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ORIGINAL PAPER

"I can do data for my people": experiences of giving back for Native undergraduates in computing

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Abstract
This paper focuses on the undergraduate experiences in computer sciences (CS) disciplines of eight Native women and two-spirit undergraduates and how their values and experiences around the communal goal of giving back enable them to persist in computing. The paper draws from a one-year study that included participants across the U.S.A from predominantly White institutions, Native serving institutions, and tribal colleges. Utilizing the decolonizing and participant-centered methods of photo elicitation, our interviews used photographs taken by participants as starting points for conversations. This method resulted in deep understandings of participants' experiences of the supports and barriers in their CS programs, and of the importance of giving back for persistence. We adapt Page-Reeves and colleagues' 2019 framework for giving back and Native students in STEM—particularly the concepts of giving back as a Native value and giving back in the context of CS education—to illuminate the ways in which participants persisted and navigated their identities as Native students and emergent computer scientists. We also introduce a new concept, culturally connected giving back, to describe the ways in which Native undergraduates in computing contributed, or planned to contribute, towards technology sovereignty and cultural preservation. CS, like many STEM fields, is typically viewed as highly individualistic and not aligned with communal goals of helping others. However, Native participants in this study identified computing as having the potential for giving back. They incorporated a broad range of giving back actions into their computing professional identities through teaching, mentoring, serving as role models, creating counterspaces, or preserving their cultures using their computing skills. Through giving back, participants fulfilled a sense of obligation to their communities or counteracted negative stereotypes about Native learners. Beneficiaries of these acts of giving back included Native and other minoritized peers, younger students, home communities, and other Native communities. Importantly, opportunities to give back served as strong motivators to persist in CS in spite of challenges. We discuss the implications of these findings for policy and practice and also explore the implications for how institutions and CS departments can support Native student recruitment, retention, and success.

Keywords Native · Undergraduate · Computing · Persistence · Giving back

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Resumen
Este artículo resalta las experiencias de ocho estudiantes indígenas en licenciatura de ciencias de la computación, quienes se identifican como mujeres o personas del tercer género (dos espíritus) y de cómo sus valores y vivencias en relación a sus objetivos de ser solidarios y ayudar a sus comunidades les ayudaron a persistir en sus estudios. El artículo presenta resultados de un estudio que duró un año y que incluyó participantes en los Estados Unidos que estudiaban en instituciones predominantemente blancas, instituciones que sirven poblaciones indígenas, o universidades tribales. El equipo usó el método de entrevistas fotográficas con intenciones descolonizantes y centradas en los participantes, quienes son los que tomaron las fotografías para luego usarlas como punto de partida para las conversaciones en las entrevistas. Este método resultó en una mejor comprensión de las experiencias de los participantes en cuanto a los apoyos y obstáculos que encontraron en sus programas en ciencias de la computación, y de la importancia que ser solidarios y ayudar a su comunidad tuvo en su persistencia. Adaptamos el marco teórico sobre el rol que tiene ser solidario y ayudar a su comunidad en la persistencia de estudiantes indígenas en carreras de ciencias y tecnología, desarrollado en 2019 por Page-Reeves y su equipo. Nos enfocamos principalmente en el concepto de ser solidarios y ayudar a la comunidad como valor indígena en el contexto de la educación en ciencias de la computación y en cómo los participantes persistieron y navegaron sus identidades como estudiantes indígenas y sus incipientes identidades como científicos. También introducimos un nuevo concepto que llamamos "ser solidario y ayudar a la comunidad de manera culturalmente conectada". Este nuevo concepto describe cómo los estudiantes de licenciatura indígenas en ciencias de la computación contribuían, o pensaban contribuir, a la soberanía tecnológica y la preservación cultural de sus grupos indígenas. Las ciencias de la computación, como muchos campos de las ciencias y la tecnología, se perciben como disciplinas altamente individualistas y que no se alinean con valores relacionados a ser solidarios y ayudar la comunidad. A pesar de eso, los participantes de este estudio identificaron las ciencias de la computación como una disciplina con potencial para implementar esos valores. Incorporaron a sus identidades profesionales en las ciencias de la computación un amplio rango de actividades para ser solidarios y ayudar a su comunidad, como enseñar, ser mentores, crear refugios sociales y culturales para sus compañeros, o preservar sus culturas utilizando sus habilidades en computación. A través de ser solidarios y ayudar a sus comunidades, los participantes cumplían con su sentido de obligación hacia sus comunidades y contrarrestaban los estereotipos negativos sobre los estudiantes indígenas. Los beneficiarios de estos actos de solidaridad y ayuda a la comunidad incluían compañeros indígenas y de otros grupos minoritarios, estudiantes más jóvenes, sus comunidades de origen, y otras comunidades indígenas. Es importante indicar que las oportunidades para ayudar a la comunidad sirvieron de gran motivación para persistir en sus estudios en ciencias de la computación a pesar de todas las dificultades. Finalmente, hablamos de las implicaciones de nuestras conclusiones para las políticas y la práctica educativa, a la vez que exploramos sus implicaciones en relación a cómo las instituciones y los departamentos de ciencias de la computación pueden apoyar el reclutamiento, la retención, y el éxito de los estudiantes indígenas.

Palabras clave Estudiantes Indígenas · estudiantes de licenciatura · ciencias de la computación · persistencia · solidaridad y ayuda a la comunidad

Despite their small numbers in the U.S.A. STEM enterprise, Native scientists have contributed significantly to the areas of biology and ecology (U.S. National Library of Medicine N.D.; Dale Walde 2006); geoscience (Riggs 2005); engineering, including Indigenous design (Parisky, Ciotti, Benning, Kant, and McCoy 2016); and mathematics and astronomy (Emory Dean Keoke and Kay Marie Porterfield 2009). Their work has also contributed towards computational understandings (Ron Eglash 2007). Utilizing their computer science (CS) and engineering knowledge and skills, Native individuals have also played pivotal roles in missions conducted by NASA, which includes sending the first Native astronaut, John Herrington, into space in 2002 (Yvette Smith 2019). Increasing the numbers of Native individuals in STEM could provide innovation for the U.S.A. STEM workforce and provide role models for future generations. CS education could also support Native people in contributing to STEM and CS infrastructure of their tribal nation. One way of retaining Native students in STEM, including CS, is providing opportunities to give back to their communities.

Existing research has found that *giving back*—which encompasses ideas such as activism, civic engagement, and helping one's community—is a cultural value in Native communities and a prominent and dynamic motivator for Native students' persistence (Justin Paul Guillory 2008). However, research also suggests that STEM fields are perceived to be highly individualistic and lacking in opportunities to fulfill communal goals such as giving back and thus are less likely to attract students from underrepresented groups among whom communal values are important, such as Native students. This paper explores the experiences of a small cohort of Native women and two-spirit undergraduates and how their values and experiences around the communal goal of giving back enable them to persist in CS, while navigating multiple identities as Native students and emergent computer scientists. We also explore the implications for how institutions and CS departments can support Native student recruitment and success.

