



SCIENCE EDUCATION
& CIVIC ENGAGEMENT

AN INTERNATIONAL JOURNAL



SPECIAL ISSUE:

'IKE Forum

VOLUME SIXTEEN
ISSUE TWO
Fall 2024



SCIENCE EDUCATION
& CIVIC ENGAGEMENT
AN INTERNATIONAL JOURNAL

Volume 16 Issue 2 · Fall 2024

ISSN: 2167-1230

Publisher

NCSCE

Executive Editor

Eliza Reilly

Editors

Matthew Fisher

Trace Jordan

Managing Editor

Marcy Dubroff

Editorial Board

Sherryl Broverman, Duke University, United States

Matthew Fisher, St. Vincent College, United States

Bob Franco, Kapi'olani Community College, United States

Ellen Goldey, Wofford College, United States

Nana Japaridze, I. Beritashvili Institute of Physiology,
Republic of Georgia

Trace Jordan, New York University, United States

Cindy Kaus, Metropolitan State University, United States

Theo Koupelis, Edison State College, United States

Jay Labov, National Research Council, United States

Amy Shachter, Santa Clara University, United States

Garon Smith, University of Montana, United States

Dauida Smyth, Texas A&M, San Antonio, United States

Mary Tiles, University of Hawaii emerita, Great Britain

**National Center for Science and Civic
Engagement**

www.ncsce.net

Partial support for this Journal was provided by the National Science Foundation's Course, Curriculum and Laboratory Improvement Program under grant DUE 0618431. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily represent the view of the National Science Foundation or the National Center for Science and Civic Engagement.

Partial support for this journal also comes from the 2017-2020 Keck Grant "Transcending Barriers to Success" and the National Center for Science and Civic Engagement funding.

VOLUME SIXTEEN
ISSUE TWO
Fall 2024

About the Journal

Science Education and Civic Engagement: An International Journal is an online, peer-reviewed journal. It publishes articles that examine how to use important civic issues as a context to engage students, stimulate their interest, and promote their success in mathematics and science. By exploring civic questions, we seek to empower students to become active participants in their learning, as well as engaged members of their communities. The journal publishes the following types of articles:

- “ *Book & Media Reports*
- “ *Point of View*
- “ *Project Reports*
- “ *Research*
- “ *Review*
- “ *Science Education & Public Policy*
- “ *Teaching & Learning*

The Journal is published twice per year in an online format. The official publisher of the journal is Stony Brook University home of the National Center for Science and Civic Engagement. Editorial offices for the Journal are located in Lancaster, PA.

WWW.SECEIJ.NET

Contents

- 5 FORUM INTRODUCTION**
Transforming the Indigenous STEM Student Experience
Forum Editorial Team
- 10 INTRODUCTION TO THE 'IKE ALLIANCE FOR TRANSFORMING STEM EDUCATION**
The Indigenous Knowledges, Encouragements, Engagements, and Experiences ('IKE) Alliance for Transforming STEM Education
Hökūlani Aikau, Ulla Hasager, Amy Shachter, and Amy Sprowles
- 19 CONVERSATIONS WITH INDIGENOUS ACADEMICS AND ELDERS**
Summer Wilkie and Dr. Marty Matlock
Delaney Schroeder-Echavarria and Dr. Cutcha Risling Baldy
Mariko Nojima-Schmunk, Dominique Hannon, and Anaya Barrera
- 45 PROJECT REPORT**
Media Arts on a Marine Research Station: Reflections on a Storytelling Course in Support of Native Hawaiian Communities
Patricia A. Kāwelū Amaral, Reanna D. Salvador, and Lisa C. McManus
- 52 PROJECT REPORT**
A Student Exploration on Advancing Multicultural Science through Ethical Indigenous Engagement
Amy E. Sprowles, Nicholas A. Woronchuk, Jessica Jones, Noah Angell, Shay Konradsdottir, Elyse McKinney, Xena Pastor-Nuila, and Marina Rose Storey
- 58 PROJECT REPORT**
Awakening Indigenuity at George Mason University
Thomas Wood, Dana Adkins, Shima Mohebbi, and Jeremy Campbell
- 62 PROJECT REPORT**
From Land Acknowledgement to Place-Based Responsibilities: Enriching University Curriculum and Learning Communities through Indigenous Epistemologies
Nasrin Mirsaleh-Kohan, Adesola Akinleye, Becky A. Rodriguez, Alana Taylor, Elisa De La Rosa, Ravan Gallenstein, Holly Griffin, Gillian Hayes, Kyndel Lee, and Richard D. Sheardy



