Work in Progress: Seeking Wa:k Community Perspectives on Engineering

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Introduction

It has been recognized STEM fields need to broaden perspectives and find ways to connect the next generation [1], [2]. Native Americans have been among the most underrepresented population in the fields of STEM [3]. To support inclusion programs already established or new engagement programs to support NA/AN inclusion in STEM, it is imperative to first understand how Native communities and cultures relate to STEM. This insight could provide effective strategies for relevant and positive engagement to STEM among Native students.

This Work in Progress research builds upon an approach for community-based educational inclusion which is a vital component of Indigenous education sovereignty as described by McCarty & Lee's culturally sustaining pedagogy [4] and Brayboy's Tribal Critical Race Theory [5]. This approach considers the unique position Native Nations hold in federal policies and systems terms of sovereignty, language, social class, and self-determination. Since community is a strong factor in Native culture, the community (elders, parents, etc.) is an integral part of student identity. McCarty & Lee [4] and Brayboy [5] point out that Native communities encourage their youth to attain education as a pathway to become leaders with traditional knowledge and formal education for the benefit of the community. In support of this, community and culture specific understanding must be considered as the engineering education community seeks to broaden participation among Indigenous people.

Context: The Tohono O'odham Tribe

Tohono O'odham Nation is one among twenty Native American tribes contributing to Arizona's rich history and culture. Historically, the Tohono O'odham people lived throughout Arizona and Sonora, Mexico. In 1917, the U.S. government established the main Tohono O'odham reservation, which is the second largest Native American land holding located in southern Arizona [6]. Today, the Tohono O'odham Nation is comprised of 11 districts: Baboquivari District, San Lucy District, Chukut Kuk District, San Xavier District, Gu Achi District, Schuk Toak District, Gu Vo District, Sells District, Hickiwan District, Sif Oidak District, and Pisinemo District. As of 2016, the Tohono O'odham have a total of approximately 34,000 enrolled members [7].

Framework

This research takes a postpositivist epistemological position as we use a social constructivist perspective to understand how members of the Wa:k community understand and perceive engineering. This philosophy holds that knowledge is constructed through social interactions as those experienced in the Wa:k community.

The framework we implement in this study is Tribal Critical Race Theory (TribalCrit) [5]. TribalCrit came from critical race theory (CRT) and the cultural empowerment movement from the 1960's Civil Rights era recognize racism and inequities entrenched in American society. Applied to education to promote equity this movement was popularized in the 1990's through various academic research [9, 10, 11]. These investigations coined several pedagogical student background based terms such as culturally responsive, culturally compatible, and culturally sustaining to academic literature [12]. All of these terms encompassed the concept of culturally relevant education (CRE).

Tribal critical race theory as it pertains to education extends critical race theory to the unique experiences and history of Native Americans [5]. TribalCrit emphasizes colonization in U.S. governmental and educational policies. It works to expose and counter these inherent injustices by promoting Native Nation sovereignty and self-determination using culturally relevant education. Through this framework, culturally relevant education becomes a tool to empower Native Nations.

This framework may help us understand the relation of engineering in the context of a Native Nation.

Literature Review

Culturally relevant education position of looking to the culture of underrepresented minorities (URM) to empower URM students has been studied for various URM populations. CRE research has suggested that students tend to find learning more meaningful when grounded in cultural and social justice learning experiences [12], [13], [14].These crucial cultural and social justice elements provide meaningful learning comes directly from the students' community.

Despite the growing research in CRE, little research and literature has been published investigating community connections between Native cultures and STEM. These connections should be explored because it has been recognized in the context of science knowledge that traditional Native American/Alaskan Native (NA/AN) and Euro-centered views are different [15]. Although we never want to homogenize Native culture into one monolithic whole, it is important to note traditional NA/AN science knowledge often takes a holistic and inclusion vantage point where as Euro-centered views are more quantitative and manipulative in nature [16]. Mazzocchi [17] provides further clarification to the differences of traditional NA/AN and Euro-centered views, "Western science isolates its objects of study from their vital context by putting them in simplified and controllable experimental environments—which also means that scientists separate themselves from nature, the object of their studies; by contrast, traditional knowledge always depends on its context and particular local conditions. [17, p. 464]". Although the focus of my proposed research is engineering not science, it stands to reason traditional NA/AN and Euro-centered views would have similar differences because science is embedded in engineering. Therefore, culture specific understanding must be considered when addressing student's prior knowledge and community relationship to STEM.

