



Ancestral Computing for Sustainability: Centering Indigenous Epistemologies in Researching Computer Science Education

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Abstract

This article offers Ancestral Computing for Sustainability (ACS) to dismantle the logics of settler colonialism that affect accessibility, identities, and epistemologies of computer science education (CSE). ACS centers Indigenous epistemologies in researching CSE across four public universities in the United States. This paper describes Ancestral Computing for Sustainability and explores reflections of two students engaging as researchers in ACS inquiry. Drawing on Indigenous methodologies and Participatory Action Research, they share their reflections as co-researchers in ACS through storywork. These critical reflections include their relationship to computing, observations of the interdependent work within ACS, ethics and sustainability, and their experiences within the focus groups. The article ends with recommendations for furthering ACS as a decolonial approach that centers Indigenous epistemologies in CSE. Recommendations for CSE education include Ancestral Knowledge Systems and adding sustainability as a topic within computing education pathways and building student-faculty relationships based on trust is recommended to foster students' academic and personal growth within CSE education and research.

Keywords Ancestral knowledge systems · Indigenous epistemologies · Decolonizing computing education · Sustainability · Participatory action research · Critical reflexivity

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Introduction

At first glance, two well-known universities did something common in reporting racial statistics, which was to contribute to the erasure of Native American presence either entirely or to relegate to “other” or “something else” categories (Blalock & Moreno Sandoval, 2020). Both Duke University (2011–2018) and Stanford University (2020) did not include Native Americans in their reports of computer science graduates and computer science majors, respectively. Even where American Indian/Alaskan Native¹ students in computer science degree attainment are included in the statistical presentation, representation is bleak. In 2019–2020, the National Center for Education (2022) Statistics (2022) reported that just 0.2% (269 of 97,047) of computer information systems and support services Bachelor’s degrees were conferred to American Indian/Alaskan Native students — across postsecondary institutions.

Could it be that Native American student data may be mis-represented? Stanislaus State did the same as Duke and Stanford in reporting data for computer science majors in 2019–2020. At Stanislaus State, and across the California State University system, Native Americans are counted if individuals choose “Native American” only in enrollment paperwork. If individuals choose the “two or more” category, “Native American” is statistically erased by “Hispanic” or “White”. For example, in the Enrollment Reporting System Operations Manual, as of 2020, students are categorized under a single race: White, Black, American Indian, Asian, or Pacific Islander. These limited and limiting designations hide actual populations represented on campus within narrow, inaccurate categories. For example, the count of Native American students according to the “What is your race?” survey question was only 18 students in the Fall of 2020. However, if multi-race responses are counted in the Native American student population, the count increases *dramatically* to 329 Native American students.

Stanislaus State population data currently *does not* reflect the actual, accurate population of Native American students (Factual, 2022). These practices *fail* to represent Native American individuals. It has and continues to pose a threat and false portrayal of Indigeneity through imprecision and erasure. Furthermore, using this settler colonial logic for racial categorization and identity representation upholds white supremacist structures. For example, the making of “Hispanics” and

“Latinos” root European histories while erasing Indigenous and African-rooted histories of the western hemisphere (Anahuac, 2022; Forbes, 1995; Mora, 2014). In order to engage in the process of unraveling and dismantling layers of settler colonial logics of accessibility, identities, and epistemologies of computer science education (CSE), the authors of this paper offer Ancestral Computing for Sustainability (ACS), an approach that centers Indigenous epistemologies in researching CSE across four public universities in the United States. This paper describes Ancestral Computing for Sustainability and explores reflections of two students engaging as researchers in ACS inquiry. We end with recommendations for furthering ACS as a decolonial approach that centers Indigenous epistemologies in CSE.

What is Ancestral Computing for Sustainability?

