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NATIVES IN STEM LITERATURE REVIEW

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Abstract

The purpose of this literature review is to examine initiatives and best practices related to antiracism, diversity, equity, and inclusion related to Native Americans in STEM higher education and the workforce. While the literature is sparse in relation to Native American experiences in STEM education and the workforce, in the last three to five years, Native and non-Native scholars have published some works in these areas. To assist the Committee on Advancing Anti-Racism, Diversity, Equity, and Inclusion in STEM Organizations at the National Academies of Sciences, Engineering, and Medicine, this analysis provides directions of how to move STEM organizations toward more equitable practices, particularly as it relates to Native Americans graduating and contributing to these fields.

Native Students in STEM

While the current research on students of color in STEM can be helpful in generalizing to all minoritized groups studying STEM, it is important to point out that most of the literature excludes and ignores Native students and their experiences. Consequently, higher education institutions, particularly mainstream or non-Native institutions, continue to struggle in the recruitment and retention of Native students in STEM fields. In 2018, Native Americans earned the least amount of all science and engineering bachelor's degrees with 0.6 percent awarded and are represented even less so in engineering bachelor's degrees with 0.3 percent awarded (NCES, 2019). Furthermore, American Indian/Alaska Native students were the only racial and ethnic group to experience a major decrease in the number of bachelor's degrees awarded in

engineering from 2010 to 2018 (NCES, 2019). The decline in engineering bachelor's degrees awarded follows a larger trend among this group, as the number of non-engineering bachelor's degrees for American Indian/Alaska Native students also declined by 19 percent from 2011 to 2016 (Anderson, Williams, Ponjuan, & Frierson, 2018). As for Native graduate students in science and engineering, they comprised 0.3% of the total graduate student population in 2016, with percentages below 1% in both fields (Bright & Jones, 2020). Enrollment at four-year colleges and universities also saw a significant decline at 23.3 percent from 2010-2016 (Anderson et al., 2018).

As indicated above, often Native students represent such a small number that they are deemed insignificant and often denoted with an asterisk (Shotton et al., 2013). The scarce research focusing on Native American undergraduate experiences in STEM lags behind research focused on African American/Black, Hispanic/Latinx, and women's experiences (Demmert, Grissmer, & Towner, 2006; Foor & Shehab, 2009). While research is necessary on all students of color in these fields, it is discouraging when Natives have been continuously left out of the research, which is why we know so little about their experiences in STEM. Developing a diverse and culturally competent STEM workforce requires a deeper understanding of what deters Native American people from pursuing STEM careers (Chakraverty, 2021). STEM educational spaces and the STEM workforce have been historically white and are hierarchical, exclusionary, and marginalizing to those valuing culturally informed pedagogies, curricula, and ways of knowing and doing (Page-Reeves et al., 2019; Barron et al., 2021; Chakraverty, 2021). Many institutions of higher education and STEM organizations do not have any awareness of the original inhabitants of the very lands they are now benefitting from and dismiss other ways of knowing outside of the realm of Westernized ways of doing STEM (Marker, 2015). The little we

do know from the sparse research expresses two major themes regarding Native students matriculating to and persisting in STEM majors: 1) that there is typically a dissonance in Westernized practices of STEM education versus traditional Indigenous ways of knowing, and 2) that Native students typically enjoy majors that embody communal goals or ways to "give back." A review of the literature around these two themes will be further discussed below.

Dissonance in epistemologies. A few scholars (Chow-Garcia, 2016; Lee Bitsoi & Lowe, 2018; Lundberg, 2007; Seymour & Hewitt, 1997; Smith et al., 2014) have noted that there may still be a dissonance between the Western practices of STEM education and Indigenous ways of knowing that prevent their matriculation to these majors. STEM epistemologies have always been a part of our world, but different words or concepts may be used that do not translate to English, nor are they acknowledged in our Westernized systems of education (Lee Bitsoi & Lowe, 2018). Moreover, Native people have and continue to rely on oral traditions as ways of passing down knowledge through generations, which is why most people are not aware that STEM is not new to us and has been a part of Indigenous cultures for centuries (Brayboy, 2006; Lee Bitsoi & Lowe, 2018). Lee Bitsoi and Lowe (2018) share vivid examples of how STEM has been integrated into Indigenous cultures in a multitude of ways: Science is taught with ethnobotany through the use of plants for medicinal or artistic use. Biology is present in the agronomy and agricultural techniques of Native people, most notably in the practice of planting corn, beans, and squash next to each other. Technology can be found in the manner in which Native people use natural waterways to design and utilize irrigation canals for their farms. Engineering can be found in the architecture of homes and ceremonial structures – the portable teepee or traditional Navajo Hogan. Math can be found in the traditional counting systems of Indigenous people through pictures or knots on a counting rope. Anatomy and physiology are

taught in the butchering of a deer, sheep, or buffalo. Astronomy and cosmology are also crucial to the way Native people tell the changing of the seasons and forecast weather. (p. 88). These ways of knowing were not published as they have been passed down orally through generations of Native people. Due to this disconnect from the Westernized ways of passing down knowledge, our ways of knowing are often questioned and deemed illegitimate, which may also contribute to why we are not seeing Native students pursue and persist in STEM degree pathways. This continues to be seen more glaringly in the STEM workforce.