Currently, there is little to no literature on Tohono O'odham perspectives connecting community and culture to engineering. Broadening the scope to consider other Native American cultures' perspectives connecting with engineering still yields little investigation in this area.

In the literature found concerning a broader Native American context, Powers [18] reports on cultural programming's larger direct and indirect effect on those students more strongly affiliated with their native culture. While Powers' study captured a snapshot of participant perspective through surveys, there is still a need to develop a deeper understanding of cultural connections. It must also be noted this finding is in the context of urban American Indian students, not students living in Native Nations.

Again the broader Native American context, Bradley [19]conducted work in the same realm of culture-based education for Native American students by investigating the use of culture in teaching mathematics. This work introduced the idea of "identity accomplishment confusion,"

where culture compromises the learning of fundamental skills. Although this report provides examples of how teaching methods (e.g., peer learning) have had positive results in teaching fundamental mathematics among Native American students, it concedes that culturally infused methods have not been evaluated. This study also acknowledges Native Americans cannot and should not be homogenized due to various environments, and differing cultures. My work will not only support research literature of Native American education but it will also contribute to the literature of STEM and Tohono O'odham connections.

Research Questions

The purpose of this work in progress research project is to understand how Tohono O'odham Wa:k community members perceive engineering. Because community shapes the education of students on both an academic and personal level, it is important to understand how the community views engineering. This work in progress study also serves as groundwork for understanding how the Tohono O'odham community's perception of engineering can influence the development of culturally contextualized strategies for positive engagement in engineering. Given this, findings have the purpose of helping provide insight for further research direction of culturally contextualized STEM curricula for Tohono O'odham students. The research question guiding this work is:

How do Tohono O'odham Wa:k community members perceive engineering in the context of their community and culture?

Researcher Role

My life experiences and beliefs shape my research role. I am a Tohono O'odham woman, born for the Diné (Navajo). I am a first-generation college graduate, an engineer, an engineering education PhD student, and a mother. Growing up on the Navajo Nation, my parents and elders encouraged me and other Native people to pursue higher education. We were encouraged to pursue education for the purpose of helping Native people, community, and culture. This sentiment is one that has resonated with me. It drives me to find ways to connect the next generation to STEM and higher education. Therefore, the prospect of supporting and strengthening Native connections and engagement to science, technology, engineering, arts, and mathematics (STEAM) is a powerful motivator for me.

My involvement in an ongoing study titled, CAREER: Engineering Design Across Navajo Culture, Community, and Society [20] inspired me to explore Tohono O'odham cultural connections to engineering. Although I will draw from my CAREER research experience, I must allow any Tohono O'odham connections to emerge without imposing results from my involvement in Dr. Jordan's study.

The relationship I would like to foster between community and researcher is one of mutual respect and collaboration. This partnership position encourages open dialogue and allows alternative perspectives to be heard. The partner relationship is important because it allows the culture and community to have a voice in the research on different levels.

To support the perspectives of my participants, I must be conscious of my views on science. It has been my personal experience that science provided me with more satisfying answers and explanations than some traditional teachings. I recognize this personal experience has led me to have a bias in favor of science and engineering as an applied science. In situations where

traditional knowledge and participant views on science and engineering conflict my position, I must respect and honor them by conceding to traditional knowledge and participant views in my data collection and data analysis.

As a member of the Tohono O'odham Nation, I have a unique and personal relationship to the participants and community. Although I am a tribal member and have roots in the Tohono O'odham community, I did not grow up in Tohono O'odham culture. I must be perceptive to my limited understanding and knowledge of the Tohono O'odham community and cultural nuances. Follow-up questions and/or participant review iterations with Tohono O'odham community advisors may help clarify or enhance understanding.

Methods

This research will be conducted using social constructivist epistemology which supports the idea that knowledge is constructed by a community in a social and cultural context [21]. Therefore knowledge is gained and influenced by Tohono O'odham individuals of the Wa:k community through their social interactions and environment [22]. From this dynamic, meaningful learning happens when community members interact in social activities [23].

To address the research questions, this research will take a phenomenological approach through the use of semi-structured interviews to answer the research question, How do Tohono O'odham Wa:k community members perceive engineering in the context of their community and culture? Semi-structured interviews will allow the exploration of a specific phenomenon and how it is experienced by individuals [24]. The interview questions will be designed to solicit responses based on participant experiences in the Wa:k community regarding the phenomena of engineering.