Decolonizing computing frameworks (Ali, 2021; Eglash, 2020; Mander, 1992; Moreno Sandoval, 2019; Van der Poll et al., 2020) assert that technology and computing education epistemologies are not accessible to minoritized communities; therefore, the very premise of its foundations must be questioned. Ancestral Computing for Sustainability (ACS) spawned from a vision to decolonize computing. This vision became an NSF funded research project within four institutions serving women of color (University of Puerto Rico at Rio Piedras, California State University Stanislaus, University of the District of Columbia, and Northern Michigan University). In this context, ACS is both a research project and an emerging theoretical framework with its own ontology, epistemology, and axiology. As a research project it draws from decolonial and indigenous methods (Tuhivai Smith, 1999; Wilson, 2008; Cajete, 2000), contemplative practices (Chatman, 2019) and youth participatory action research. Moreover, as ACS research ensued, it concentrated its experience by administering a survey that gathered information about: a. Computing identity; b. Ancestrality; and c. sustainable computing. Consequently, ACS hosted three or more contemplative focus groups for each of the institutions involved in this project.

As an emerging theoretical framework, ACS findings are guiding the articulation of an Ancestral Paradigm. This Ancestral paradigm has several guiding principles: a. Embracing Ancestral Knowledge Systems; b. Relational Accountability; c. Computing as a life-asserting and preserving the body of knowledge; and d. Research as a praxis of healing. While ACS does not center the colonial experience as decolonizing frameworks can do, ACS moves towards centering Indigenous computational epistemologies that have existed for time immemorial. Ancestral Computing for Sustainability furthers decolonizing computing education with a focus on ancestrality, a process that precedes the idea of race. By centering ancestrality and moving away

¹ For the purposes of this essay, Native American, American Indian, Alaska Native and Indigenous identities are used interchangeably. While each category has its own history and legal visibility, the scope of this paper includes these representations of ancestral identities to the western hemisphere together to advance the need for Indigenous epistemologies in research practice.

from race-based frameworks, we move closer to Indigeneity across the globe and lean closer to earth-based knowledge, which are ancestral knowledge systems. Interweaving ancestral knowledge systems, computing education, and sustainability efforts create a tapestry of possibilities for dignified and responsible computing. It is essential to understand the problems of erasure because we are all on stolen land. Being able to realize that we are walking among native land is important. Those with little knowledge and understanding of this issue should consider what they know about Indigenous history and their education. Indigenous cultures have been thought to be non-existent and not prevalent in modern society. It is the erasure of culture, sovereignty, identity, and life.

Ancestral Knowledge Systems For over 20 years, the field of research has been critical to the colonizing effects of both research and knowledge creation (Tuhiwai Smith et al., 2019; Moreno Sandoval, 2019). The university as a site of domination, domestication, and acculturation forces academia to ponder the extent that the negation of other forms of knowledge defeats any attempt to diversify and increase the contribution of historically underrepresented populations (Grosfoguel et al., 2016). In an attempt to counter the invisibilization of knowledge, deemed as primitive, several scholars (Makoons Geniusz, 2016; Moreno Sandoval et al., 2016) have contributed to a body of knowledge that has been conceptualized as Ancestral Knowledge Systems (Womack, 2013). Ancestral Knowledge brings to the forefront Indigenous knowledge as legitimate bodies of knowledge that can contribute to the sustainable solutions of some of the most complex problems humanity faces today, including economy-agriculture-production and climate change.

Cultural and Contextual Considerations For those who identify as Black or of African descent, Indigenous, or identities with a strong connection to the earth, Ancestral Knowledge provides a perfect opportunity to examine and center the social, historical, and cultural realities of their lives and bring those discoveries into their educational experience (Tuhiwai Smith et al., 2019). This research allows us to explore the extent to which we can speak of collective/shared identities, such that the present meets the past while it faces an inclusive future respectful of the bodies of knowledge that honor students' ancestry (Akbar, 1996).

African Americans and Ancestral Knowledge Although ancestral reverence is a foundational concept in many Indigenous groups, this remains a sensitive area for some African Americans and other students of color. Many African American students, who may hold varied ancestry, some of which they cannot identify, may also hold painful memories of ancestors and bring to light possible traumatic experiences like post-traumatic slave syndrome disorder (DeGruy,

2005). Traditional or Indigenous African religious systems, which incorporate elements of ancestral reverence, have been maligned and misrepresented by and within Western culture and remain obscure to many African American and African-descended families. African-centered education (Asante, 1991) breaks from this, for education is political, contextual, and should be liberatory (Friere, 2004; Hooks, 1999, 2003). Moreover, for African American and other Indigenous/earth-centered communities, their ancestral knowledge may be embedded in the daily lived experience and cultural aspects of life such as foodways (family recipes, food stories/ethnographies; farming and food growing practices); language (expressions, sayings, idioms); childrearing and family socialization practices (family reunions, oral histories); and religious/spiritual aspects (dreams, visions, baptismal and tent revival stories); and other dimensions of shared family knowledge. Therefore, CSE should not be removed from the daily challenges that students of color face. Rather, CS curriculum and education should be utilized to help solve the problems within their own lives and problems in society at large.

