# The Role of Giving Back and Two-Eyed Seeing for Engineering & Computer Science Indigenous Students Transitioning to the Workplace


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## ABSTRACT

Transitions often bring reflection and change. This paper illuminates transformational change initiated by Native students who are transitioning into the workplace in engineering and computer science. Drawing on surveys (n=36) and photo elicitation interviews (n=4) from a larger, longitudinal project, and grounded in transitions theory, the paper describes how these new professionals are guided by values of culturally connected giving back, such as promoting technology sovereignty, and how they engage Two-Eyed Seeing to bring together western and Native knowledges. The paper concludes with recommendations for attracting and retaining Native scientists in E&CS through opportunities of giving back and Two-Eyed Seeing.



## CCS CONCEPTS

• Social and professional topics → Race and ethnicity • Social and professional topics → Cultural characteristics • Social and professional topics → Computing education.

## KEYWORDS

Indigenous; Native; Giving back; Two-Eyed Seeing; Technology sovereignty; Higher education; STEM; Transitions

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## 1 INTRODUCTION

In this paper, we address the experiences of Native new professionals transitioning from higher education to the workplace in engineering and computer science (E&CS). We examined the experiences of participants in the study, *Native STEM Portraits: A Longitudinal, Mixed-Methods Study of the Intersectional experiences of Native Learners and Professionals in STEM* (NSF/EHR-2000619), who were undergraduate or graduate students in E&CS and transitioned to the workplace within the span of the study. We found that, upon transitioning, participants redefined their roles as Native scientists. Guided by the value of culturally connected giving back, they utilized the power in their new roles to work toward supporting members of Native communities. Participants also engaged in Two-Eyed Seeing, bringing together their Native knowledges and western knowledge into their work in E&CS.

## 2 THEORETICAL FRAMEWORK

This paper is framed by three intertwining theories: transition theory, giving back, and Two-Eyed Seeing. Schlossberg [1, 2] described transition as an event that creates a disruption of roles, routine, and relationships for the individual experiencing the transition. Transition prompts individuals to reflect deeply about their future and their role in creating that future. Schlossberg, Waters, and Goodman [3] noted that the transition experience requires an immense amount of adaptability and coping strategies with the end goal being a positive "emergent growth process" (p. 49) during the transition. In the case of Native new professionals in engineering and computer science this reflection is connected to their cultures and values.

Giving back is a paradigmatic view that reflects Native peoples' communal value orientation where individuals are directed toward contributing to the generational wellness of their communities and others. Giving back also contributes to Native students' persistence in STEM higher education by

providing them with opportunities to fulfill their communal orientation as they use their STEM skills [4,5]. This definition of giving back encompasses the concept of culturally connected giving back which involves Native individuals' "empowerment of Native communities" and creating positive change "through the engagement of Native values, culture, and resources" [4, p. 5]. Examples of CCGB include the use of Native knowledge of the sun and the seasons to improve the efficiency of solar panels and Nation building activities like working towards digital sovereignty.

Two-Eyed Seeing was first introduced in the literature by Mi'kmaq elders, Albert and Murdena Marshall, which emphasizes the importance of viewing the world from two different, balanced lenses of western and Native worldviews [6]. However, Two-Eyed Seeing, or similar concepts, have been used for many years across various tribal cultures. Two-Eyed Seeing enables Native STEM students and professionals to respectfully and effectively balance both western and Native knowledge systems. Within STEM, Two-Eyed Seeing means finding the strengths in each culture to innovate in STEM fields and careers [7].

## 3 RESEARCH QUESTION

The research question that we address in this paper seeks to understand how moments of transition from higher education to the workplace provide opportunities for deep reflection about and transformation of their roles. This article seeks to answer the following research question: *What is the role of giving back and Two-Eyed Seeing for E&CS Native students transitioning into the workplace?*

## 4 POSITIONALITY STATEMENT

The authors of this paper are advocates for increasing the presence of people of color in E&CS. Team members identify as minoritized individuals due to their intersecting identities and/or their national origins/cultural backgrounds. One author is Native (Smith) and four authors are non-Native. As such, the team works to promote social change by calling for the dismantling of institutionalized systems that oppress and marginalize Native individuals. Our identities and experiences as minoritized individuals and as researchers in STEM education equity and inclusion influence how we reshare our participants' stories and the meaning of those stories, increasing our findings' trustworthiness.