Deloria (1992) explained that Indigenous knowledge revolves around the idea that everything is interconnected. Furthermore, Wilson (2008) notes that "a change in one affects the others, which in turn effects new change in the original. All parts…are equal; no part can claim superiority over, or even exist without the [others]" (p. 70). This same holistic and interconnected view is often seen with how Native students approach and perceive education, which is contrary to Westernized ways of individual subject areas. Bang and Medin (2010) note that Native students should be supported and encouraged to navigate the multiple epistemologies they are faced with in school STEM environments. Science is often exclusionary with its history on invalidating Indigenous knowledge and can perpetuate inequities in terms of who can access science and what constitutes science knowledge (Barron et al., 2021). There continues to be a lack of acknowledgement of the original inhabitants of the land that many of these institutions and organizations now sit and thrive. This further invisibilizes Native Americans and heightens feelings of not belonging in these historically white educational spaces. Chakraverty (2021) notes that these cultural differences and the pressure to assimilate into a predominantly Western way of knowledge making can lead to further feelings of being an impostor in these STEM environments.

The few studies that exist on exploring Native American student experiences in STEM highlight the importance of relevance to their community in choosing their career paths, as well as creating a communal environment in these technical majors when on campus. In Shehab, Walden, and Wellborn's (2015) study of students of color at one large research institution in Southwest U.S., they found that Native American students primarily noted interest in engineering and social supports to have the highest influence on engineering major choice. Additionally noteworthy was that Native students were minimally motivated by social recognition, being influenced the least from that category. Furthermore, Shehab et al. (2015) emphasized early exposure to engineering through everything from small events to STEM- focused high schools and curriculum, educating students on relevant employment prospects and the high demand for engineers in the workforce, and access to knowledgeable high school counselors and teachers as being important to their engineering career choice.

In another study, Native American students were found to observe tribal taboos that conflict with science classes (Williams & Shipley, 2018). The authors define the "taboo" as a "strong cultural warning or prohibition against an action, such that violating a taboo is an action of serious aberrance which can result in feelings of guilt or shame and/or direct or indirect social sanction" (Williams & Shipley, 2018, p. 2). Examples of these types of taboos included the dissection of humans, animals and other creatures (Williams & Shipley, 2018). Accommodating these concerns could easily be made to create a more welcoming and inclusive space for learning, and has the potential to empower Natives to teach and perform research in a way that is relevant for them.

In understanding that cultural relevance is important to Native students in career choices, it should not be surprising that giving back to our community is at the epicenter of who we are and what we choose to do in life. With that in mind, one of the most common themes found in the sparse literature on Native students' matriculation and participation in STEM majors was the

importance of communal goals. Often, this is contrary to the competitive and individual cultures of Westernized academic institutions, and particularly in engineering majors. As noted previously, family support and involvement is a key factor that has been shown to influence Native student success in higher education (Jackson, Smith, & Hill, 2013). Consequently, communal goals – or the importance of the collective – is at the forefront of importance in Indigenous students' major selection and persistence in college.

Communal goals. Another possible reason for such underrepresentation of Natives in STEM could be the incongruences between cultural beliefs pertaining to communal goals, which includes working with others and giving back to the community. In Smith, Metz, Cech, Hunatoon, and Moyer's (2014) study of Native first-year students in science and engineering programs, they found a strong link of students who grew up in traditional tribal communities with communal goals of specifically wanting to preserve and contribute to their tribal communities for their motivation in pursuing these degrees. Belonging amongst their STEM peers was found to be most important for those who did not grow up in traditional tribal communities (Smith et al., 2014). Additionally, those with the strongest sense of belonging were well-integrated into Native American student support programs (Smith et al., 2014), which supports earlier research on general Native student success (Martin & Thunder, 2013; Shotton et al., 2013).