Literature review

In this section, we define our meaning of giving back in this paper, followed by a brief outline of the literature on how communal goals, such as giving back, relate to STEM pursuit and persistence. The section concludes with a summary of Native perspectives on giving back, particularly with regard to undergraduates in STEM.

Definition of giving back

We use *giving back* as the organizing concept of the paper, though different terms have been used for the same concept in the higher education literature. We have found terms such as activism (Ko, Kachchaf, Hodari, and Ong 2014), civic engagement (Zukin, Keeter, Andolina, Jenkins, and Carpini 2006), service learning (Manning-Ouellette, Chrystal, and Parrott 2018), and volunteering (Keeter, Zukin, Andolina, and Jenkins 2002), among others, all referring to a similar idea. Each definition relates to "behaviors associated with improving an individual's community and helping others" (Page 2010, p. 10) and "creating change in attitudes, knowledge, behavior, and/or symbols"

(Tony Chambers and Christine Phelps 1993, p. 20). Based on this literature, we define giving back as engagement in activities that contribute to the empowerment of one's communities and to creating positive change.

Communal goals and STEM pursuit and persistence

Giving back is embedded in the concept of *communal goals* advanced by Amanda Diekman and Mia Steinberg (2013), who contend that individuals with communal goals for their careers have working with or helping others as their objective. Those who value communal goals do not typically consider STEM careers, given the pervasive perception of STEM fields, especially CS, as individualistic and competitive (Diekman, Steinberg, Brown, Belanger, and Clark 2017). Compounding the issue are popular ideas about computer scientists as being solely technology-oriented, lacking in interpersonal skills, unattractive (e.g., Cheryan, Plaut, Handron, and Hudson 2013), and operating in a discipline with a masculine culture (Berdahl, Cooper, Glick, Livingston, and Williams 2018). These ideas influence who pursues and persists in these fields. According to Kathryn Boucher, Melissa Fuesting, Amanda Diekman, and Mary Murphy (2017), "members of groups underrepresented in STEM fields (i.e., women, racial and ethnic minorities, and first-generation college students) tend to value communal goals to a greater extent than members of groups that are better represented" in these fields, such as White men (p. 4). Thus, these groups are less likely to pursue or persist in careers they perceive as not fulfilling as many communal goals.

Giving back as a Native cultural value

There is significant and compelling evidence of the communal goal of giving back as an important value for Native people. Justin Guillory (2008) described giving back as a Native cultural value, indicating that Native communities have a communal value orientation, where individuals are oriented towards giving back to others in their communities. As regards education, many Native Americans believe their education and work should result in benefits not only for themselves but for their family and communities (Okagaki, Helling, and Bingham 2009). Raphael Guillory and Mimi Wolverton (2008) suggested giving back as a positive source of motivation for Native American college students, helping them to overcome other stressors. Justin Guillory (2008) pointed out values such as generosity and sharing, group orientation, maintaining extended family connections, and commitment to community as values that Native students are using "as a source of strength to persist through college" (p. 32). Jessi Smith, Erin Cech, Anneke Metz, Meghan Huntoon, and Christina Moyer (2014) found a significantly higher endorsement of giving back to community among Native American students than their White male counterparts.

Jessi Smith, Erin Cech, Anneke Metz, Meghan Huntoon, and Christina Moyer (2014) noted concerns arising from incongruity between the communal goals of Native students in STEM and the STEM culture with its perceived lack of opportunities to give back: "Native American STEM students with strong endorsement of communal work goals at the start of their college career had lower self-reported motivation, weaker persistence intentions, and reported poorer performance in STEM" suggesting that "the communal work goals valued by these students may have been incongruent with the culture of science they experienced in their academic major" (p. 419). The authors found that Native students who grew up

in more traditional communities or on reservations with strong communal orientations had difficulties integrating and feeling like they belonged in college; their strong sense of belonging with families and tribal communities did not translate to a sense of belonging as STEM majors.

While Janet Page-Reeves, Gabriel Cortez, Yoenesha Ortiz, Mark Moffett, Kathy DeerInWater, and Douglas Medin (2019) had similar findings to those in the 2014 study by Smith and colleagues (2014), they also found that when opportunities for giving back arose for Native undergraduates, they served as motivators for them to persist in STEM. Below, we describe the giving back model by Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019), which we adapt and modify as the theoretical frame for this paper.

Theoretical framework

This study's analysis is grounded in Page-Reeves and colleagues' 2019 framework for giving back and Native American students in STEM, which includes five different domains of giving back: (1) giving back due to a sense of duty, responsibility, and obligation to their community, which are further distilled into dimensions of answering expectations of family or community, practicing resilience, countering stereotypes, and reciprocating acts of helping; (2) defining success in STEM in relation to the purpose of giving back, instead of traditional STEM measures of success, such as grades; (3) serving as a translator or bridge of STEM knowledge for the benefit of their Native communities; (4) being a role model and a trailblazer in STEM; and (5) constituting a challenge in STEM fields which appear to lack giving back opportunities valued by Native students. This model is particularly salient for framing two major findings in our paper, giving back as a cultural value and giving back in the context of CS education. We also extend this framework by proposing the concept of culturally connected giving back which involves the incorporation of culture in giving back. This concept will frame our third major finding. It is further described below.

Culturally connected giving back

We propose the use of the term *culturally connected giving back* (CCGB) to define activities where Native individuals contribute to the empowerment of Native communities and to create positive change through the engagement of Native values, culture, and resources. In a departure from Page-Reeves, Cortez, Ortiz, Moffett, DeerInwater, and Medin (2019), who argue that all giving back efforts are Nation building, we hold that giving back, even CCGB, may or may not be directed towards Nation building. For example, participants might feel a cultural responsibility to reach out to other Native students in CS. While this act may be mutually beneficial in terms of academic and social support, it does not, presumably, directly lead to tribal or community sovereignty or self-determination, outcomes that characterize Nation building.

We consider Nation building, then, to be a specific form of CCGB. Bryan Brayboy, Amy Fann, Angelina Castagno, and Jessica Solyom (2012) define Nation building as a process that

> …consists of legal and political, cultural, economic, health and nutrition, spiritual, and educational elements with the well-being, sovereignty, self-determination, and autonomy of the community as the driving force… (pp. 12–13).

They argue for the importance of a college education in contributing to Nation building and strengthening of sovereignty, noting that "pursuing higher education folds into a larger agenda of tribal nation building, and vice versa—that nation building cannot be fully or adequately pursued without some agenda of higher education" (p. 27). Higher education, the authors contend, facilitates self-determination, or "the inherent right of tribal nations to direct their futures and engage the world in ways that are meaningful to them" (p. 17). Following this argument, educating Native undergraduates in CS could lead to CCGB acts towards *technology sovereignty* and *cultural preservation*, which in turn could support the realization of tribal sovereignty and self-determination.