70 RESEARCH REPORT

Listening to Learn: Using a Talking Circle Approach to Understand the Indigenous STEM Student Experience

Cutchá Risling Baldy, H. Eve Robinson, Adrienne Colegrove-Raymond, Marlene' Dusek, Nievita Bueno Watts, Melitta Jackson, and Amy Sprowles

89 RESEARCH REPORT

Integrating Indigenous Science, Culture, and Social Justice Concerns into First-Year STEM Curriculum: Improving Intellectual Growth, Psychosocial Factors Associated with Retention, and Academic Achievement of Students from Racially Minoritized Groups Historically Underrepresented in STEM

Amy E Sprowles, Steven Margell, Kerri J. Malloy, Lisa Morehead-Hillman, L. Chook Chook Hillman, Angela Rich, Jessica Smith, Frank Shaughnessy, Matthew P. Hurst, Morbolla Mazzag, Dale Oliver, Sonja Manor, Eileen Cashman, Patricia Siering, Alison O'Dowd, P. Dawn Goley, Gillian Black, Katilin R. Goldenberg, and Matthew D. Johnson

106 SCIENCE EDUCATION AND PUBLIC POLICY

Centering Indigenous Knowledge in Undergraduate Student Research: Strengthening Cultural Resilience in Resilience Hub Planning on O'ahu

Kaua Kalaiwa'a, Lomani H. Rova, Honu'aina Nichols, and Miku M. Lenentine



FORUM INTRODUCTION

INTRODUCTION

Transforming the Indigenous STEM Student Experience

THIS SPECIAL FORUM is a collection of interviews, research articles, project reports, and policy papers from members of the 'IKE Alliance, a group of Indigenous and non-Indigenous educators and leaders from Hawai'i to the East Coast of Turtle Island (the continental United States) who support and facilitate increasing participation of Native American, Alaska Native, Native Hawaiian, and Pacific Islander (NAAN-NHPI) students in science, technology, engineering, and/or mathematics (STEM). The 'IKE Alliance is the outcome of a more than a decade-long collaboration among the editors and the contributors. As a collective, we have grappled with the challenges, barriers, and possibilities associated with transforming the Indigenous STEM student experience. 'IKE, the acronym for this Alliance (The Indigenous Knowledges, Encouragements, Engagements, and Experiences), is the Hawaiian term for knowledge. It also means to know, understand, experience, and recognize. Its use grounds the 'IKE Alliance in the distinct Indigenous worldviews of the NAAN-NHPI students it supports.

This project started in 2013 among members of the Science Education for New Civic Engagements and Responsibilities (SENCER) reform project. When we began

working together, we focused on increasing the participation of NAAN-NHPI students in STEM. Early on in our time together, our conversations moved from a focus on the kinds of pedagogical changes that could be made to individual STEM courses to one focused on the kinds of systemic changes needed to truly address ongoing underrepresentation of Indigenous students. Literature reviews supported this shift in direction, as others have shown that providing Indigenous students with clear learning pathways and a sense of belonging were essential for success (e.g., Cajete, 1999). As we dove deeper into the literature, conducted research on our campuses, and critically reflected on our collective experiences, we identified additional dimensions of institutional change needed to support Indigenous students. We also realized that we needed to expand our understanding of the student experience beyond existing models that focus on recruitment, retention, matriculation, and entry into the workforce. We needed to revise our thinking to harmonize with what our students were telling us was important to them: a holistic approach to the student life cycle (Figure 1). The 'IKE approach attends to those activities that are focused on the right half of the student life cycle as depicted in Fig. 1;

FIGURE 1. The 'IKE Alliance Student Life Cycle Model (Aikau et al., 2024)