## 5 RESEARCH DESIGN AND METHODS

### 5.1 Research Design

The study's design is a longitudinal mixed methods study that includes surveys and photo elicitation interviews with Native students in STEM higher education and careers. This study looks at the experiences of Native students and professionals in four different disciplinary areas in STEM (computing and engineering, life sciences, physical sciences, earth sciences and math). For this paper, we selected the Native students in computing and engineering undergraduate and graduate programs who transitioned to the workplace during the study. Using qualitative longitudinal research nested in a mixed-methods design has the promise of "movement between the particular and the general without relinquishing the situated specificity of the individual case nor the ability to trace antecedents and consequences" [8, p. 12].

### 5.2 Participants

The overall study included a total of 276 survey and 40 photo elicitation interview participants in 2021, and 173 surveys and 27 photo elicitation interview participants in 2023. This paper includes a subset of participants in E&CS higher education, which consists of a total of 36 survey participants (28 undergraduate and 8 graduate students), and four photo elicitation interview participants (2 undergraduate and 2 graduate students) from 2023 (see Table 1). Out of the 36 survey participants, 10 participants transitioned to jobs (7 undergraduates and 3 graduates). All four photo elicitation participants transitioned to jobs, so their perspectives as new professionals are reflected in the findings. Table 1 includes further details about photo elicitation participants, such as tribal affiliation region and type of institution of higher education.

| Pseudonym | Tribal Affiliation Region | Education Level | Discipline | Type of Institution |
|---|---|---|---|---|
| Kanaka | Hawaiian/Pacific Region | Undergraduate | Engineering | Predominantly White |
| Krista | Southwest Region | Undergraduate | Computer Science & Engineering | Tribal |
| North | Eastern Woodlands Region | Graduate | Computer Science | Predominantly White |
| River | Southwest Region | Graduate | Engineering | Predominantly White |

**Table 1: Engineering and computer science students transitioning to the workplace who participated in photo elicitation**

### 5.3 Data Collection and Analysis Methods

The survey included constructs identified from the literature, such as giving back and Nation building, and was piloted with a small sample to ensure construct validity. The survey has been implemented twice, once in 2021 and once in 2023. We initially used a repeated-measures ANOVA model to respondent changes over time, but results did not indicate meaningful changes in individuals' responses. Therefore, for this study, we summarized 2023 survey item responses with descriptive and summary statistics.

The main instrument for qualitative longitudinal research in this study is photo elicitation interviews [9] that took place after survey implementation in 2021 and again in 2023, with an emphasis on the second set of interviews. Photo elicitation interviewees were drawn from survey participants who indicated interest. Photo elicitation "is based on the simple idea of inserting a photograph into a research interview" [9, p. 13]. Participants in 2023 were asked to take three photos in response to each of three prompts: (1) changes in the supports they experienced in the last year as a Native undergraduate or graduate student in their STEM discipline; (2) changes in the barriers they experienced in the last year as a Native undergraduate or graduate student in their STEM discipline; and (3) changes experienced in how they identified in the last year as a Native undergraduate or graduate student in their STEM discipline. Although the prompts were guidelines for generating the photos which grounded the interview, the interview protocol itself was not a series of structured questions to strictly follow. Rather, the photo elicitation interview protocol was semi-structured with a series of topics to ask participants as they related to the photos provided. The combination of participant-generated images and photo elicitation is particularly powerful because photographs have the potential to elicit emotion, vivid memories, and cultural perspectives. Furthermore, photo elicitation is an appropriate method to use with Native participants as a decolonizing and participant-empowering approach because it prioritizes the participant's perspective and tends to generate storytelling and life-history responses [10].

## 5.4 Coding

Photo elicitation data was analyzed employing a deductive approach using constructs from the literature (e.g., giving back, Nation building) as the main coding structure. When examining the photo elicitation interview transcripts, the team developed a codebook utilizing a hybrid approach of inductive and deductive coding while conducting thematic analysis [11]. Before analysis, the team developed a codebook with deductive codes that we expected to see in the data, such as giving back and culturally connected giving back [4]. During analysis, members of the team inductively noticed patterns of deep reflection amongst participants who transitioned from higher education to careers, prompting us to develop related codes, which we later connected to the work of Schlossberg [1, 2]. As the team examined more transcripts, these two sets of codes were consolidated into a single living document that continues to be refined as we conduct additional analysis.