Technology sovereignty and cultural preservation are recognized components of Nation building. Technology sovereignty refers to Native tribes' sovereignty over their data, both in terms of cultural heritage (Tahu Kukutai and John Taylor 2016) and of data about themselves for governance purposes (Diane Smith 2016). Kukutai and Taylor (2016) pointed out that the dearth of data on Native groups' numbers and locations, and groups' lack of access to complete information on their individual and collective rights, all hinder decision-making and program implementation to address needs. Language and cultural preservation refer to the protection of Native language and culture within the context of cultural sovereignty to chart a course for the future. It includes protecting Native rights to language, art, spirituality, traditions, artifacts, and other cultural elements (Wallace Coffey and Rebecca Tsosie 2001). In the Discussion, we explore how our modified framework is inclusive of the model of giving back by Janet Page-Reeves, Gabriel Leroy Cortez, Yoenesha Ortiz, Mark Moffett, Kathy DeerInwater, and Douglas Medin (2019), and adds CCGB towards technology sovereignty and cultural preservation elucidates the experiences of Native women and two-spirit undergraduates in CS.

Methods

For this study, we conducted photo elicitation interviews with eight Native undergraduate students in computing: seven participants identified as Native women and one participant identified as a Native two-spirit man. Participants attended a mixture of predominantly White institutions, Native serving institutions, and tribal colleges across the U.S.

Data collection

We utilized Photo elicitation to enhance the narratives of participants. In this method participants are asked to respond to open-ended and semi-structured prompts that address the research constructs and questions about photographs they took. Photo elicitation "is based on the simple idea of inserting a photograph into a research interview" (Douglas Harper 2002, p. 13). As Douglas Harper (2002) points out, photo elicitation decenters the authority of the researcher and overcomes difficulties posed by in-depth interviewing by shifting the focus from the interviewee to the photograph. Photo elicitation has the potential for photographs to elicit "emotional statements about the informant's life" (John Collier 1957, p. 858). Used with Native participants, photo elicitation is a decolonizing and participant-empowering approach (Linda Tuhiwai Smith 2021); it prioritizes the participant's perspective and tends to generate storytelling and life-history responses. It is more culturally responsive than other interview techniques, in that it

sidesteps what is seen as an extractive and inappropriate question-and-answer format among certain Native groups.

All study participants were first asked to take 10–30 digital photographs over the course of a month, depicting aspects of their lives—supports, barriers, and identities—that reflected their experiences as Native women or two-spirit individuals in computing higher education. The images could depict any objects or compositions that did not include faces or other identifiable markers. Participants were directed to not photographing others in ways that would be identifiable. Participants generated a total of 120 photographs.

Then, each student participated in a collaborative interview process with our research team, following processes described in Neil Jenkings, Rachel Woodward, and Trish Winter's (2008) work. During these photo elicitation interviews, each participant shared images they selected and described how they represented their experiences as CS students and/or as Native undergraduates. Interviews were conducted using Zoom, a video conference software, and lasted one to two hours. Sessions were recorded and transcribed verbatim. Interviews were conducted in alignment with values described in critical race theory, particularly the centrality and intersectionality of race and racism, the commitment to social justice, and the centrality of experiential knowledge (Daniel Solórzano 1997). The study obtained IRB approval.

Coding and data analysis

Based on previous work (see Ong, Jaumot-Pascual, and Ko 2020), the team created a codebook using both deductive and inductive coding (Jennifer Fereday and Eimear Muir-Cochrane 2006). The coding framework utilized code categories (e.g., person/support entity, action/type of support), "primary" codes (e.g., giving back, engagement with Native communities), and "secondary" codes (e.g., teaching, engaging Native values). When sections of transcripts addressed more than one topic, team members used more than one code in the same category. We call this "double coding." This type of coding helped us develop themes that may have been less obvious. See Table 1 for an example of the coding structure for giving back-related codes and double coding. A "parking lot" code was used for data to be considered that did not initially fit into another primary code and that might lead to the creation of new primary codes like School Life/Culture balance. Additional code categories included advice provided by the participants that were used to develop the recommendations section of this paper. The team's codebook was a living document and was updated throughout the coding process and refined by team consensus as we coded, analyzed, and recorded the transcripts (John Creswell 2013). The 120 photographs themselves were not coded, only the transcripts of conversations about the images from the interviews, as well as photograph titles and captions written by the participants, which had been collected and provided context for all photographs whether or not they were discussed during the interviews.

The team initially coded the transcripts and photograph captions in a process in which research team members first coded whole transcripts individually using Microsoft Word, and then came together in pairs to compare coding decisions and reach consensus. In the rare instance where a pair could not come to agreement, the conflicting codes were presented to the whole team and consensus would be made then. To limit favoritism or bias against particular codes, team members rotated their coding partners for each transcript. Additionally, for codes related specifically to the Native experience (e.g., engaging Native values), our Native team member reviewed and confirmed that these passages were

Table 1 Example of the coding and analysis process

Code category: action/type of support				
Primary code	Secondary code	Sample Quote	Double coding	Themes
Giving back	Teaching	"I've moved to the closest city where I'm from, to get knowledge and to one day to come back and do computer literacy for my reservation, to have them learn about computers." (Tokala[a])	N/A	Giving back as a Native value
	Mentoring and being a role model	"I want to be an example for someone like me who didn't have anyone to look up to, like an urban Native who was not connected to her culture. That's my goal, if I can be that little bit of inspiration for someone who is like me, then that's what's good for me." (Bell)	N/A	
	Recruiting and encouraging others to pursue CS	"If I'm in computer science as a Native woman, there's no reason why I can't take this part of me and try and encourage other people with their own computer science journey. 'Cause I feel like it's sort of like a chain." (Libby)	N/A	
	Connecting others with counterspaces	"I'm part of a lot of organizations that support minorities in the sciences. They hook me up with resources and give me support whenever I need it. I have also started a student organization with some friends, and we support each other." (Callie)	N/A	Giving back in the CS education context

Table 1 (continued)

Code category: action/type of support				
Primary code	Secondary code	Sample Quote	Double coding	Themes
Engagement with Native cultures and communities	Engaging Native values	"The entire idea of the video game is to really, like the intention is to have people reflect on their choices, but overall, was to give aloha, to recognize that people have differences, and it's hard, and to ask for understanding." (Leigh)	Double coded with Giving Back	Culturally Connected Giving Back
	Using CS to support Native communities	"I want to come back and help my people … We have technology in here. The thing is that they don't learn, or they don't know much about cybersecurity … Everybody's been prone to identity theft and stuff like that, and we're also prone to losing documentation. And in the field of IT, I want to bring that, to go paperless at some point, to say, hey guys, technology is convenient in this way because you can store it on the cloud, but also teach them to be aware that it can also be a bad thing, because people could hack into it, or somebody could take your identity." (Krista)	Double coded with Giving Back	Culturally Connected Giving Back Sub-theme: Nation Building
	Preserving cultural artifacts	"[Native] books can be saved electronically now. There's different ways you can do it. So, I'd like to help out, by preserving books or different documents that haven't been preserved electronically." (Callie)	Double coded with Giving Back	Culturally Connected Giving Back Sub-theme: Nation Building

[a]Participants' names have been replaced with pseudonyms

appropriately coded. After pair coding, the coded files were transferred to NVivo, a qualitative data coding software program, for further examination.

