being in the world. In order for STEMM to leverage the knowledge and expertise of Indigenous people, the pathways need to evolve so that people do not have to engage in activities that conflict with who they are and the epistemologies, axiologies, and ontologies that have sustained their communities for generations.

DISCUSSION

The insights gained from this research should guide action on the part of leaders in STEMM fields in order to positively impact the participation of Indigenous people in STEMM fields. We suggest that professional societies, both disciplinary and those that support specific populations, can play a significant role in stimulating change within higher education and the professional workplace.

Disciplinary professional societies are structured to support members who identify with a specific discipline. This support is typically manifest as education and information in the form of journals, awards, and defining standards within the discipline (National Academy of Sciences et al., 2016). Disciplinary

professional societies review trends in their specific disciplinary fields with respect to federal agencies, industry, and higher education. These societies are well-positioned to promote change within their disciplines through publications, policy statements, conferences, lectureships, and awards. In a variety of disciplines, professional societies lead the transformation of curriculum used to train the next STEMM generation, as well as develop policy around professional best practices in industry, federal agencies, and higher education. For example, the American Society for Engineering Education's (ASEE) mission is to advance innovation, excellence, and education for the engineering profession (American Society for Engineering Education, 2021). This organization provides input on engineering educational policy that, in turn, impacts curriculum for engineering students earning certified degrees. Likewise, the American Chemical Society - through the Committee on Professional Training - guides modifications to their certified chemistry degree as dictated trends within their field (American Chemical Society, 2021). Professional societies can also promote best practices and professional development in their disciplines for professionals and educators.

In many professional disciplinary societies, diversity, equity, and inclusion (DEI) issues are promoted through committees or subdivisions. For example, in the Ecological Society of America (ESA), the Committee on Diversity is focused on enhancing recruitment, training and retention of women and people of color in the ecological sciences and encouraging the equitable treatment and representation of all ecologists, regardless of gender, age, race, sexual orientation or cultural background (Ecological Society of America, 2021a). Additionally, some professional societies are not disciplinary-specific, but instead support members from specific populations, such as the American Indian Science and Engineering Society (AISES) and the Society to Advance Chicanos/Hispanics and Native Americans in Science (SACNAS). These societies focus on support of specific populations in a variety of disciplines to increase the diversity within these disciplines, such as science and engineering.

We applaud the efforts of both disciplinary and population-based professional societies on their efforts to address DEI issues, but there is still much more that can be done. In Stewart and Valian's (2018) discussion of gender and race schemas in higher education, they note that the values, norms, and ways of being of certain groups (generally White, male, straight, middle class, English-speaking, Christian groups) can be undervalued while others can be overvalued within organizations, and this often happens with little awareness by those in the organization. This is in part due to most people's tendencies toward homophily, which exacerbates the homogeneity among staff and especially among leadership within organizations. When these patterns of seeking out those who are similar to oneself and valuing particular values, norms, and ways of being are named and conversation is invited about the patterns, it is not uncommon to be met with denial or other forms of resistance. A common response for denying these patterns and attitudes is the comment "I don't see race (or color, etc.)," which is often referred to as color-blindness or color-neutrality, and it implies that race does not matter and that

everyone's lived experiences are the same. The result of this attitude is that people who do not acknowledge biases, do not believe they need instruction in DEI and, therefore, resist participation in any efforts to learn about DEI issues. Thus, strategies to best engage and inform the majority of people in STEMM, particularly those in leadership roles, must include a variety of approaches and must begin with understanding the common responses and forms of resistance to this work. Otherwise, efforts to address DEI issues will be limited to those who already understand the challenges, and can therefore be viewed as "preaching to the choir."