Accordingly, Smith et al. (2014) recommend "reshaping the culture of STEM to one that integrates and values communion" (p. 424), which would be more inclusive of an Indigenous perspective. Smith et al. (2014) expanded the definition of communal goals to include the value of connection, caring for others, and doing work that benefits students' Indigenous community. Conrad and Gasman (2015) further support STEM practices that relate to Indigenous

communities by discussing best practices from a tribal college that emphasizes the Native worldview and applicability of STEM to tribal communities through the clustering of science programs and undergraduate research on relevant issues. Much of the dissonance between Indigenous communities and STEM is not having a clear understanding of how these professions are beneficial to society and tribal communities (Miller, 2010; Tsui, 2007). Consequently, STEM organizations should look to tribal colleges and universities, for guidance on creating culturally informed practices, the inclusion of Indigenous knowledge systems, and more supportive environments for Native people.

Best Practices for Supporting Native People in STEM

With the understanding that STEM education and the workforce embody Westernized and white views that conflict with Indigenous ways of knowing and being, it is important to turn to ways that scholars have found in leading to their persistence in these fields. Many scholars emphasize the importance of family support and engagement, supportive faculty and staff both Native and non-Native, mentoring relationships and programs, connection to culture through student services and programs, and relevant research projects that encourage nation building (Brown & Robinson-Kurpius, 1997; Chow-Garcia, 2018; Lundberg, 2014; Lundberg & Lowe, 2016; Mendez et al., 2011; Shotton et al., 2013; Shotton, Oosahwee, & Cintron, 2007; Smith, 2019; Waterman, 2007). Many of these strategies of support from higher education serve as best practices for organizations to consider weaving into their diversity, equity, and inclusion efforts to better support Natives in STEM fields and careers.

The Inclusion of Family and Community

Martin and Thunder (2013) share an example of connecting to culture as they advocate for involvement of elders in higher education programs stating they “can bring a sense of

comfort, connection, and belonging among Native American students, and strengthen bonds among the university, Native American students, and tribal communities" (p. 43). Consequently, consulting with elders and tribal leaders of local and/or relevant tribal communities in understanding Indigenous knowledge systems and relevant needs would be a way for STEM organizations to be a good relative to Indigenous communities.

Furthermore, Jackson et al. (2003) reported that successful students acknowledged family support and encouragement as a key factor to their persistence (Chow-Garcia, 2016; Jackson et al., 2003; Smith, 2019). Family support is often not limited to parents, rather it involves extended family members such as grandparents, aunts, uncles, children, and/or cousins (Jackson et al., 2003). Guillory and Wolverton (2008) found in their study of Native American student persistence that family was the most influential factor in motivating students and helping them overcome adversity to succeed in college. For Native American students, "it's all about family" (Guillory & Wolverton, 2008, p. 84).

The connection to place and family continue to play a vital role in college success for Indigenous students, and I would argue, this continues beyond the college experience. While financial aid is still a crucial component to their going to college, there is a need to move beyond just monetary means of getting students to our higher education institutions, but to retain them by creating ways to connect them with the institution and their home communities (Guillory & Wolverton, 2008; Waterman, 2007, 2012; Shotton et al., 2013). Embodying a strong sense of cultural identity has also been linked to Native student persistence in higher education (Brayboy, 2005; Deyhle, 1995; Huffman, 2001; Jackson & Smith, 2001; Kirkness & Barnhardt, 1991; Tachine, 2015; Waterman, 2007), and particularly in STEM (Chow-Garcia, 2016; Johnson et al., 2017; Smith, 2019). Jackson and Smith (2001) and Huffman (2001) affirmed that Native students

can and should resist the notion that their culture is an impediment to their college success, but rather their cultural identity provides a strong foundation for their success. In her study with Haudosaunee students, Waterman (2007) posits that their connection to "culture, community, and family" led to their persistence in college. Furthermore, the previous examples give insight into the unique needs of Indigenous students in higher education, and how institutions and organizations can make policy and environmental changes to support their success.

The Inclusion of Mentoring Support

Mentoring programs informed by Indigenous paradigms were noted as being another best practice to support Natives in STEM fields and careers (Brown, Windchief, Komlos & Arouca, 2020; Chelberg & Bosman, 2020; Chow-Garcia, 2016; Grant et al., 2022; Estrada, Hernandez, & Schultz, 2018; Smith, 2019; Stevens, Andrade, & Page, 2016; Windchief, 2019). Estrada et al. (2018) found that when minoritized students engage in undergraduate research and have quality mentorship, they are more likely to socially integrate and persist in STEM fields. Stevens et al. (2016) discovered that the "inclusion of culturally relevant activities led to a greater understanding by the mentees and the ability to re-teach others, thereby increasing their self-efficacy and their pride in their culture" (p. 958). Furthermore, they found that the inclusion of family members on field trips and the development of a Family STEM Guide that included STEM educational opportunities within their local community were successful strategies to retaining Native STEM students and intriguing their families.

