Honoring Culture Within STEM Education Partnerships

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The last of the 'Honoring' series of books to examine Science, Technology, Engineering, and Mathematics (STEM) education was in *Honoring Our Heritage* (Reyhner, Gilbert, & Lockard, 2011). In the decade since this STEM focused edition, much has changed with STEM disciplines, including the volume of rallying cries for inclusivity of historically excluded populations, yet the actual numbers of historically excluded populations enter STEM has either only slowly increased or, in the case of Native American and other Indigenous students, have declined. Therefore, our goal for this chapter is to update readers on some of the recent initiatives focused on increasing Native American representation, interest, and achievement in STEM that are currently being made, including strategies for increasing participation of Native American and Indigenous students.

In a chapter focusing on valuing cultural diversity in science education with Native students, Quartaroli and Sherman (2011, p. 71) stated:

> there is a tremendous need for Native American and other students to pursue careers in science, mathematics and technology. Tribal agencies desperately search for tribal members who are qualified for professional positions that are crucial in resolving community problems by making decisions for the benefit of the tribe from both Western and Native perspectives.

Yet, we have witnessed a stagnancy in the number of Indigenous students entering STEM and have had to question why this is the case, although we see continuous requests for Native American and Indigenous students to enter STEM from tribal leadership, Indigenous knowledge holders, and Indigenous scientists. In order to help meet this goal, the National Science Foundation (NSF) prioritized several initiatives that focus on supporting tribal nations in STEM (NSF, 2023).

Over 20% of the overall Native American population of the United States lives in the 'Four Corners' states (NCES, 2019). The authors of this paper are faculty at Northern Arizona University, which is a Native American-Serving Non-Tribal Institution that serves close to 1,500 Native American students from over 90 tribes, located in the Four Corners region of the United States. We will first share initiatives that the authors of this chapter have personally been involved in to increase the engagement and understanding of Native American students in STEM and then will share information about additional projects, progress, and lessons learned.

Jeffrey Hovermill, the lead author of this chapter, is an Associate Professor in the Northern Arizona University Department of Mathematics and Statistics. He is helping to direct two NSF-funded projects focused on the integration of community, culture, and language within Navajo Nation classrooms. One project, titled Collaborative Creation of Culturally Relevant STEM (or Co-STEM) is focused on Mathematics and Science Education. Another, titled 'Let's Talk Code' is focused on Computer Science Education.

Collaborative Creation of Culturally Relevant STEM (Co-STEM)

The goal of the NSF-funded Co-STEM project is to promote STEM career interest and opportunities for youth from the Navajo Nation through relevant and meaningful experiences with STEM during their critical development years in middle school. Project activities include working collaboratively with school and community partners to support teachers in providing STEM learning activities that involve students in actively investigating data relevant to their communities.

Over 50 Native American serving middle grades teachers in the Four Corners have participated in professional learning focused on the development and implementation of these engaging lessons to more than 1500 students over 3+ years. All of the teacher-developed lessons utilized in Co-STEM classrooms engage students in actively investigating data using technology in order to understand aspects of their communities.

These types of lessons have shown to increase student interest and engagement in STEM learning (Stevens et al., 2016). Educators of Indigenous youth are in ideal settings to engage youth in thinking critically and purposely about the contexts of their people and land (Shirley, 2022). This kind of pedagogy, referred to in STEM education literature as "place-based education," which "recognizes and validates a community's unique features and strengths, thus taking a specific, asset-oriented approach to teaching and learning." Woodhouse and Knapp (in Aziz, 2022, p. 241) describe place-based education as having five fundamental characteristics: It emerges from the particular attributes of a place, it is inherently multi-disciplinary, it is inherently experiential, it is reflective of an educational philosophy that is broader than "learn to earn," and it connects place with self and community.

Some examples of Project Co-STEM place-based lessons have included explorations of air quality, water quality, and Native American agricultural practices. Project Co-STEM evaluations have found that 100% of teacher participants felt 'Confident' or 'Very Confident' in their ability to design and implement culturally-responsive, data and technology-supported, investigative lessons. Their students also reflected positively on their experiences. One student, for example, mentioned "The most interesting thing about the unit was the actual hands on learning; I enjoyed this unit a lot." Another student stated that "It felt like I was making some sort of a difference in the world by learning about these very real problems." Several students summarized that these activities reinforced or taught them that they "have their own choice of what career

they want to pursue' and that 'science is interesting' and that they 'want to be a scientist!" Several students who have participated in Co-STEM activities have first presented their findings to their classrooms and schools and then gone on to do so at regional Science Fairs and STEM nights. It has been exciting to witness large groups of teachers, students, and community members engaged in sharing details of scientific investigations.

Let's Talk Code (LTC) Project

The goal of the NSF-funded Let's Talk Code (LTC) project is to introduce Computer Science to Native American serving teachers and their students. Navajo Technical University and Northern Arizona University faculty and students provide technological and logistical support to teachers to learn how to design and code apps that will engage students to learn Native language and culture as well as academic content and coding skills. Over 50 teachers in the Four Corners region have participated in professional learning focused on the development and implementation of these computer science lessons to more than 1000 students over 3+ years. Many of the LTC teachers have developed apps that engage their students in learning subject matter content along with Native language and culture, as pictured below. Teachers who participated in Project LTC significantly increased their confidence (100% felt Very Confident or Extremely Confident) in making computing and coding relevant to their students.