## 5.5 Trustworthiness

This team, composed of Native and non-Native researchers, approaches trustworthiness by implementing the four R's described by Kirkness and Barnhardt [12]. The four R's— respect, relevance, reciprocity, and responsibility—comprise an Indigenous analytic framework to decolonize teaching and research. Furthermore, the team is careful to center Native perspectives, purposes, and methods to work towards an understanding of Native students' perspectives of their transitions from higher education to the workplace. The research focuses on the topic of the persistence of Native students and professionals in STEM, a topic of great relevance for Native communities, as well as to STEM equity and education communities. Team members strive to develop reciprocal relationships with Native communities through bringing back to them research findings and products. An example of reciprocity is the development of a photo exhibition developed from the study that traveled to an AISES annual conference and university campuses with high Native populations (see Discussion and Conclusions section for more detail). The team endeavors to conduct the research responsibly, providing participants with thorough information on the research's purposes and methods to ensure that they have opportunities to make informed decisions about their participation in the study.

## 5.6 Limitations

A constraint in this study lies in the limited number of photo elicitation interview participants. Even though we originally had eight participants in the first round of interviews with undergraduate and graduate students in E&CS, only four transitioned to careers and participated in both rounds despite increasing the stipend for participation in the second interview. Other E&CS students were not included in this data set as they had not completed their degrees nor transitioned into the workplace at the time of the second round of photo elicitation interviews. When considering attrition in our photo elicitation interviews, we attribute it primarily to video conference fatigue due to the pandemic and continued impact by ongoing pandemic losses. Another limitation of this study is related to the fact that two of the four photo elicitation participants transitioned into academic positions, which is not a common outcome (relative to entering industry) and heavily influences our findings.

# 6 Results/Findings

The move from higher education to the job market is understood as a key transition in young adulthood that creates disruption in different dimensions of life. The change from student to employee involves disruptions of roles, routines, and relationships that compel individuals to deeply reflect about their future [2]. In the case of Native individuals in this study, these transitions liberated them from the constraints of being students, which allowed them to deeply reflect about their futures and the role of their Native values in both the types of activities in which they engaged and how they implemented their knowledges at work. These clearly manifested through their engagement in culturally connected giving back and their commitment to Two-Eyed Seeing.

The following findings include photographs and quotes that resulted from the study's photo elicitation interviews. The quotes are part of what participants said as we conversed about the

accompanying photographs and exemplify the core themes in our findings.

## 6.1 Giving Back

Both quantitative and qualitative data support the centrality of giving back as a Native paradigmatic view that motivates Native students to pursue E&CS higher education and that supports the persistence of Native students and professionals in their disciplines.

A majority of survey respondents across all three levels in E&CS (undergraduate, graduate, and new professionals) wanted to have a career that positively impacts society (97%) and chose their majors because they wanted to help others (92%). In addition to this general orientation to give back, a vast majority of participants wanted their giving back activities to benefit their Native communities. For example, they expressed that they wanted to give back to Native communities by contributing to solve problems that are specific to them (75%) and sharing their STEM knowledge with these communities (92%) (see Table 2).

| *Item* | *Undergraduate* | *Graduate* | *New Professionals* | *Total* |
|---|---|---|---|---|
| I majored in STEM to give back to Native communities. | 76% (16/21) | 100% (5/5) | 70% (7/10) | 78% (28/36) |
| I think it is important to share STEM knowledge with Native communities. | 95% (20/21) | 80% (4/5) | 90% (9/10) | 92% (33/36) |
| I want to use my degree to solve specific problems in Native communities. | 81% (17/21) | 100% (5/5) | 50% (5/10) | 75% (27/36) |
| It is important for me to have a career that positively impacts society. | 100% (21/21) | 100% (5/5) | 90% (9/10) | 97% (35/36) |
| I chose my major because I want to help others. | 100% (21/21) | 100% (5/5) | 70% (7/10) | 92% (33/36) |
| I chose my major because Natives are underrepresented in the field. | 52% (11/21) | 40% (2/5) | 80% (8/10) | 58% (21/36) |

**Table 2: Percentages of participants who agreed or strongly agreed to survey items related to giving back.**

The photo elicitation interviews yielded illustrative narratives about the value of giving back held by most participants. River, who earned his doctorate in engineering and became a professor during the study, exemplifies how new professionals reflected on how the transition to their careers provided them with transformational opportunities to deeply reflect on their work and to use their E&CS skills to benefit their Native communities. In River's case, he was thinking beyond his own community and the community where he was physically located, considering additionally how to use his skills to have a positive impact on "Indigenous peoples on a global level." When talking about his photo titled "Mocs international" (Fig. 1), he reflected:

> I have a lot more ability to kind of [ask], how do I want my research to engage with communities? … What I want to pull out of it is kind of being able to connect your work to your identity … So, how does it impact the community that raised you? … How do you give it both a local context but also a global context? How does it impact other communities? How does it impact even Indigenous peoples on a global level? Are there ways to do that? And I think that's something that has really made my work feel more meaningful.