Honoring Students' Identity through Contemplative Pedagogy Contemplative pedagogical approaches have emerged in the last two decades as viable ways to engage students of color in exploring issues of deep meaning and relevance. To make computer science liberatory and culturally sustaining, not just in content but also in perspective, necessitates new epistemologies that integrate ancestral bodies of knowledge. Grounding CSE with ancestral knowledge is a step in that direction. The research team was conscious that before ACS can propose new bodies of knowledge, it needed to engage in research with students' academic identities as they relate to computing and computational thinking. Contemplative approaches have been used by Indigenous peoples around the world. However, they have been only recently incorporated into the objectivist, western educational model, as scholars and educators themselves respond to the call for an education that is integrated and steeped in values that sustain the planet and humanity (Wapner, 2016). Contemplative pedagogy is strongly aligned with the liberatory aims of ancestral knowledge systems that emerged in higher education and is a particularly useful pedagogical approach for decolonizing research and education and advancing anti-oppressive structures in higher education (Berilla, 2014; Berila, 2016). Practices such as meditation, mindfulness, deep listening, storytelling, contemplative arts, and even portable labyrinths are actively used in higher education research and teaching (Barbezat & Bush, 2014). Yet these approaches are not only used for promoting learning but also to connect students to deeper values, particularly useful for students of color who emerge from cultural groups where these practices are already deeply embedded (Chatman, 2019; Fleming et al., 2022; Palmer & Rodger, 2009; Rendon, 2009).

Sustainable Computing and Computational Thinking The vast bodies of ancestral knowledge are currently used as a source of a deeper understanding of fields such as biodiversity, ecosystems, and climate change. To this end, UNESCO (United Nations Educational, Scientific and Cultural Organization) has created a division that has generated a series of research and publications where science is enriched with native science (Cajete, 2000). Consequently, the impact of computing on the environment, the way computing is practiced, and the production of its devices need to shift in a way that is not detrimental to the environment. Futuristic thinking contained within ancestral knowledge systems provides a different focus and understanding that can transform computing in a way that honors, protects, and takes care of the earth. Computing needs to incorporate a body of knowledge and praxis that cares for the livelihood of the next seven generations. Sustainable computational thinking, as a different mindset, nurtures the process of problem-solving by utilizing the power of computing in a way that ensures sustainability.

ACS invited what would traditionally be research assistants as researchers and authors of the process. Two of them are the lead authors of this paper. The following sections describe the method and their reflections on working as co-researchers.

Methodology

To create our narratives, we considered Indigenous methodologies' epistemological and methodological reflections and Participatory Action Research (PAR). Indigenous methodologies are ways of researching and building knowledge that honor Indigenous worldviews, ways of being, and seeing (Evans et al., 2009). We focused on storywork and reflexivity. Indigenous research recognizes that important historical and cultural knowledge is often held in Indigenous communities in the form of story and song lines, (Stewart-Harawira, 2013). Stories were central during the gatherings in ACS.

Jo-ann Archibald (cited in Stewart-Harawira, 2013) describes deep storying, or storywork, as an Indigenous research methodology which builds on seven critical principles of respect, responsibility, reciprocity, reverence, holism, interrelatedness, and synergy that form a framework for understanding the characteristics of stories, appreciating the process of storytelling, establishing a receptive learning context, and engaging in holistics meaning-making. Indigenous research also highlights the importance of relationality, including physical and spiritual dimensions (Peltier, 2018). Relationality considers the researcher, how they relate to the research, and how their stories and relationships connect to the projects. Accountability is a central part of relationality. Relational

accountability considers how we honor our relationships within research and honor and fulfill our roles within different relationships (Nicholls, 2009).