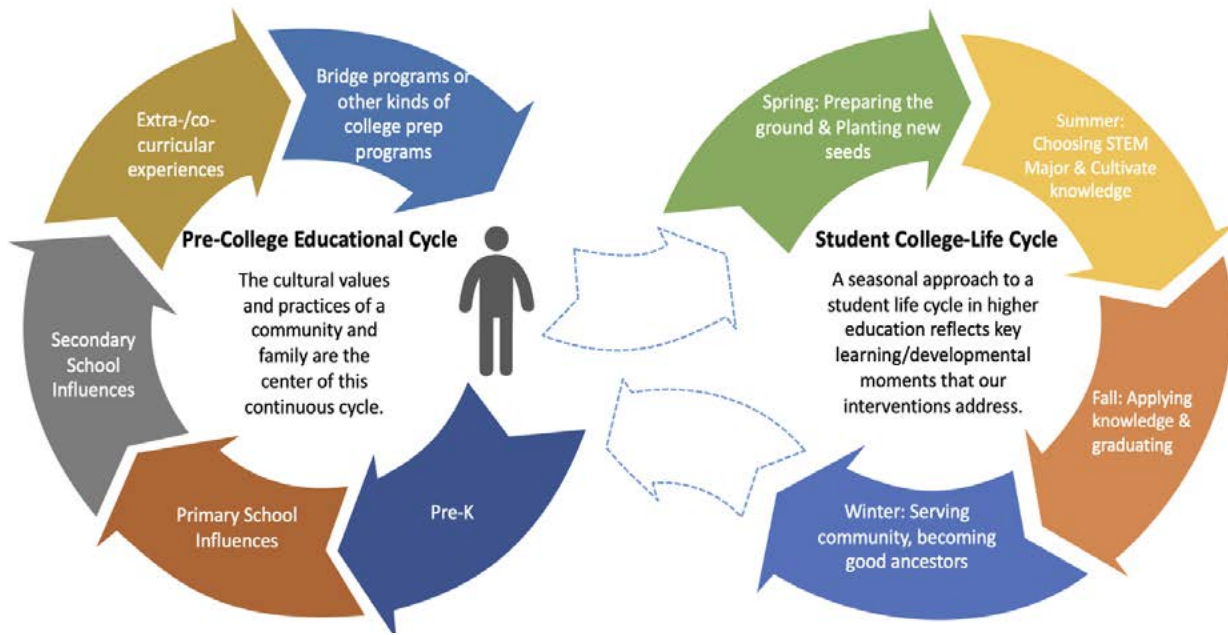
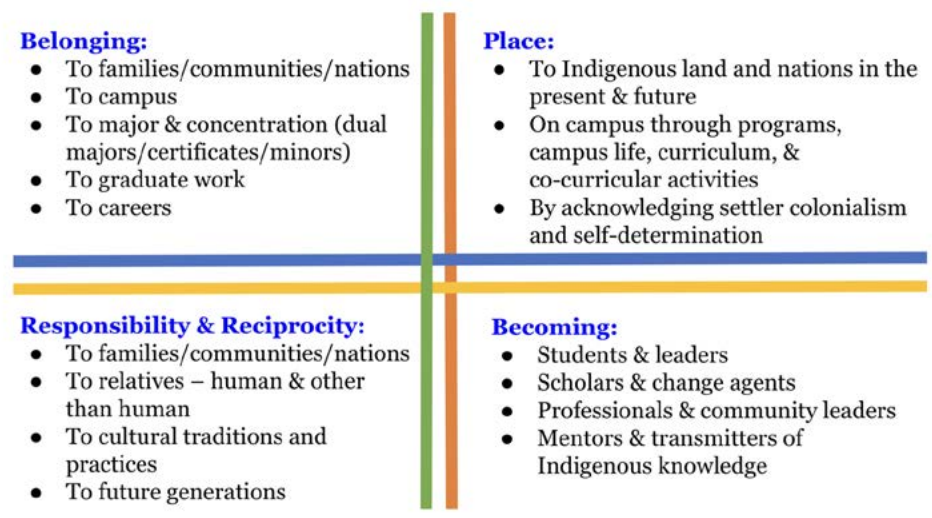


FIGURE 2. 'IKE Alliance Four-Strand Model for Student Success (Aikau et al., 2024)



however, we contend that to achieve our goal, we must be mindful of the entire cycle.