Participants

The San Xavier District is the home of the Wa:k community where the research will be conducted. As this study seeks to explore the perceptions of Tohono O'odham community members whom The research duration will be scheduled to take 1 year. $20 gift cards will be offered to participate in study. This study intends to serve as the groundwork for creating culturally relevant education for Tohono O'odham students. Therefore, the population this study is focusing on are community adults since they are charged with making decisions for the community and in home of the students. At least 15 adult (18 years and older) Tohono O'odham Wa:k community members will be recruited for this study. Ideally, participants to be recruited must also have the experience of living in the Tohono O'odham community for approximately 8 years as this range would mean the youngest participant (18 years old) 10 years old as they are immersed in the community. Recruitment will conducted through community meetings, events, and community member referrals. One-on-one semi-structured interviews will be comprised of questions to encourage discussion and capture ideas in the participant's own words. Interviews will be approximately 60 minutes per participant. These interviews will be audio recorded. Recordings will be anonymized, transcribed, and all data will be password protected on a secure electronic device.

To keep in-line with participant perspectives, built-in probing interview questions and/or respondent validation, in which the participant will be asked to elaborate or confirm their

position, is another way to mitigate misconnections [25]. In unforeseen situations where traditional knowledge may conflict with the research, community, traditional, and cultural sensitivities will be respected and supported. To ensure respect of culture, this study will consult with a Tohono O'odham cultural advisor throughout the duration, yet to be identified.

Progress and results will be shared with Tohono O'odham Nation, Wa:k community, and general education community.

Interview protocol development

Interview questions were originally based on an interview protocol from Dr. Jordan's study [20] which focused on Navajo connections to engineering. These questions were centered on understanding how participants defined engineering, their culture and community. Initial changes shifted tribal references from Navajo to Tohono O'odham. After sessions of peer review, the questions were revised and supplemented with self-generated items. Currently, the semi-structured interview questions are:

> How would you describe Tohono O'odham culture?
> How would you describe your community?
> When you hear the term "engineering", what are your thoughts?
> When you say (*insert participant thought about the term "engineering" here*), why do you suppose that is?
> We have all experienced running into a problem where something broke or we needed something to work a certain way. Tell me about a time you had to solve a problem. What steps did you take to solve the problem? *(Example: You did not have a stove to cook outside, how would you build it?)*
> Tell me about a time when you recognized engineering in Tohono O'odham culture. (Stories, Observation, and Experience)
> How do you see Tohono O'odham culture influencing engineering?
> How do you see engineering influencing your community?

Before conducting formal interviews, the interview questions be revised to ensure alignment to theoretical framework.

Analytical Procedures

Dedoose software will be used for qualitative analysis involving various coding techniques (In Vivo, Concept) that seek to draw out varied meaning from participants as well as reduce or "lump" this meaning into more refined categories and themes [25]. The general analysis of the data include three stages of data analysis (preliminary, secondary, and final).

Preliminary Data Analysis: This phase will include transcribing data and first cycle coding, where initial codes will be generated. Guided by the motivation to stay close to participants' own words, the first cycle coding will use In Vivo coding. In Vivo coding captures participant words and phrases specific to their culture which may provide insight to their worldviews [26]. Each code was used to help to define categories. These categories will be based on the participants' rituals, rules, roles, and relationships as suggested by Saldana's "five Rs" [26].

Secondary Data Analysis: In this phase, the transcripts will be reread using concept coding as second cycle coding. Concept coding looks beyond tangible or observable aspects to ideas and meaning. Building on In Vivo coding which allows the data to stay close to the participant's own words, concept coding will capture the "read between the lines" data. This will add another dimension to my understanding of the data. Analytical memos will play in important role to organize and condense codes. At this stage, themes may start to develop.

Final Data Analysis: Codes will be refined and themes defined. Strategies will include FRAMES (Focal sentence, Rich thick description, Analysis, Meaning, Expansion, and So what?) and Codeweaving. FRAMES is a technique which forms an aggregate statement to develop toward theory to explain a phenomenon. Codeweaving a technique which seeks to connect key codes in a narrative or process which may illuminate themes.

References

[1] U.S. Government Accountability Office. "Higher Education: Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends," *United States Government Accountability Office*. 2005. [Online]. Available: http://www.gao.gov/new.items/d06114.pdf.

[2] National Science Foundation, "*Pathways to broadening underrepresented minorities,"* National Science Foundation. 2014. [Online]. Available: https://www.nsf.gov/od/broadeningparticipation/PathwaysToBroadeningParticipationInResponseToCEOSE2011-2012Recommendation_Nov2014.pdf.