Nicholls (2009) describes reflexivity as multilayered, including three levels: Self-reflexivity, interpersonal reflexivity, and collective reflexivity. Self-reflexivity includes considering researchers' assumptions about the research, including theoretical approaches. Additional layers of reflexivity consider the relational parts of research (Nicholls, 2009). Interpersonal reflexivity tends to the researcher's place in the project and the awareness of collaborative relationships in the research. While collective reflexivity asks about participation in a project, how it is determined, and helped define the research. From a narrative inquiry, perspective reflexivity is an ongoing process in which researchers reflect on knowledge construction and research (Pino Gavidia & Adu, 2022).

The role of reflexivity is central to Narrative inquiry or narrative approach. This approach focuses on stories as central to constructing meaning and knowledge (Pino Gavidia & Adu, 2022). It tends to the personal and social/relational aspects of meaning-making. Narrative Inquiry focuses on three key elements: sociality, including personal and social dimensions from emotions to social conditions, temporality, and place (Pino Gavidia & Adu, 2022). Narrative inquiry acknowledges the construction of knowledge in research as a relational activity in which the researcher's role and interpretations are key. Self-reflexivity is critical in this process requiring the researchers to reflect and document different dimensions of their engagement in research. From their relationship to the subject to reflections on being and relationships as research progresses. Among the storywork approaches, autoethnography collects a narrative of how a researcher encounters the subject, establishes relationships, and thinks about the research. Autoethnography provides a roadmap to reflect on feelings, events, and thoughts from a personal perspective (Lac & Fine, 2018).

PAR is an epistemological approach to research that focuses on changing power dynamics and relationships, recognizing all parties' knowledge and lived experiences within research activities (Evans et al., 2009; Peltier, 2018). It works toward building solutions and alternate realities for marginalized populations (Uribe Ingrid et al., 2019). Within PAR, the notion of reflexivity is central to all parties involved in the projects (Lac & Fine, 2018). This refers to the awareness of the researcher's role and impact within research (Nicholls, 2009; Probst, 2015). Reflections regarding the researcher's role include their impact on the topic, the ideas, cultural position, emotions, attachments, and actions (Probst, 2015).

ACS study focuses on Women of Color's experiences in computing. It includes survey data and focus groups we call gatherings, as we conducted these gatherings three times or more for each institution. The research data and analysis is

written in another paper. Considering the centrality of reflexivity, indigenous research, PAR, and narrative inquiry, we reflected upon our experiences becoming ACS co-researchers. We started considering our origin story and relationships to computing, reflecting on the way relationships are built within ACS and reflections on our experiences within the gatherings. Our narratives include citations to support our reflections.

Reflections: Our Journeys as ACS Researchers

Drawing on Indigenous methodologies (Archibald, 2008; Denzin, Lincoln & Smith, 2008; Windchief & San Pedro, 2019) and Participatory Action Research (Bang & Vosoughi, 2016; Cammarota and Fine, 2008; Paris & Winn, 2013) we share parts of our journeys as researchers in ACS. We start by narrating how we came into the project and our relationship with computing before we became researchers. Then we share our reflections on trust and relationality in research (interdependence), ethics and sustainability, and our experiences in the sprout gatherings. The experiences we reflect on include both the seed group and sprout group gatherings. The seed group refers to the researchers whose ideas and work started ACS, while the sprout groups include the groups established as part of the research in the four directions across four universities. We end this essay discussing recommendations for CSE and research drawing on an ACS as a decolonial perspective.

Marlen: I was born and raised in California. I am currently a student majoring in computer science at California State University Stanislaus. I have gathered work in research centered around human–computer interaction and data analysis. These experiences, including this research, helped shape me as a student. My academic journey started when I started university as a lost first-year student. As a first-generation student, the first in my family to be in university, my computing experience was on the other side of the spectrum. I had no knowledge of computer science, or anything related. When I was in middle school, there were no courses related to CS; this kept my interest non-existent. In high school, I was on the route to work in the healthcare industry, but later changed interests and was exploring what I wanted to do. I only knew I would study computer science once I stepped foot into the university.