**Figure 1. "Mocs international" by River**

The questions that River asked himself demonstrate the deep reflective moment he found himself in as he started his academic career. He had the opportunity to consider how he wanted to bring community, both his own and at a global level, into his work to imbue it with meaning beyond engineering.

Similarly, Krista, who was graduating with her bachelor's in engineering and transitioning from an internship to a job at the internship institution, reflected on how she would implement her engineering skills to improve the living conditions of families on her reservation. When talking about her photo titled "Put skills to work" (Fig. 2), she commented:

> Doing what I do in the lab now, with the things that I'm working on plays a huge role into, not just only me or my situation, but as a reservation as a whole. Because a lot of families don't have running water or electricity. And what I work with and how it ties back into who I am is … I think about those things. … How can I bring it back to my home and help the people that I care about?

**Figure 2. "Put skills to work" by Krista**

Like River, Krista found herself in a reflective moment where she considered how to use her E&CS training upon graduation to benefit her community on the reservation where she grew up. Her knowledge of the reality of her reservation allowed her to think beyond herself to find ways to give back.

## 6.2 Culturally Connected Giving Back

New professionals in transition in E&CS engaged in giving back that was culturally connected and contributed to Nation building, specifically regarding data sovereignty and land preservation (which are part of Nation building) [4]. The data showed that upon graduation and their move into the workforce our participants no longer felt constrained by western education and its imposed standards. Thus, they could more freely and openly engage their Native values as emergent science professionals in their new workspaces. They sought involvement in activities that supported and benefited their Native communities' cultures and futures. Such support included promoting data sovereignty and land preservation, as shown in the examples below.

North, who transitioned from his doctorate in CS to a faculty position during the study, explained how working with Native groups and publicly expressing his views about data sovereignty as related to his work made him proud. As he talked about his photo titled "Data back" (Fig. 3) North explained:

> It is a picture of a really cool sticker I got at a conference recently, that says 'data back,' as opposed to the land back movement. It is more about data sovereignty. … We also want to take data back, whether that's the data server warehouse where all this data's being processed, the land where the data's being collected from … whether it's actual physical samples of taking that data and taking ownership of that data. … It's all about this relationship and ecosystem of researchers and engineers and companies working with data from sovereign tribes, and that idea of data sovereignty being key if we really want land back and we want our culture back, the data is part of that workflow. … I was extremely proud to put that [sticker] up there, 'cause … It felt like a great representation of my identity to have that up, front-facing on my nice new fancy office door.


**Figure 3. "Data back" by Nort**

For North, it was important to bring together his identity as a Native man and his CS work by advocating for data sovereignty. He viewed his work for data sovereignty as a fundamental step toward culture and land decolonizing efforts.

Another example of culturally connected giving back that our participants engaged in as new professionals revolved around land preservation. For instance, in one of her first projects, Kanaka engaged in stream restoration for food and cultural uses for local communities where she grew up. During our conversation about her photo titled "Hāloa" (Fig. 4), she explained:

> My service [as an environmental engineer] specifically has a focus on their stream restoration project, which is basically stream monitoring and sampling. … ʻĀina translates to land, but for us it means natural resources, or anything that the land touches is also considered ʻĀina … Our main focus is to re-establish food systems and a cultural hub for our community.

**Figure 4. "Hāloa" by Kanaka**

In Kanaka's case, she brought together her Native identity with her engineering training through her land restoration work. Thus, as she transitioned into her role as a new professional engineer, Kanaka was able to engage her values of giving back, and to do so in ways that honored both her western training and her Native Hawaiian understanding of the land and its people.

## 6.3 Two-Eyed Seeing: Weaving Western and Indigenous Science

In their transitions to work, the four interview participants found that they were not restricted to western E&CS knowledge, and this provided them with opportunities to engage in Two-Eyed Seeing. They brought together their Native knowledges and their western academic knowledge according to the needs of their work and their personal vision, and they identified where western science could be harmful and where it could be adapted or used in benefit of the environment and Native communities.