During the Summer of 2023, Project Let's Talk Code staff teamed up with other Computer Science educators from the southwest region to host the first ever 'Four Corners Computer Science Convening. Over 150 Native American Computer Science teachers pictured on the next page came together in Durango, Colorado to share ways that they are engaging their students in Computing and Coding.

Co-STEM and Let's Talk Code are examples of projects focused on culturally based STEM curriculum and instruction. Gilbert (2011, p. 54) highlighted that 'culturally based STEM curriculum may not only improve student academic achievement in science education and other content areas, but also change the

students' attitudes in a positive direction that will in turn, help Native American communities maintain their language, culture and traditional "ways of knowing." Werito (2020) highlights the value of this kind of culture-centered pedagogy as part of a transformative, empowering educational agenda.

Braiding Indigenous Knowledges and Science

Historically, Western-based sciences have viewed Indigenous Peoples as research specimen and have relegated their oral histories and their knowledges to myth, while also assuming the role of "Indigenous expert" with the ability to identify and define who and what is "Indigenous" based on Western-based research approaches (Smith 2012). This kind of research has provided a sort of justification for ignoring Indigenous insights into the lands and environments that they have cared for and maintained intimate relationships with for thousands of years. Dr. Marek-Martinez's field of anthropology and archaeology was founded based upon the ideologies of colonization that actively suppressed other ways of knowing and being, particularly Indigenous Knowledge systems. This understanding of the negative impact of colonial-based research has on Indigenous Peoples has created the space for Dr. Marek-Martinez to teach and share an Indigenous research methodology that braids Indigenous Knowledge systems with Western Science systems to enhance learning and teaching at NAU.

Ora Marek-Martinez, a co-author of this chapter, is an assistant professor in the Anthropology Department at NAU, and the associate vice-president of the Office of Native American Initiatives. She is directing the Mellon Foundation funded Seven Generations Indigenous Knowledges Center, and is helping to lead the newly announced NSF Center for Braiding Indigenous Knowledges and Science's Southwest Hub at NAU, which focuses on braiding Indigenous knowledges with "western" sciences to address some of the more pressing issues affecting people worldwide. The center will work on complex, evolving challenges brought on by climate change, including dire impacts affecting land, water and plant and animal life; the danger posed to irreplaceable archaeological

sites, sacred places, and cultural heritage; and the challenges of changing food systems, all of which disproportionately affect Indigenous communities.

Braiding of knowledge systems refers to the process in which multiple types of knowledge and practices are brought together to better understand an issue. The term "braiding" describes the process of learning how to braid Indigenous knowledge systems, methodologies, and protocols of care with Western-based sciences in a manner that maintains the integrity of each knowledge system and allows for mutual learning and emotional and spiritual understanding (Alexander et al., 2019: Atalay, 2019). Through the cultivation of respectful dialogue and collaboration and learning from centuries of data collected by Indigenous land stewards, the braiding knowledge of systems can support ethical approaches to research that promotes equity, Indigenous self-determination, and begins to address the historical and ongoing injustices in Western-based academic research (Kanatami, 2018; McGregor, 2008, 2018; Marek-Martinez, 2021, Nelson, 2014; Sidik, 2022; Wilson et al., 2018). The action metaphor of braiding indicates the importance of action, of utilizing Indigenous Knowledge systems and Western Science in research that addresses a shared problem for mutual benefit. Just as with strands in a braid, this approach allows both knowledge systems to retain integrity and they become stronger once they are braided together.

Indigenous knowledge systems speak of the interconnections among all relations (i.e., humans, non-humans, and tangible and intangible relations) and emphasize land-based ethics and values (McGregor, 2008, 2009, 2018; Marek-Martinez 2016; Nelson 2014; Wilcox et al., 2023). There is a concerted effort from Indigenous Peoples and scientists to collaborate and braid knowledge systems to provide innovative and enhanced approaches to issues that impact all of us. An excellent example of the importance of braiding Indigenous and Western Science is outlined in a recent National Geographic podcast focused on the use of fire for forest management. (Overheard at National Geographic: This Indigenous Practice Fights Fire with Fire). Braided approaches such as these shift scientific knowledge systems and praxis towards research that is relational and responsible to and for all people. Relationships that are maintained through stewardship with lands and waters, changing the nature and process of scientific research.

There are currently many exciting and promising initiatives involving local education systems and communities in support of Indigenous STEM. Our work here at NAU is also demonstrative of the shift in academic research from an individualized enterprise to one of a community-based experience working to build capacity and create pathways into academia for Indigenous and other historically marginalized youth and community members. Castagno and her colleagues emphasized that 'colleges and universities must take seriously tribal nations' needs, goals, and policies … and facilitate knowledge and leadership within local communities (2015, p. 70). As a local example, a recent Native Science Report (2023) feature, highlighted the impact Dr. Irene Anyangwe at Navajo Technical University in helping to develop the next generation of Indigenous STEM scholars. This is important as the number of Native STEM graduates and workforce members has not increased much since the last Honoring STEM

articles in 2011. A recent report (NCSES, 2023) found that although American Indians and Alaska Natives (AIAN) made up 1.2% of the total population, they represented only 0.4% of all Science and Engineering degrees at the Bachelor's, Master's, and Doctoral levels—the same percentages as 2011. In 2011, only 0.4% of the US STEM Workforce were AIAN. By 2021, however, this percentage had increased to 0.6%. The authors of this paper, and others working in this space, are optimistic that more and more Indigenous students will be interested, confident, and able to successfully engage in STEM studies and careers.

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