During the first-year orientation in the summer of 2017, I had a feeling that was hard to describe. A feeling pulled me towards CS. At the time, I was in the criminal justice program. I switched my major immediately and went towards the group that had computer science students. I became more interested in computing during my first year, and it was not until I learned more about the field that I knew it would be a challenge. I realized my interest was solid in computer science after taking

multiple internships and research opportunities. Each experience I had affected me in a variety of positive ways when it came to developing my interests as a career. I joined the ACS research family in March 2020, during the early days of the covid-19 pandemic. The day I joined was the beginning of finding my voice and self, and throughout these years up to the current time. The research team has created a space for everyone. This space is intentionally uplifting and has helped uncover my voice. From the ACS research, I have gained more confidence in my skills and my voice due to the space created in the research team. These spaces are necessary for many research students because they bring to light hidden skills that were not brought before. When I reflect on my education as a computer science student, I have been fortunate to have been surrounded by talented and supportive faculty and students. With our similar backgrounds, we brought connectedness to the team.

Alyssa: I was born and raised in Puerto Rico. I am currently a graduate student of Social Community Psychology at the University of Puerto Rico, Rio Piedras Campus. Most of my experience as a volunteer, student, and research assistant has been with grassroots community organizations and environmental groups, conducting research with community members and through popular education initiatives. These experiences have been informed by the theoretical approaches of Liberation Psychology, Participatory Action Research, Popular Education, and Decoloniality (Miranda Gierbolini, 2021). In these experiences, I learned about issues related to sustainability. Reflections on relationships, ethics, and social change in research and practice have been a part of my classes and experiences. Both sustainability and relationships are central parts of the Ancestral Computing for Sustainability research project and were the parts I connected to at the beginning. I joined the gathering as a researcher in February 2020. I did not know much about computing, computational thinking, or CSE. My understanding of these has broadened after becoming a part of the gatherings. As a graduate student of Social Community Psychology, I did learn about the use of statistics, including computers, although not programming specifically. Computers and digital connections are essential when thinking about concepts like the self, subjectivity, community, and groups from a social community psychology perspective (Figueroa Sarriera, 2006a, b). My contact with CSE has been minimal. In my middle school years, I took computer classes but did not have the opportunity to explore or be creative. At that time, the focus was on learning about computer hardware and software. At a university level, I never attended a CS-specific course.

Interdependence

Marlen: I joined the research team in March 2020 during the time of the COVID-19 pandemic. I was not in the best mental health or mindset at this time: the pandemic and the

months in between impacted my mental health. Many external factors led me to give myself an overall negative outlook. I felt all kinds of emotions rampaging at this time, especially wanting to ensure my family was safe and taken care of. Not being able to visit them was difficult. I was also trying to work as best as possible, but financial issues at the table brought many thoughts. Nevertheless, joining the team has helped me trust my professor so that we can count on each other to perform the work and have a new way of dynamic relationships. I think many students were feeling this way and felt this pandemic brought an impossible weight to our studies, research, and work.

While this happened, I attended my first research meeting with the team online. Since many of the faculty researchers are all across the United States, we met through zoom. While getting to know the researchers and student researchers, I was slowly building a relationship with the team. As we started working more with each other, we also had trust built onto our dynamic between professor and student. With the trust building up over time, I could talk about sensitive topics such as mental health. With being able to discuss this, it is easier to discuss other matters that are affecting us as students. Mentors who help students focus on a substantive project, such as conducting research, learning a new skill, or collaborating on a particular area of activism, appear to be particularly influential on student outcomes (Raposa et al., 2021). This also helps bring a clear decision on the next steps in either taking a break and diving back into research or continuing until a specific deadline. It should be noted that Raposa's analyses cannot prove a causal link between factors like extracurricular engagement and faculty-student bonding (Raposa et al., 2021). The lives of university students are quite unpredictable because of the factors that need to be considered. These can include financial aid, part or full-time jobs, course assignments and exams, class projects, research, family situations, and other factors. These decisions significantly impact a student, especially since these are what help a student's productivity and mental health. Throughout the time in research, I heard this direct quote through personal communication with Cueponcaxochitl during the 2022 year, "becoming more of a creator than a helper." We were able to create without feeling restricted to set guidelines. This gave us room for creativity and inspiration for our research meetings, research work, and productivity.