After coding, we utilized thematic analysis to develop our key themes around the factors that influence women and two-spirit Native students' persistence in computing undergraduate education. See Table 1 for an example of how the team used primary and secondary codes to develop the giving back-related themes included in this manuscript.

Positionality statement

We, the authors, are advocates for increasing the presence of people of color, and particularly women and gender/sexual minorities, in computing and STEM. Our project team consists of scholars who identify as Asian American, Native, and Filipina American, and as a Spanish immigrant. We work to promote social change by critiquing and call for the dismantling of institutionalized systems that oppress and marginalize Native individuals in computing education. Our identities and experiences as minoritized women and as researchers in STEM education equity and inclusion influence how we reshare our participants' stories and the meanings of those stories. We strive for trustworthiness through rigor in our methods, with a goal of sharing findings that closely reflect participants' experiences.

Findings

The following findings section is organized in three subsections: (1) giving back as a Native value; (2) giving back in the context of CS education; and (3) culturally connected giving back. Our analysis focuses on ways participants give back to their communities utilizing their computing skills; the implications of these findings for policy and practice; and recommendations for future research.

Giving back as cultural value

Our study's participants affirmed that they share giving back as a cultural value. One participant, Johanna, expressed her understanding of giving back as central to her tribe's values:

> [My] tribe is pretty compassionate, and I identify with that, and I feel that's our primary trait. … I think everyone needs to be shown compassion, and that someone cares. That is just our responsibility as a community to build each other up. I like trying to make people's lives easier as a Native American woman, because I definitely want to help people.

When discussing her photo entitled *Nature*, Leigh explained what she considered to be a uniquely Native Hawaiian value: to receive from the community so that later she can give back.

> We were planting these trees, and then afterwards, you have to say a saying, "E Ola 'oe, e ola mākou nei, e ola". That means "you live, we all live," and that tells the tree we're planting, you've got to give good energy, planting you, and then you're helping us in the end. We're helping you in the beginning, you'll help us in the end. ... I think that's kind of what my program has kind of done, [what] a lot of people around me have done. They helped me in the beginning so that in the end, I can help them. I think that's specifically Hawaiian.

When talking about her photograph, *Perspective*, Libby reflected on the importance of giving back as her responsibility as a Native woman to ensure Native voices are included in the development of new technology.

When I think about what it means to be a Native woman in computing, I think about the different perspective that each of us bring to the field because of our experiences growing up Native and our relationship with that part of our identity. Without these different Native voices in this field, we won't have a say in the way that technology—which is increasingly becoming a bigger and bigger part of life— is developed and shaped. We have important perspectives to share with the world. As a Native woman in computing, I do feel a responsibility to complete my degree and to make my contribution.

Giving back in the context of CS education

Six of the eight participants described how they planned to give back specifically in the context of CS education. We categorize these giving back approaches as (1) teaching and tutoring; (2) connecting to and creating counterspaces; (3) mentoring; and (4) serving as role models.

Teaching and tutoring

Krista shared how she gives back to her campus community by tutoring in various subjects. She uses this position to not only help others but find ways to empower herself:

> I'm also a tutor. And so, when I help individuals, they say… 'Wow, I didn't know you did this. You know how to do computers?' They praise you for helping them when you're a tutor. And it feels good to me, and I feel glad that I can help… [with] Diné language, culture, reading and writing, mathematics, up to, I would say up to elementary statistics, and then intro to computers, programming…

Here we see that Krista not only provides tutoring for CS-related coursework to her peers, but also helps others learn more about Diné language and culture, exposing others to backgrounds that may not have familiarity with.

Connecting to and creating counterspaces

Ong, Smith, and Ko (2018) describe counterspaces as "safe spaces" where women of color were able to find solace in an environment surrounded by those who shared the same or similar social identities as themselves. Three participants describe how they give back through connecting fellow peers to counterspaces or even creating counterspaces themselves. Bell, a senior, reaches out to Native students to help connect them with the American Indian Student Association on their campus:

> I like to talk, and I'm a little bit nosy. I ask people where they're from. What's their major? If I see someone's Native … I'll get them plugged in. That's my favorite thing to do. If it's a Native student, I'll get them plugged in with the American Indian Student Association.

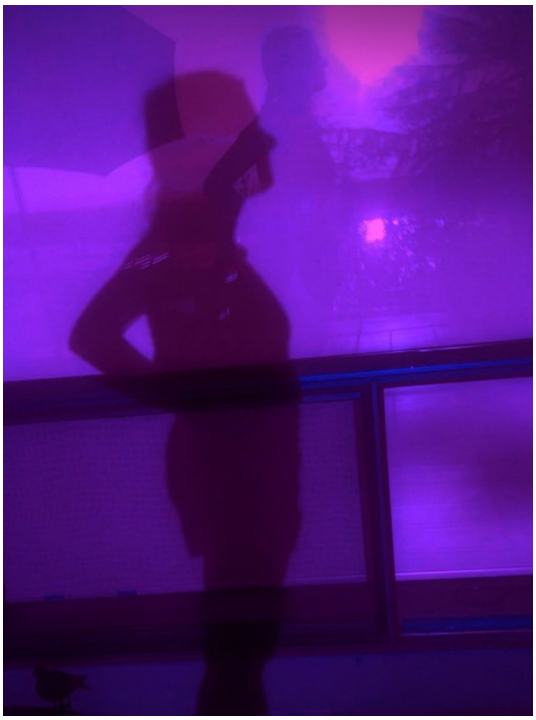
When describing her photograph, *My Anchors*, Callie, a senior, shares how she anchors herself in counterspaces like campus organizations that support minoritized groups within STEM and even created her own student group in CS:

> My anchors are like the roots of this tree that anchor the rocks to the cliffs. I'm part of a lot of organizations that support minorities in the sciences. They hook me up with resources and give me support whenever I need it. I have also started a student organization, [Women in Computing], with some friends, and we support each other.