Although not specifically asked about experiences of Two-Eyed Seeing, Kanaka reflected throughout her interview on the ways in which she was able to bring together her Native and western knowledges of science in her fieldwork upon graduating and returning home to begin a job in land preservation within a Native organization. She stated about her photo titled "Hanaka Lima" (Fig. 5):

> Being in STEM is my defense, offense, and torment. And it was interesting, ʻcause I realized when I looked back at that, even though I have the same goals and vision in my engineering, now that I'm home and in this space … I don't really feel that fear and anger of engineering anymore. I'm much more fueled, but I'm fueled more through humbleness and appreciation and a readiness to go and figure these things out.

**Figure 5. "Hanaka Lima" by Kanaka**

Kanaka marveled that she could practice aloha ʻāina (or love for the land) as a framework for her engineering work, saying "it's almost too good to be true, how happy I am just being out

on the land every single day, and the fact that I get to do that while getting support and trying to figure out my western engineering skills in this space." She further reflected on how her work converged with Native values, when describing the photo "Hanaka Lima" (Fig. 5), Kanaka shared how her philosophy toward conducting science was summarized by the Native Hawaiian phrase that translates as "shut the mouth, observe with the eyes, work with the hands." Her ability to engage in Two-Eyed Seeing once out of academia felt transformational to Kanaka.

River, the engineering professor, reflected on the role of concepts from his Native culture that considers natural balance as "a beautiful state" in balancing the western science and tech that he learned in his academic journey. As he talked about his photo titled "Water" (Fig. 6), he said:

**Figure 6. "Water" by River**

> There's so much interaction between the natural world, but also all of the science and tech that we've built up. So, how do we make sure that we understand that relationships between the two, harmful and non-harmful, and try to find better ways to make it a bit more balanced and harmonious, which is now what we call that concept of Hózhó, or the beauty. That concept in our language is when things return to a beautiful state. … And so, I think I see that as one of the biggest foundations of my work and research. … How do we understand these relationships better and try to reduce the harm of it, and the way that things interact with each other?

River made it his work to use Indigenous concepts such as Hózhó that may not otherwise be available to scientists to reduce the harm that western science can inflict if left unchecked. The use of these concepts inserted intentions toward balance and harmony that are often absent from work that involves technology.

## 7 Discussion and Conclusions

Our initial analysis of the overall study's data indicates that the patterns that we have identified for E&CS students transitioning to the workplace also apply to participants in other STEM disciplines that are not included in this paper. For example, Witman, a recent doctoral graduate in physical sciences, was in a deeply reflective moment where she questioned why she was working in basic science projects that did not benefit her Native community, emphasizing her desire to give back. At the same time, she was thrilled that she had recently received funding for a study where she was applying concepts from her tribe related to natural phenomena, allowing her to bring together her western training and tribal science.

Data from students in other STEM disciplines also show a different side of transitioning to the workplace that we have not explored in this paper. For Olive, a doctoral graduate also in the physical sciences, graduating from her program meant an opportunity to turn inward and heal from the trauma of enduring a doctoral program where she suffered unrelenting emotional abuse from her advisor. She talked about being interested in different forms of giving back, but her recent graduation and transition to the workplace meant that she had yet to have the time and capacity to move beyond the process on healing from her negative experiences in graduate school.

The literature includes studies that detail the trauma of Native graduate students in and out of STEM disciplines [13, 14]. Though the trauma endured by Native graduate students while in higher education is well known, how they heal from it once they transition out of graduate school and into the workplace is an area that warrants further research.

Culturally connected giving back and Two-Eyed Seeing are essential elements in the transitions of Native students into the E&CS workplace. Both are drivers of Native individual success in that they directly tie to community and are internal motivators for persistence in these fields. Giving back is a paradigmatic approach of Native students who are motivated to continue to contribute to their Nations and to create more space and opportunities for future generations of Native individuals. Additionally, Two-Eyed Seeing is a perspective they bring to western STEM organizations in bringing intergenerational tribal knowledges to the table. They are also able to bring western knowledge back to their tribal communities to protect their land and resources, revitalize tribal languages, and improve health outcomes for their communities. Consequently, this balance of

two different knowledge systems strengthens tribal sovereignty and self-determination, which in turn, strengthens our nation.