Alyssa: I became an ACS researcher in February 2020, a month before the pandemic. As a researcher in ACS, I have continued learning how to perform research and reflecting on ethics. This was the moment of transition from face-to-face classes to online classes (Eringfeld, 2021). In these challenging times, ACS's unique way of managing itself has been crucial in facilitating learning as a researcher. From a mentoring in higher education

perspective, this makes sense as supportive professors are vital in helping students navigate the hardships of college and further their academic, professional, and personal development (Raposa et al., 2021). Research is one of the activities where students and faculty meet and develop significant relationships within academia (Raposa et al., 2021). However, student-faculty relationships have challenges considering the power disparity between students and teachers, worries about limiting the information shared, and time limitations for both parties (Elin Meyers Hoffman, 2014).

As part of the gatherings, particular ways of relating and researching are built, honoring Indigenous epistemologies, and transforming notions linked to colonial worldviews. Time itself, the expectations of productivity tied to it, and the academic culture have been challenged by how work has flowed within the project. Every task has been completed taking recent events and personal and collective needs into consideration, and not from a logic that centers time on productivity and sacrifices well-being at its expense (Shahjahan, 2015). This has been quite different from the logic we find within academia in courses and projects with many deadlines and the fear of being left out of academic programs if things are not done in a certain way or within a specific time frame (Shahjahan, 2015). This has been key to managing recent historical events (power outages and hurricanes in Puerto Rico, the COVID-19 pandemic, among others) and how we relate to each other within the gatherings. Honoring relationships and time beyond productivity has been central to my experiences as a student and collaborator with some grassroots organizations. However, it is not necessarily associated with research practices within academia. Relationships take time to form in these contexts, characterized by friendship, familiarity, and solidarity (Miranda Gierbolini, 2021). All of these are part of ACS. I had time to complete research-related tasks and space to process all the events that were going on.

As student researchers, we receive support, have spaces for dialogue and questions, and learn how to do things. This also follows relational accountability as a cornerstone of the project (Nicholls, 2009). Beyond the practical parts of research, there have been several moments to consider how we relate to the project. I remember a conversation about our identities and how we identify ourselves. This helped me to know more about the concept of *mestizaje* and its colonial roots. This has been important coming from a country where our racial description relies on being a mix between Indigenous, African and Spanish heritage, but where there is still discrimination against those with darker skin tones (Llorens, 2018). Learning more about Indigenous research and epistemologies has introduced other ways of looking at identity and race.

Ethics and Computer Science

Marlen: The topic of ethics mentioned in our gatherings is the connection between computer science and sustainability. This was a topic that caught my attention and has impacted me to do further research on the relationship between CS and sustainability. While performing the research, one of the things that occurred to me was coming across various fields that contribute to sustainability. One of them is an interdisciplinary field that uses techniques in computer science and other fields called computational sustainability. Computational sustainability is focused on three sustainable areas noted from the following: balancing environmental and socio-economic needs, biodiversity and conservation, and renewable and sustainable energy materials (Gomes et al., 2019). This area also contains three computational themes from the following: the first theme is optimization, dynamical models, and simulation; the second theme revolves around data and machine learning, multi-agent systems, and finally, crowdsourcing and citizen science (Gomes et al., 2019). This field has specific areas it focuses on based on the term computational sustainability. We also see other areas in computer science that contribute to sustainability. We have artificial intelligence (AI) making its way to providing more sustainable technological changes. Machine learning, a subset area in AI, provides many ways to help the environment. This can be things such as finding and being able to label animals by pictures or videos and see their overall behaviors. This helps us give an overview of the animals and how the population is doing. We can learn what we must do to maintain their population or protect their ecosystem.

Alyssa: The topic of ethics in computing was mentioned by many people within the gatherings, specifically those studying CSE. The topic of ethics is discussed in terms of the relationship and impact of computing on the environment and future generations (sustainability). This speaks of relational accountability in human interaction and considering all living beings and the planet itself. Listening to these discussions, I have seen the connection of computing with other ways of doing and practices that are more conscious of the planet. Before I participated in ACS, I had taken a class on Environmental psychology and read about different approaches to pollution and human practices that damage the environment. These readings presented two possible paths to resolve the ecological crisis we are facing: either dealing with it by changing people's behavior or solving it through the creation of efficient technology. Changes in human behavior are identified as crucial in achieving sustainability (Lengfeld et al., 2020). By being part of ACS, I have become familiar with possible technological changes and applications that might help address environmental issues.