Mentoring

Several participants emphasized the importance of giving back through being a mentor to others, especially to peers, young girls or women, and/or younger relatives who are also Native. While mentorship is important for most undergraduates, it can be vital means of persistence for those who are severely underrepresented, such as Native students in computing. We adapt Stacy Blake-Beard, Melisa Bayne, Faye Crosby, and Carol Muller's (2011) definition of mentoring as "an interpersonal exchange between an experienced senior colleague (mentor) and less experienced junior colleague (protégé)," wherein the mentor provides the protégé support in professional development (e.g., coaching), psychosocial functions (e.g., counseling, emotional support) and role modeling (2011, p. 623).

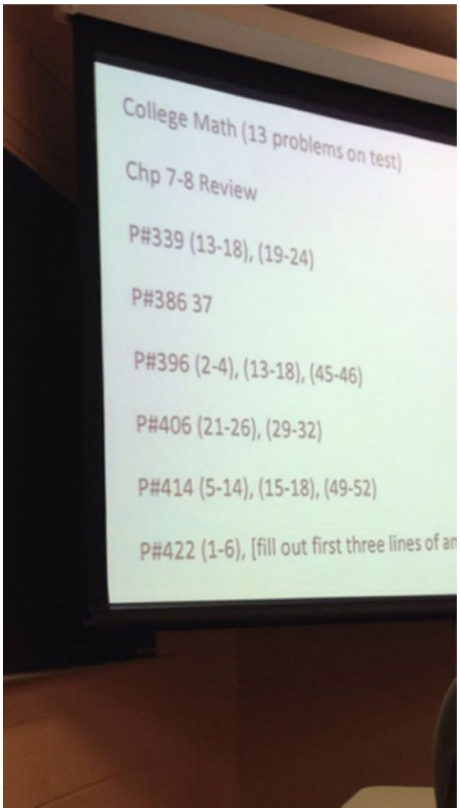
Participants shared how meaningful it is to be mentored by Native women in computing. In turn, they shared, or planned to share, their struggles and strategies for persistence and success with others as a means of providing psychosocial support. In explaining her photograph, *Mentor,* Libby related the value of having mentors, who were also family members, in the CS field:



I have two female cousins who have been incredible mentors to me throughout my time in computing. And it is my hope that someday, there are a great many Native women in computing to be mentors to others hoping to pursue computing.

Libby noted that she benefited from her two senior cousins, and she went on to imagine herself as part of the "great many Native women" who would encourage younger Native girls and women to enter computing.

Similarly, Johanna was active as an informal mentor to other women in her computing-related courses, giving back to members of her peer community. As she described her photograph, *Struggles*, Johanna discussed how she shared her struggles and vulnerabilities in a course, and, in doing so, she enabled others to see they were not alone:



> I feel like it's helped other women when I actually tell them, "Hey, I'm struggling with that as well." For example, testing, like math tests were a bit difficult for me, and they were difficult for a lot of other people, but no one was really sharing their troubles one time in math class, and I kind of just started talking to the other girls near me. And one of them actually was Native American as well, and I actually think it helped her to know that I was also struggling. And then we ended up actually studying together to try and like get through it.

It is noteworthy that when Johanna reached out to offer psychosocial support to classmates, she gained a mutually beneficial relationship with another Native woman. This example is one of several in our data that show how giving back is not unidirectional but can often benefit the person who is giving.

Serving as role models

Participants spoke extensively and ardently about the seriousness with which they took the responsibility of serving as a role model to other Native individuals interested in computing and STEM. Blake-Beard, Bayne, Crosby, and Muller, (2011) explain that in role modeling, the mentor is viewed by the protégé "as a source of guidance in shaping her own behavior, values, and attitudes" (p. 623). An illustration from our study is how Libby envisioned her own academic persistence as part of a phenomenon that could encourage "widespread" representation of Native women in computing:

> Another part of getting a computing degree is that the more of us who get our degrees, the more Native women in computer science become widespread. Then maybe other Native women and girls will be encouraged to follow or continue in their computing degrees.

Projecting oneself as a role model can serve as motivation for persisting in computing education, even in the face of struggle. Bell reflected on the photograph, *Self Expression*:

> I'm really proud of myself for doing this, 'cause even now, sometimes I'll just tell myself, "I can't do this." You know, "I'm not qualified, and I can't." And then I'll do it. You know, it's like, "Wow. Okay, maybe I can." And then I also want to be an example for someone like me who didn't have anyone to look up to, like an urban Native who was not connected to her culture, and was just lost, basically.

> That's like my goal, if I can be … inspiration for someone who is like me, then that's what's good for me.

Thus, Libby and Bell saw their persistence in computing as not individual endeavors but acts of giving back to the present and future Native women who might consider computing as a career.

Tokala regarded himself as a leader responsible for creating pathways in computing for others and diminishing any apprehensions they may have about succeeding in the field. Wanting to "inspire more Natives and two-spirit individuals" to pursue CS, he remarked while discussing his image, *My First Step*:

> I'm the only Native in my class, actually in almost all my classes. I don't think of it as a bad thing. I just think of it as there are people who are kind of scared to go into this field. But when they see me actually in this field … it gives [them] more confidence … and it makes them feel that, "Well, if he can go through it, then I'm pretty sure I could." … Which is why I mostly just power on and keep going, and then I [note] to myself that, I don't follow no one, but I know I can create paths, and creating paths is a good thing. It gives people opportunities.

Tokala demonstrated his understanding that giving back by serving as a role model came with sacrifices, such as isolation, which he was willing and eager to make for the benefit of future generations.

Culturally connected giving back

Study participants engaged in a variety of forms of culturally connected giving back (CCGB) by contributing, or planning to contribute, to the empowerment of Native communities through the engagement of Native values, culture, and resources. CCGB was expressed in three main ways: (1) integrating their Native culture with their giving back activities; and supporting Nation building by using, or planning to use, their CS skills towards (2) technology sovereignty; and (3) cultural preservation.

Integrating Native culture with giving back activities

Libby, Callie, Tokala, and Leigh expressed interest in integrating elements of their Native cultures with giving back activities that used their CS skills. Libby expressed the desire to combine her computing skills and Native culture, stating "I would really want to be part of a project that would bring the two together. I feel like… it's just, twice as fruitful." Tokala, discussed how his Native culture looks to nature as a source of knowledge and creation, and suggested he use this view of nature, with his technical education, to inform technological advances.

> I would like to improve more on the solar panels, [make them] differently, add [natural] designs. 'Cause nature is pretty much fundamental … design follows everything. And nature does give us everything, just about, and gives us ideas for many other things. And it's great … to have in your head that nature always was here before us and everything. And so… in my culture… we examine the plants or trees. But what we do get ideas from a lot of our surroundings, and how we would like to implement new ways or new things.