### 7.1 The Role of Research

This project's ultimate goal is to seed important conversations and influence policy to support positive outcomes for Native students and professionals in STEM. For that purpose, we are using creative outreach and dissemination efforts that showcase the importance of giving back and Two-Eyed Seeing for Native students' persistence. During this project, a subset of the photos collected through the study's photo elicitation interviews were developed into a traveling photo exhibition that showcased 16 photos, matched with captions, that highlighted participants' experiences. The photo exhibition has been hosted by two research universities and at the AISES National Conference in 2022.

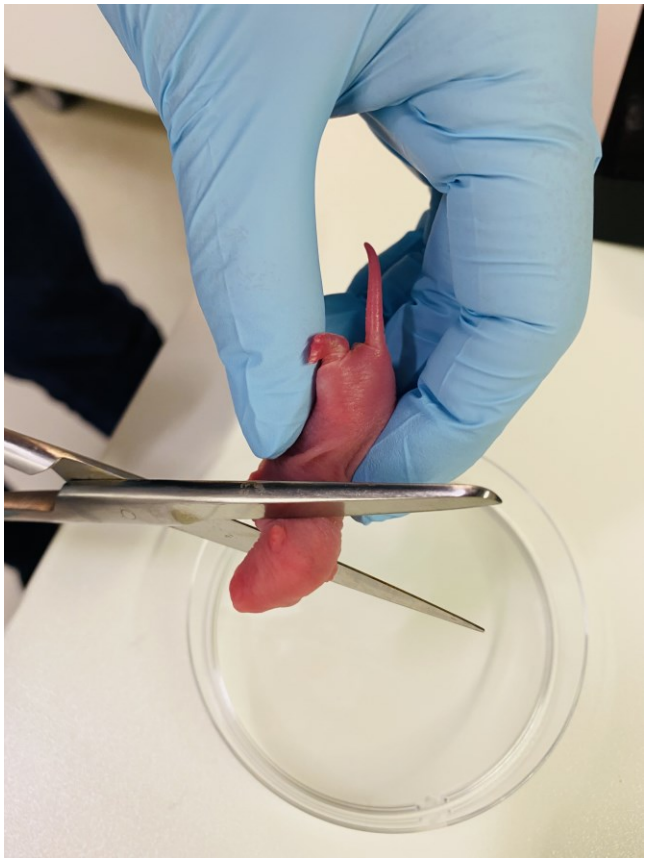

**Figure 7. "Sacrifice" by Daphnia**

The photo exhibition is influencing important conversations on the experience of Native students and professionals in their STEM disciplines. At one of the universities, one of the photos showing a rat pup being euthanized by decapitation with scissors for neuroscience research (see Fig. 7) became the center of controversy among administrators and faculty. Initially, the conversation focused on the ethics and legal issues around showing this photo due to the sensitive nature of its content. Eventually, the conversation shifted towards highlighting the need to show the ethical dilemmas that Native students face when engaging in STEM practices that go against their traditional values. Ultimately, the photo created productive conflict which led to administrators' and faculty's decision-making regarding freedom of speech and the importance of considering the perspectives of minoritized groups.

In another example, one photo in the exhibition, "Circular Table" taken by Autumn, an engineering graduate student, was chosen to be published in the Winter 2024 issue of *Issues in Science & Technology*, a publication of the National Academies of Science, Engineering, and Medicine and Arizona State University [15]. This journal explicitly addresses public policy and engages topics of the advancement of science and knowledge to achieve social goals. This photo shows an oval table that is half in the light and half in the shadow and criticizes the hierarchical nature of the research world and contrasts it with the inclusive nature of Native practices like talking circles. Publication in this journal has potential to generate thought and debate that may lead to changes in policy and practice.

## 8 Implications for Research and Practice

In continuing to uplift and visibilize Native experiences in STEM, practitioners and policy makers should be open to creating opportunities for culturally connected giving back and the integration of Two-Eyed Seeing in their work. Researchers should continue to highlight Native students' experiences in STEM by further studying their transitions to the STEM workplace and how this strengthens their persistence and innovation in these fields. To recruit and support Native students in E&CS, more integration of Native knowledge systems should be woven into the foundation of teaching and research. More research projects working with tribal communities and geared toward giving back and Nation building are critical. Furthermore, the use of arts-informed methods should be considered for future studies with Native and other marginalized groups. Methods such as photo elicitation bring deeper, more reflective meaning and storytelling to the surface for a more nuanced and rich analysis.

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