We have confidence that professional societies can play an important role in impacting changes that address attitudes and practices in STEMM fields that are in conflict with Indigenous people. We recommend that professional societies weave the findings from this study as well as other studies on barriers for Indigenous individuals entering STEMM into the fabric of their societal activities. The first step would be for the leadership of the professional societies to become acquainted with barriers that Indigenous people face in entering STEMM fields. As our research indicates, there are different cultural and spiritual conflicts for Indigenous people depending on the specific discipline. Understanding the types of cultural and spiritual conflicts within a specific discipline will provide a path for professional societies to develop strategies to address these conflicts. For example, in medical training, students are required to dissect animals and/or cadavers. Some synthetic animal models already exist and are being used in classrooms, such as the synthetic frog. Substitution of these types of synthetic models early in the educational training of Indigenous students may increase their likelihood of continuing in biology or medical career paths. This example leads to the recommendation to find alternate curricular approaches for teaching concepts that do not present conflicts for Indigenous students. It may be difficult for non-Indigenous educators to develop these alternatives on their own, but we encourage collaboration with Indigenous scholars and traditional knowledge holders. Once these alternative approaches are developed, the new curricular approach should be shared with educators through professional societies' journals, conferences, and websites as a resource to others. Educational practices and curriculum in STEMM fields do evolve over time, but these evolutions are often the result of new technology or changes in our understanding of best practices as determined by "evidenced-based research" in teaching. Professional societies can play an important leadership role in introducing changes based on research such as ours, as well as by providing resources and incentives to universities and STEMM educators to initiate change in their curriculum.

A more difficult recommendation for professional societies is to change the attitudes of their members toward disciplinary activities utilized for many years but that presents a conflict for some Indigenous people. One approach that is often taken by professional societies is to have symposia or special sessions at their national or regional conferences that are focused specifically on DEI issues. While this is an admirable use of resources for the professional societies, it is often attended by members that are already committed to addressing DEI issues,

which means the impact on the larger professional society membership is minimal. Another approach that can be taken is to require members to attend mandatory DEI training. Studies have shown (Dobbin and Kalev, 2016) that diversity training rarely lasts beyond a few days after the training. We suggest in addition to DEI special sessions at professional society conferences, that Indigenous issues in STEMM be woven into keynote addresses and subject matter sessions in the context of gaining increased insights and participation of Indigenous peoples. Recently, there has been a movement among some disciplines to include Traditional Ecological Knowledge (TEK) as a framework for studying environmental and other complex STEMM challenges. The ESA has a TEK Section within their organizational structure that is tasked with stimulating research that incorporates TEK and participation of Indigenous people (Ecological Society of American, 2021b). The Wildlife Society has a Native Peoples' Wildlife Management Working Group as part of their societal structure (The Wildlife Society, 2021). Indigenous scholars provide an important example to non-Indigenous professional society members that having a diverse lens is an important contribution to their disciplines.

The final recommendation is to encourage the leadership of professional societies to work with Indigenous scholars and traditional knowledge holders on developing and disseminating policy statements that provide a pathway for change in education and professional practice to address concerns among Indigenous people. Policy statements are organization-level documents that prescribe acceptable methods or behaviors. A policy dictates how things are done within an organization. These statements guide the organization; they can be modified over time, which allows for advances for the organization. Policy statements focused on change associated with educational and professional practices that improve the participation of Indigenous people are important steps for inclusivity.

If scholars, leaders, educators, and employers in STEMM are genuine in their calls for broader participation from diverse people, these culturally-informed ethical conflicts must be addressed. The increasingly popular calls for more role models and mentors, affinity groups, and curricula that are relevant to Indigenous communities' needs are all important, but they will not change the high levels of concern many Indigenous people have about participating in certain activities considered to be standard practice in STEMM fields. Instead, consideration should be given to alternate activities or ways to navigate activities so as to minimize the cultural or spiritual conflicts for Indigenous people. An important approach is to seek guidance from Indigenous people themselves about culturally appropriate alternatives. These alternatives are not just beneficial for the Indigenous people who experience conflicts we describe in this paper; the alternatives would also open up new opportunities to learn and innovate for everyone in STEMM. Professional societies have a critical role to play in educating their memberships and leading these changes across the field National Academy of Sciences, 2005.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Northern Arizona University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JI and AC - development of project, funding, oversight of data collection, review of manuscript. JI development of manuscript. AC also contributed to the manuscript development. RC statistical analysis of data and development of data table. DB administration of survey and review of manuscript.

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