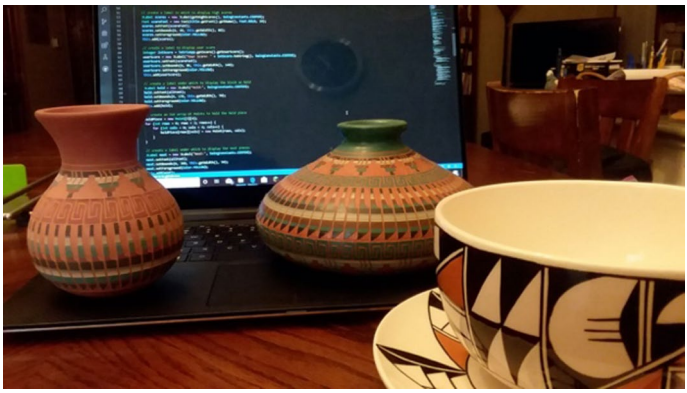
Similar to Tokala's plans to engage Native culture with technology, Callie discussed how bringing together the two can support the environment. She stated, "our [Native] culture is centered a lot in keeping the earth healthy … even though we've done a good job of destroying a lot, we can still use these technologies to reverse a lot of that too."

CCGB is also manifested in Leigh's engagement with the Native Hawaiian cultural value of aloha, which means kindness and sharing, especially in the context of family, where people are welcomed and there is reciprocity and collective benefit (Stephanie Teves 2012). Leigh's development of a video game to promote mental health, which she described while sharing her photograph, *Pohoiki,* is driven and informed by her understanding of aloha.

I think the entire idea of the video game is to really, the intention is to have people reflect on their choices, but overall, was to give aloha, to recognize that people have differences, and it's hard, and like, to ask for understanding. (originally cited in Silva, Jaumot-Pascual, Ong, and DeerInWater (2021a, p. 3).

Technology sovereignty

Callie, Bell, Krista, and Diana expressed keen awareness of their Nations' needs related to the management and use of tribal data for decision-making—the importance of which is delineated in Tahu Kukutai and John Taylor (2016)—such as the storage and management of data, cybersecurity, and tribal presence on the internet. Callie and Bell planned to use their technology skills to manage data for their respective Native communities and bring Indigenous viewpoints to information management by doing things such as helping Native facilities, such as health clinics and schools, to transition from paper to electronic forms. As Callie pointed out, "A lot of places aren't that tech savvy at all, and there's a lot of forms that could be made electronic that aren't. … There's a lot of books that should be electronic that aren't, and all they need is the person to do it." Diana and Callie would also like to increase their tribe's presence on the internet by creating virtual tours and having more extensive tribal websites with more information. When describing her photograph, *A Collection of Art*, Diana shared:



> I would like to help my tribe become more fluent in the language of the internet. We don't have a very big presence on the internet. We just have a few government sites on there, so I think it would be beneficial or cool to put some more information and help our tribe become more fluent in using the internet for things, instead of just paper. (originally cited in Silva, Jaumot-Pascual, Ong, and DeerInWater 2021a, p. 5)

Krista was very interested in using her CS skills to help her tribe implement technological solutions, such as increasing data security and electronically tracking the tribe's resources to help ensure equity within the tribe. She reflected:

> [My community has] housing discretionary [plans]. So, they allocate them $700 to buy lumber for their house to be rebuilt. And on the agenda when I attend meetings it's the same people on those agenda every time receiving that funding, which I think is unfair. … I'm like, how can we implement [a system] for my community that we can use so everybody gets help, and not just the same individual people. … This technology could help them create a system where they're not giving the same funding to the same people, and [so] that it's not a problem to our community.

Krista identifies potential problems with her tribe's governance and suggests computing and technological solutions to improve it, which we argue represents giving back through technology sovereignty. In her interview she implied that the current management of tribal resources could potentially result in grudges among community members, thus limiting community participation or trust in governance. With the technology-enhanced systems she planned on implementing, she foresaw more community involvement in chapter meetings, due to the fairer distribution of resources among members.

Cultural preservation

Callie, Diana, and Krista discussed their interests in preserving cultural artifacts, including books and documentation, and preserving their tribal languages. Both Callie and Diana talked about using their technology skills to create apps that would help preserve their tribal languages and help others learn them. Diana expressed her desire to create an app that would keep her language alive and explained that she had

"been to seminars given by other tribes, [about] how they have used technology to help their people learn their language and become fluent." Callie had begun building an app to preserve and teach her Native community's language that included features like translation from English to the language, counting, weather phrases, and recordings of songs. She selected Alexa for the platform "so that the language is preserved orally in the way it was created," a decision rooted in the Native values of her community (Silva, Jaumot-Pascual, Ong, and DeerInWater 2021a, p. 6). Callie planned to involve women from the campus counterspaces in which she participates to help her add more vocabulary:

> I volunteer with the Girls Who Code club at the university, and that club [which] is run through the computer science department, is joining with the American Indian Studies department and myself, and we're going to build more on my app, or maybe build other things that have to do with the [Native] language. So, with that, I'll definitely get the girls to put in a bunch more words into my app, and then hopefully add other features.

Krista also shared an interest in cultural preservation efforts. She wanted to work with an Elder from the same tribe who was trying to push the development of new words for new concepts based on traditional Native knowledge. Because Krista spoke her Native language and held her tribe's traditional knowledge, she wanted to collaborate in the creation of Native words for computing terminology. When discussing her photograph, *Look Beyond What You See*, she shared:

> [I want to work] with individuals who … give names now for a comput[ing devices] in our language. …[A]bout four, five decades ago, our people didn't have language for computers, because we didn't have the technology. They didn't have a word for telephone. And we got words for telephone now. … There's an individual … working in … [Native] culture, language, and leadership … I could give her more ideas about how my grandparents talked a long time ago, and how they used certain words… I think that if I'm able to push that into [computing] … it will allow me to be a better person in the computing field, and give me more of that confidence, that you know, I can do both.

Krista's interest in cultural preservation did not involve simply protecting the past. She wanted to help update her tribe's language and knowledge base to include terminology that reflected today's technology. She thought this way of giving back to her tribe would help balance what she experienced as the contradictions of being a traditional Native woman and being trained in technology.

Discussion

In this section, we apply to our findings the five domains of giving back set forth by Page-Reeves, Cortez, Ortiz, Moffett, DeerInwater, and Medin (2019): (1) duty, expectation, and obligation; (2) defining success in STEM in relation to giving back; (3) translating and bridging STEM knowledge; (4) being a role model; and (5) the challenge to find ways to give back in STEM. We show how the experiences of our cohort of Native women and two-spirit undergraduates in computing align with their broader findings about the importance of giving back for Native students across STEM; highlight a significant area where our findings diverge from theirs; and reflect on implications about how CS is a field that does not include opportunities to give back.