[3] S. Stevens, R. Andrade, and M. Page, "Motivating Young Native American Students to Pursue STEM Learning through a Culturally Relevant Science Program," *Journal of Science Education and Technology*, vol. 25, no. 6, 947-960. 2016.

[4] T. McCarty and T. Lee, "Critical culturally sustaining/revitalizing pedagogy and indigenous education sovereignty," *Harvard Educational Review*, vol. 84, no. 1, pp. 101-124. 2014.

[5] B. Brayboy, "Toward tribal critical race theory in education," *The Urban Review*, vol. 37, no. 5, pp 425-446. [Online]. Available: https://link-springer-com.ezproxy1.lib.asu.edu/article/10.1007/s11256-005-0018-y.

[6] Tohono O'odham Nation, "History," *tohono-oodham-nsn.gov*, 2016. [Online]. Available: http://www.tonation-nsn.gov/tohono-oodham-history/.

[7] Tohono O'odham Nation, "Districts," *tohono-oodham-nsn.gov*, 2016. [Online]. Available: http://www.tonation-nsn.gov/districts/.

[8] San Xavier District, "A brief history," *waknet.org*. 2019. [Online]. Available: https://www.waknet.org/history.htm

[9] G. Ladson-Billings, and W. Tate, "Toward a critical race theory of education. *Teachers College Record*, vol. 97, no. 1, 47-68. 1995.

[10] G. Gay,(2010). *Culturally responsive teaching : Theory, research, and practice*, 2nd ed., Multicultural education series, New York, N.Y. New York: Teachers College. 2010.

[11] Lee, C. (1998). Culturally Responsive Pedagogy and Performance-Based Assessment. *The Journal of Negro Education, 67*(3), 268-279. doi:10.2307/2668195

[12] B. Aronson and J. Laughter, "The theory and practice of culturally relevant education: A synthesis of research across content areas," *Review of Educational Research,* vol. 86, no. 1, p. 163-206. March 1, 2016. [Online]. Available: https://journals.sagepub.com/doi/abs/10.3102/0034654315582066.

[13] E. Gutstein, E. *Reading and writing the world with mathematics: Toward a pedagogy for social justice.* New York, NY: Routledge. 2006.

[14] J. Leonard, *Culturally specific pedagogy in the mathematics classroom: Strategies for teachers and students*. New York, NY: Routledge. 2008.

[15] D. Nakashima and M. Roué, Indigenous knowledge, peoples and sustainable practice, *Social and Economic Dimensions of Global Environmental Change*, vol 5, p. 314–324. 2002. [Online]. Available http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/sc_LINKS-art%20EGEC.pdf.

[16] G. Aikenhead and M. Ogawa, *Cultural Studies of Science Education,* 2(3), 539-620, July 2007. [Online] Available: https://doi-org.ezproxy1.lib.asu.edu/10.1007/s11422-007-9067-8.

[17] F. Mazzocchi, "Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other," *EMBO Reports*, vol. 7, no. 5, 463-6. 2006.

[18] K. M. Powers, "An Exploratory Study of Cultural Identity and Culture-Based Educational Programs for Urban American Indian Students," *Urban Education*, vol. 41, no. 1, pp. 20–49, 2006.

[19] C. Bradley, "Issues in Mathematics Education for Native Americans and Directions for Research," *Journal for Research in Mathematics Education*, vol. 15, no. 2, pp. 96–106, 1984.

[20] S. Jordan, "CAREER: Engineering design across Navajo culture, community, and society." In Proceedings of the American Society for Engineering Education (ASEE) Annual Conference and Exposition, Seattle, WA (Paper ID #11910). 2015.

[21] R. Prawat and R. Floden, "Philosophical perspectives on constructivist views of learning," *Educational Psychologist*, vol. 29, no. 1, 37-48. 1994

[22] R. Gephart, "Paradigms and research methods," *Research Methods Forum*, 1999. [Online]. Available: http://www.aom.pace.edu/rmd/1999_RMD_Forum_Paradigms_and_Research_Methods.htm.

[23] M. McMahon, "Social constructivism and the world wide web - A paradigm for learning" in Paper presented at the ASCILITE conference. Perth, Australia. December 1997.
[24] J. Creswell, *30 essential skills for the qualitative researcher*. Sage. 2016.

[25] J. A. Maxwell, *Qualitative Research Design: An Interactive Approach (Applied Social Research Methods)*, 3rd ed., vol. 41. Thousand Oaks, CA: SAGE Publications, 2013.

[26] J. Saldana, *The coding manual for qualitative researchers*, 3rd ed. Los Angeles, CA; London: SAGE, 2016