In his study on supporting Native graduate students in STEM with an Indigenous mentoring program grounded in an Indigenous paradigm, Windchief (2019) found that students experience success when the Indigenous perspective is "place-based, cognizant of institutional culture, aware of holistic student development, and finds faculty committed to the students that

they mentor" (p. 12). This program's main points of success were its partnership with local tribal institutions and strategic allyship with faculty mentors who were invested in Native graduate students' success in STEM and conscious of students' varying levels of understanding of their Indigenous identities and worldviews (Windchief, 2019). Faculty training centered on a nine-module framework that emphasized cultural humility and paired with informal gatherings to truly help non-Native faculty "move from an ethnocentric ideation of cultural competence to a more ethnorelative experience of life-long learning" (p. 16). Furthermore, non-Native faculty gained Indigenous knowledge and competence that promotes diversity and inclusion in STEM fields (Brown, et al., 2020). The Indigenous Mentoring Program emphasized the importance of training Native allies and accomplices to better support Native students in STEM and take the burden off the few Native faculty that are most historically white institutions.

Tribal colleges and universities have done much of the work to craft culturally grounded and affirming spaces for Native Americans to study science, including engaging family members as partners involving them in cultural and social activities. However, historically white institutions remain the primary conduit for Native Americans to obtain an undergraduate or graduate education in STEM. Consequently, most STEM organizations are predominantly white and must begin to shift their structures and paradigms to be inclusive of Indigenous knowledge and perspectives to increase their participation and advancement in STEM fields. Integrating culturally grounded mentoring programs that are grounding in Indigenous frameworks from collaborative efforts with local tribal leaders and community members is a best practice that will show commitment to being in a good relationship with Native peoples. Involving family in educational and social activities will express a commitment to a reciprocal relationship that truly fosters Native success in STEM fields and careers.

Conclusion

As demonstrated above, supporting Native STEM success in a variety of organizations must start from collaborative programs outreaching to tribal communities. STEM organizations must be intentional and transparent in their goals for seeking out these collaborative efforts to tribal communities in an effort to truly create a committed and reciprocal relationship with them. Too much harm has already been done in the past, and organizations would not want to recreate that harm with a continued mentality of taking from Indigenous communities. Looking to organizations that embody Indigenous values at the intersections of STEM, like the American Indian Science and Engineering Society (AISES) or the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), would be helpful in providing models for supporting antiracism and diversity, equity, and inclusion work to support Native Americans in STEM fields. Organizations must look to new ways of combining both the Westernized and Indigenous knowledge systems together to "find a pedagogy of holism combining the best of both" to assist in building capacity for tribal sovereignty (Marker, 2015, p. 3). This may involve the uncomfortable process of assessing internal structures and practices, and involving Indigenous students, employees, and local tribal members in the development of these processes. However, the outcomes of providing culturally relevant STEM efforts can support tribal nations' ability to mitigate complex environmental change and protect natural resources (Torso, Kern, & Meyer, 2021).

Additionally important are providing support structures like formal mentoring programs or affinity spaces for Native Americans in higher education and in STEM organizations. An Indigenous mentoring program for Native American students, faculty and professionals in the workplace could provide a vital component of support for their persistence and advancement in these fields (Brown et al., 2020; Windchief, 2019), despite how few of them there may be.

Furthermore, predominantly white STEM organizations can focus on culturally competent training and cross-cultural mentoring that acknowledges and celebrates cultural differences, rather than assimilating Native American and other minoritized groups into the dominant culture and ways of understanding science. Culturally sensitive mentoring could alleviate feelings of isolation and psychological distress for Native STEM individuals (Chakraverty, 2022).

Estrada, Eroy-Reveles, and Matsui (2018) affirm that "connection to professional community is often measured as acquisition of a professional identity or sense of belonging" and that "academic environments that foster kindness cues affirming social inclusion potentially create micro-climates and cultures that 'warm up' institutional environments for diverse students in STEM educational environments" (p. 278). Values of kindness and community cannot be effective if not fully woven into the organizational structure with top-down support. While affinity spaces and Native organizations are imperative to Native American persistence in STEM fields and careers, organizations must heed the responsibility of integrating and prioritizing Indigenous knowledge by working in community with tribal nations on these efforts. Additionally, creating an environment of respectful collaboration, learning and growth that offers new skill sets, knowledge, experience and perspectives further supports tribal sovereignty, which only strengthens the impact of STEM education and organizations.

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