Duty, responsibility, and obligation

Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) found that the primary motivation for giving back for Native STEM students and professionals was "because they feel a sense of duty, responsibility, and obligation" (p. 9), which the authors further distilled into dimensions of answering expectations; practicing resilience in the face of adversity; countering negative stereotypes, and reciprocating acts of giving. In our study, we found evidence of each dimension, which are briefly described below.

Answering expectations

The expectations dimension manifested in our study as efforts to live up to the expectations of family or community members. For example, Johanna expressed awareness of her tribe's expectations that she give back by "trying to make people's lives easier" and "help[ing] people." She pointed out that "our responsibility as a [Native] community [is] to build each other up."

Practicing resilience

The resilience dimension emerged when participants, facing challenges or adversity in their CS programs, used their sense of duty or obligation as a source of strength to persist. Tokala, for instance, reported that he would "power through" challenges at school, including academically difficult courses and social isolation as the only Native and two-spirit person in his program, motivated by his goal of giving back through "modernizing" and bringing computer literacy to his reservation. Tokala's narrative illustrates Page-Reeves

and colleagues' claim that community could be "a source of strength to be able to confront educational and professional challenges" (2019, p. 10).

Countering stereotypes

Some participants sensed a personal duty to persist and succeed to counter negative stereotypes and avoid "reinforc[ing] … narratives about Native American ability" (Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin 2019, p. 10), especially in STEM. For example, Libby felt a responsibility to complete her degree so she could contribute her perspective as a Native woman to the computing field. She challenged stereotypes about Native ability by declaring that Native women in CS have "important perspectives to share with the world."

Reciprocating

Finally, duty or sense of obligation manifested in participants' emphases on reciprocity, which Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin, define as the "acknowledgement of a debt created by personal benefit" (2019, pp. 10–11). As an illustration, through her Native Hawaiian saying, "you live, we all live," Leigh invokes the value of reciprocity instilled by her Native culture. She shows her awareness that, as an undergraduate student, she is in position to receive (here, an education) so that, once she graduates, she can give back to her community.

Defining success in STEM in relation to giving back

Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) found Native students measured personal success in STEM "by how one's individual achievement contributes to the wellbeing of others and their community" (p. 13), and described STEM achievement "not necessarily based on … the grants or the publications" (p.13) but on an ability to use their skill set to give back to and invest in their communities. The authors describe a purpose-driven mentality that is spiritually motivated giving Native students strength to overcome challenges in their field and enhancing their ability to derive meaning from science. We connect this mentality to our study participants' goals around CCGB which relate to engaging Native values in their work, including spirituality. Participants expressed the interlocking goals of using their cultural knowledge to enhance technological solutions and employing their technology skills to contribute to tribal wellbeing through Nation building.

For example, Tokala aimed at improving a technological solution by incorporating Native cultural values. In thinking about improving solar panels, he expressed his belief that "nature is pretty much fundamental. … design follows everything. And nature does give us everything, just about, and gives us ideas for many other things." He is expressing how his values and spiritual connection to nature as a Native person can motivate him to see a new technological solution. Leigh likewise incorporated her Native Hawaiian values into one of her achievements, her mental health game, explaining that the value of aloha was the "entire idea of the video game."

Participants expressed desire to use their computing skills to support tribal sovereignty, an aspect of Nation building, through efforts around technology sovereignty and cultural

preservation. Callie recognized a need for her community to transition away from paper data collection to electronic data management, and she sees how her skill set is of great value to her tribe and its digital infrastructure. Krista also identified that "technology could help [her tribe] create a system" to better manage data, a technological solution that Krista could help develop and implement. Other students gave back through Nation building by contributing to cultural preservation. This took two forms: developing apps to teach language and culture, and translating technology-related words into Native languages. These activities incorporate the students' computing knowledge and their Native cultures, and demonstrate ways that students find purpose and meaning in their computing education through engaging Native values.

Translating and bridging functions of giving back in STEM

Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) found that Native students understand they have the ability and responsibility to "translate scientific concepts to make them more meaningful for people in the community who do not have scientific training or who might not understand the issues" (p. 13), and that this role is particularly salient because that "technical and scientific knowledge … has implications for benefiting Native American communities" (p. 13). Five of our eight study participants helped or planned to help their Native communities understand how to use computing to their benefit, or they were using their computing skills to contribute to their communities' technology sovereignty.

In the examples of Diana and Krista, we see Native students finding ways to take their CS knowledge and make it more meaningful and beneficial to their tribes. Both women wanted to help their tribes incorporate computing knowledge into everyday Native knowledge and practices. Diana saw a need for her tribe to increase their presence on the internet and wanted to help transition them from conducting business solely on paper to being more tech savvy. She sought to act as a bridge between the computing classroom and her community, bringing knowledge about "become more fluent in the language of the internet" back to her tribe who were not receiving the same training. Krista expressed an interest in functioning, literally, as a translator, working with an Elder to translate the language of technology into her Native language. In doing so, she would not only be providing new words to her tribe's language, but also helping them use contemporary technologies in a culturally appropriate manner and allowing her tribal members access to knowledge that is not readily available or accessible within their community.

Krista noted how contributing to her Native language through translating computer terms also served as a motivator to persist, making her "a better person in the computing field and give [her] more confidence" that she can be both a CS major and Native. Her comment aligns with previous findings by Justin Paul Guillory (2008) and Raphael M. Guillory and Mimi Wolverton (2008), who found that giving back serves as a positive motivator for Native students who pursue postsecondary degrees.

Being a role model and blazing a trail in STEM

Our study revealed rich evidence of participants giving back by serving as role models and trailblazers. Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) highlight the importance of role-modeling in "setting an example for others, especially for young people. … Individuals who are successful become concrete evidence for kids that they

have options, breaking out of stereotypes or expanding kids' sense of who they can be" (pp. 13–14). Several of our participants demonstrated that they embraced this role with an eye on the future but also as a means to support themselves when they struggled to persist.

Libby described feelings of not belonging and of missing her family, but also saw herself as part of a continuum of Native women in computing. Her elder cousins supported and motivated her; in turn, she wanted to be the next link in the "chain" of Native women that would inspire the next generation in computing. Bell struggled with her coursework but persisted by being open and vocal about her difficulties, thus creating opportunity to connect with others, break stereotypes, and serve as an "example for someone like [her] who didn't have anyone to look up to."

Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) noted that their study participants "repeatedly used the metaphor of '*traveling a path*' to describe their experience" (p. 15), while acknowledging the STEM path was a difficult one that sometimes required "blazing a trail" (p. 15). Tokala mirrored this language as he saw himself as a role model and trailblazer instilling confidence in his younger cousins and in others—"more Natives and two-spirit individuals"—by setting an example of success in computing, and by creating pathways in the field for them (see also Silva, Jaumot-Pascual, Ong, and DeerInWater 2021b). Krista also used a trailblazing metaphor of "paving the way" for Native people in computing, and she directly stated of junior Native women: "I want to be their role model. I want to be that person who didn't give up," reflecting how giving back to others also supports her own persistence. Callie, meanwhile, blazed a new pathway to support for herself and friends on campus by forming a counterspace, Women in Computing, to fill a gap in the support services offered by her school to marginalized groups in the computing field.