Along with sustainability, ancestral knowledge systems include epistemologies and worldviews that differ from

western and capitalist views within academia (Moreno Sandoval et al., 2016). Considering different knowledge systems connects the experience of communities to computing. I have worked with grassroots community organizations and ecologist groups whose goals are on environmental justice and endogenous development that allows them to subsist economically in harmony with the environment (Miranda Gierbolini et al., 2020). Within their practices, they have gone back to ancestral ways such as fishing and agriculture. These speak of other ways of relating to earth and what is typically referred to as "resources" and exploited without considering the impact (Miranda Gierbolini et al., 2020). More inclusive computing that accounts for different knowledge systems could be relevant to people in the communities, become part of their education and lives, and be part of the efforts created to change the world. From then on, more people could be interested in pursuing careers in computing and STEM in general, seeing these as relevant to their realities and identities.

The Gatherings

While we will not go into the results from the gatherings, we will share our experiences as part of these meetings. As co-researchers, we have worked with recruiting participants, a process affected by the pandemic. For starters, all the contact with participants was through email; this affected the number of people that reached out to us. At another time, we could have used flyers or visited courses as ways to invite students to be part of the gatherings. Feelings of tiredness and overwhelm due to the pandemic and a virtual school setting have been expressed within the sprout gatherings. The university was lost as an embodied experience and community interaction space (Eringsfeld, 2021). Due to the changing world and challenges we were dealing with as students, we knew that reaching out and communicating with other students in a manner consistent with the ACS meant being honest about the impact of these events.

Participating in seed and sprout gatherings has been a learning and growing experience. These spaces have been established as safe spaces for everyone that joins them, including everyone on our research team. Meetings begin with checking in, sharing how everyone is doing, and acknowledging events people go through. The seed gatherings have all taken place during the pandemic. This means the gatherings and conversations within have taken on special meaning. During some periods of time, most academic and research activities have been held using virtual tools. This leaves little space for the spontaneous conversations that were part of the culture of universities in person. Gatherings allow for connections with others and our own stories. They have been significant in managing isolation and have allowed students to connect with personal dimensions, such as their ancestors. In addition, it is recognized and

maintained as a space where there are conversations that the students want to have. As researchers, we have been part of many gatherings; for this essay, we will each share our reflection on the California and Puerto Rico groups, as these are the ones we feel most familiar with.

Marlen: The great thing about our gatherings is that we can connect online despite being in different places since it is through zoom. We surround ourselves with a supportive community of students. With this, we also allow sharing what they are comfortable with. This allowed students to have no limitations on what they could and could not say. I remember people shared their experiences with their family history and their computer science experiences. With family, people explained the hardships they endured at young ages because of language barriers in the classroom. This was before entering university. They spoke on the subjects they struggled with and their efforts to catch up with their peers. With computer science education, many students had positive experiences with support from faculty, peers, and their network.

The gatherings discussed topics related to computer science and the overall experience in computer science education. One of the main things I learned was hearing the positive experiences between professors and students in the classroom. This positive experience impacts their interests and what they want to pursue after graduation. It shows how these courses inspire students to take the next step in their education by pursuing internships, personal projects, readings, or videos to further their interests.

Alyssa: The traditional distinctions between researcher and participants were not observed in the sprout groups. There was no distinction between who asked and who answered questions. Although I observed this in many groups, this was more evident during the second session of the focus groups in location 1 where the researcher said: “we will not ask you to do anything that we are not willing to do.” This meant that the gathering space would be one for sharing stories. In that session, we talked about our ancestors and ancestral computing. Everyone shared stories and images representing their elders. This made me reflect on PAR and how it challenges power dynamics, even the traditional distinctions between researcher and participant (Evans et al., 2009; Peltier, 2018). From other research perspectives, there is a difference between who asks questions and who answers them, leaving little space for dialogue and relational knowledge construction. Within the gatherings, people shared different ideas and projects related to transforming computer science. Many students have commented on their feelings about the gatherings, sharing that the space is safe to talk about topics rarely discussed within their classes. It also speaks to a transformative agenda in research, where not only is there an aspiration for change at the institutional or structural level around computer science education, but space is given for transformation in relationships and at the subjective level, true to a decolonial approach (Miranda Gierbolini, 2021; Uribe Ingrid et al., 2019).

Discussion

The experience of being co-researchers within Ancestral Computing for Sustainability has allowed us to connect our educational experiences with the possibility of building more inclusive computing-centering Ancestral Knowledge Systems. From our research experiences, we can mention several dimensions within ACS that highlight its transformational aspects for CSE and research within the field. These include relationality, Indigenous worldviews, Ancestral Knowledge Systems, and sustainability.

During the research meetings and focus groups, meaningful relationships and ways of interaction were built. These spaces served as nurturing spaces for all participants in which trust became a central element. As co-researchers, we connected with personal experiences related to mental health during the pandemic, the stories of our ancestors, and our identities. In the research meetings, there was always space to check on how everyone was doing. As students, we could build relationships with professors/researchers from trust, allowing us to share more and learn more. We could ask for help and feedback without fear of being perceived as incapable; We could offer our opinions and contribute to the research as equals. In terms of research, we have some suggestions that may help the overall relationship between professor and student in research. Among these, building trust and honoring relationships between professors and students makes for horizontal relationships that shift from traditional roles within research, where students are typically assistants and not researchers. This takes from Participatory Action Research in that students become researchers themselves (Evans et al., 2009; Peltier, 2018). Horizontal relationships between professors and students make for a profound learning experience, learning by completing each step of a research project, fostering the possibility of communicating about complex topics relevant to student development and growth. Centering relationships challenges academic ways that revolve around productivity that sacrifice well-being (Nicholls, 2009; Shahjahan, 2015). It can also make for experiences in research that honor students’ stories and lived experiences to make education engaging and relevant to people from different backgrounds.

Within the sprout gatherings/focus groups, students were open and honest about what they were going through. Conversations went from discussions about academic load to other issues. These gatherings were a space for learning and growing and have made a safe space for the students to share how they are doing. As researchers, we shared our stories and reflected on different subjects like our ancestors, identities, and sustainability. Incorporating experiences and talking freely about different topics made a learning experience for everyone. The gatherings were organized around

contemplative practices. It is essential to incorporate contemplative practices and spaces where students can reflect on their experiences and how they relate to what is taught in class. This allows for incorporating different knowledge systems within CSE and makes it easier for students of marginalized backgrounds to participate in building sustainable computing. It draws from what they know to create knowledge and alternatives to create a different CSE. During the conversations, different ideas came forth on transforming CS that went from how things are done to time and how relationships are built. These things are part of the cultural identity and heritage of students. It was familiar to them and, during conversations, made the possibilities and change more exciting and relevant.

Sustainability and computer science have been the main topics in our gatherings. From this, we have reflected on how the areas exist together. From this reflection, we identified fields within computing that incorporate sustainability (Gomes et al., 2019). An example of this is the interdisciplinary field of computational sustainability. This relatively new area combines the computational and sustainability side of things. There are many ways sustainable computing can help the environment, and many come from various areas in the field of CS. Ancestral Computing for Sustainability allows for conversation with ways of knowing and initiatives created within different communities that stem from thinking about future generations and humanity's impact on the planet. On this topic, we recommend creating a sustainability-focused course in CSE. Also, adding an Ancestral Knowledge focus would allow for conversations and projects that include solving problems, addressing issues already present within different cultural frameworks, and transforming computation into an inclusive field. This may make the field more relevant and appeal to different communities that have been kept out of the conversation so far. It can also motivate more people to create in ways that are more significant to the community and environmental conditions in different places. Ways to incorporate Ancestral Knowledge Systems can include courses centered around different cultures and contemplative practices in the classroom that allow for reflection and connection with students' stories and identities and their connection to CS.

These recommendations, including a course with a sustainability focus, will help students see that sustainability is an essential aspect of computer science. As well as honor the identities and knowledge of cultures that have been left out of CSE. From our experience as researchers in ACS, we can say that Ancestral Computing for Sustainability is a path toward the transformation of CS. Our experiences highlight the value of relationships with each other and our stories as ways to build computing that honors different identities and works towards a better future.

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