The challenge to find ways to give back

The study by Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) aligns with other communal goals studies (e.g., Amanda B. Diekman and Mia Steinberg 2013) in finding that STEM fields are commonly (mis)perceived as being non-communal. Page-Reeves and colleagues state, "While giving back is a clearly articulated objective for Native Americans … figuring out exactly what giving back entails is not as obvious" (p. 16). This is the only domain of the Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019) giving back rubric for which we found no evidence in our study. All participants had multiple, ready ideas of how they could give back to their communities, especially by using their computing knowledge and skills. Some were already engaging in giving-back actions, even as undergraduates. They wanted to give back to their families, peoples, reservations, peers and/or younger generations that were women and/or Native, or two-spirit.

We surmise that, compared to other STEM fields like astronomy, it may be easier to imagine ways computing could help and care for others (Brown, Thoman, Smith, and Diekman 2015). For many, technology is a visible part of daily life (both on and off campus), and perhaps our participants saw ample, highly visible examples of using their disciplines to help their communities, or the potential for them. It is also possible that our method of photo elicitation, which prompted them to think about their Native and computing identities, primed them to reflect on their Native values of giving back and consider ways to do so (even though "giving back" was never an explicit interview topic).

Finally, it may be that our small sample of eight undergraduates was atypical in not being challenged to think of ways to give back. More research is needed on this topic.

Conclusion and recommendations

Through our work, we confirm and extend the domains of giving back for Native undergraduates in STEM posited by Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019). Using methods of photo elicitation, in the specific context of CS, we underscored several themes that these authors identify related to giving back: duty, responsibility, and obligation to benefit one's home community with newfound knowledge; defining success in relation to giving back; translating and bridging functions of giving back; and being a role model and blazing a trail.

Although computing is stereotypically perceived as being less aligned with individual's communal goals of helping and working with others (Boucher, Fuesting, Diekman, and Murphy 2017), we found that our participants identified computing as having the potential for giving back and incorporated this into their computing professional identities through teaching, mentoring, creating counterspaces, or preserving their cultures using their computing skills. This is the only domain in which our findings contrasted with Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019): Native students in computing were not challenged to find ways to give back, perhaps because of the ubiquity of computing in everyday life.

This work contributes an understanding of CCGB to the existing knowledge base about Native participation in STEM fields. We uncovered multiple ways that students practiced CCGB, meaning they contributed, or plan to contribute, to the empowerment of Native communities through engagement of Native capital and values. Notably, most CCGB actions had a technology-related component. Many of them also came with Nation-building intent, such as applying web design skills to increase tribes' presence on the internet; creating technological solutions to assist in tribal governance; and using technology, such as language apps, for cultural preservation. With the development of the concept of CCGB, however, we depart from Page-Reeves and colleagues (2019) in another important way: we do not regard *all* acts of giving back as Nation building. We view the categorization of Nation-building, or not, as dependent on the intention of the act and who benefits from it. Some acts of CCGB that engage Native culture are not necessarily Nation building, for instance, Leigh's incorporation of the concept of aloha into her video game design, which certainly invokes and educates about Native Hawaiian culture but does not necessarily lead to group self-determination.

Our study suggests that once firmly in computing as majors, Native students can generate ways to give back in their field. However, younger people may need support in getting to the CS door. Departments and institutions interested in recruiting Native students into CS should conduct active, ongoing outreach to elementary, middle, and high schools with high populations of Native youth, with programs that emphasize the abilities of CS and STEM to help others, especially Native people and communities. Equally important, elders in the community should be educated on how CS skills can help their tribes and people so they may lend their influence and support to those interested in CS pursuits (Roli Varma and Vanessa Galindo-Sanchez 2006).

Faculty of introductory computing college courses should consciously work to help Native students identify ways to give back that align with their own communal goals,

potentially with emphasis on CCGB. Instructors might incorporate into their courses examples that emphasize how computing has been used, or could be used, to benefit Native people or communities, for example, the importance of cybersecurity for achieving Indigenous technology sovereignty. As Page-Reeves, Cortez, Ortiz, Moffett, Deerinwater, and Medin (2019, p. 31) suggest, departments or institutions could work with their Native STEM students or with the American Indian Science and Engineering Society (AISES), a national nonprofit dedicated to advancing Native participation in STEM, to "develop course content, curriculum, workshops, and presentations" to assist students in attaining a career in STEM that aligns with their communal goals (our project team includes Kathy DeerInWater from AISES).

Moreover, departments should provide Native students with opportunities for community building and for giving and receiving mentoring and role modeling. Departments should also be open to, and financially supportive of, student-initiated actions such as creating an AISES or SACNAS (Society of Advancement of Chicanos/Hispanics and Native Americans in Science) chapter or a women-in-science group. Campuses should continue to support a strong presence of groups, programs, and centers that meaningfully contribute to a sense of belonging for members of minoritized groups and that provide opportunities for giving back. Moreover, there should be counterspaces available for those who embody multiple marginalities, such as Native women and people of color who identify as LGBTQ2 (lesbian, gay, bisexual, trans, queer/questioning, and two-spirit). Based on our findings, we further encourage giving back as a potentially highly beneficial practice in STEM teaching in general. Departmental leaders and faculty should apply giving back as a strategic pedagogical approach or community offering organized by the department, such as working with communities that reflect students' identities to create STEM-based solutions or mentoring or tutoring younger students in need in local K-12 schools.

More research is needed in the areas of giving back for Native undergraduates in computing. Topics for future research include understanding how curricula and pedagogy may be effectively reformed, using the concept of giving back, to recruit Native youth and higher education students in computing and STEM; how Native students' aspirations to give back might be supported on computing and STEM pathways (Christina Hobson Foster 2016); how cultural or Native capital may be understood to contribute to computing and STEM (Christina Hobson Foster 2016); how intersectionality is enacted and experienced for Native women or Native two-spirit individuals with regard to giving back in computing and STEM; and whether and how experiences with regard to giving back is similar to, or different from other groups, such as Latinx, African American and Black, or White undergraduates in computing, Native graduate students and Native professionals in computing, and Native undergraduates in other STEM fields. Researchers should further undertake the broader study of giving back for other student populations in computing and other STEM disciplines, especially attending to ways in which culturally connected giving back is similar to, and different from, the findings reported here. Finally, more research is needed on the effects of using decolonizing methodologies such as photo elicitation with study participants underrepresented in STEM. Other decolonizing methods, such as arts-informed elicitation, should also be explored.

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Declarations

Competing interests The authors declare no competing interests.

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