We developed a four-strand model that responds to Indigenous students’ needs across their full academic life cycle. The four strands of the model are: a Sense of Belonging, a Sense of Place, a Sense of Responsibility and Reciprocity, and a Sense of Becoming (i.e., having a vision of where one is headed in life) (Figure 2). Studies in education highlight the importance that NAAN-NHPI students attribute to feeling that they belong to their chosen academic community and that they clearly

envision the professional path in front of them. By establishing authentic and reciprocal relationships with Native communities, STEM education environments will be more inclusive and aligned with Indigenous communities, making NAAN-NHPI students feel that they belong there and helping them to be more confident in pursuing a career in their field of interest. Thus, our four-strand model attends to a process of *Belonging and Becoming* to take this journey. *Belonging* means students need to feel that they are legitimate members of the academic community, rather than strangers in a strange land

(McClellan, 2018). *Becoming* means they need to have a clear vision of the path in front of them, so they know *where* they are going and *how* they will get there (Ward et al., 2019). While the means of creating a supportive culture will be dependent on individual institutional context, we start with a shared vision for integrating Indigenous knowledge, cultural practices, and cultural wealth with Western knowledge systems and frameworks in order to improve STEM success for NAAN-NHPI students. Reciprocity and responsibility are crucial values for many NAAN-NHPI communities, as their worldviews often emphasize the responsibility that individuals have towards others in their lives, their communities, their nations, and nature, as well as the value of both giving and receiving what their more-than-human kin have to offer. Due to the history of colonization in the US, Indigenous communities also feel a responsibility to protect and cultivate their heritage, which is deeply entrenched in the 'IKE Alliance's mission. These strands are sustained by establishing and maintaining long-lasting authentic relationships based on respect, humility, honesty, and trust.

The 'IKE Forum

This special forum of SECEIJ intends to inspire and expand our work to support Indigenous STEM students.

The forum begins with an introduction of the 'IKE Alliance and its strategic plan, "The Indigenous Knowledges, Encouragements, Engagements, and Experiences ('IKE) Alliance for Transforming STEM Education."

This is followed by conversations between Native students and the Indigenous academics and elders who have guided us in this work.

Dr. Marty Matlock is a Cherokee scholar at the University of Arkansas, a tenured faculty member at the University of Arkansas in the Biological and Agricultural Engineering Department. He is also an advocate for Native American and Indigenous students. His interview offers insights into how institutions have changed and must continue to change, especially within STEM education and

careers, to further encourage and support Indigenous scholars in these fields of study.

Dr. Cutcha Risling Baldy is Hupa/Yurok/Karuk, an enrolled Hoopa Valley Tribal member, Associate Professor of Native American Studies at California State Polytechnic University Humboldt, and author of the award-winning book *We Are Dancing For You: Native Feminisms & The Revitalization of Women's Coming-of-Age Ceremonies* (2018). In her interview, Dr. Risling Baldy discusses what it means to have Traditional Ecological Knowledge as a foundation for her work and her experience within STEM academia as an Indigenous person in universities that reside on stolen Native lands.

Anaya Barrera is an Apache elder and Road Man. He discusses the connection and disconnection to Indigenous cultures experienced by Kānaka Maoli (the indigenous people of Hawai'i) as well as Indigenous peoples on the North American continent (also known as Turtle Island). We learn how Indigenous thinking can be respectfully brought into traditional ("Western") academia, as well how to create and maintain reciprocal and authentic relationships with Indigenous peoples.

The conversations are followed by four project reports that describe projects and activities designed to support the Indigenous student life cycle and transform STEM research and education.

The project report "Media Arts on a Marine Research Station: Reflections on a Storytelling Course in Support of Native Hawaiian Communities" describes a course aimed at guiding students in creating media content (filmmaking) rooted in Hawaiian epistemologies and praxis, bridging Indigenous knowledge with Western scientific perspectives through art, creativity, and visual communication to promote interdisciplinary dialogue.

"A Student Exploration on Advancing Multicultural Science through Ethical Indigenous Engagement" is a project report written by six students and a faculty member who spent a semester exploring how to move towards a multicultural scientific

approach through the ethical, authentic inclusion of Indigenous Science.

The “Awakening Indigenuity at George Mason University” project report, written by three faculty members and a Chickahominy Environmental Director, addresses the urgent need to recognize the wisdom of Indigenous people to stem the tide of climate change, biodiversity loss, and deterioration of ecosystems. It specifically reports on an inspiring example of the collaborative project, “The Indigenous Environmental Mapping & Resilience Planning Project” with the Chickahominy Tribe, where faculty, Indigenous students, community members, and locally residing elders from many Indigenous communities promote mutual respect through knowledge and wisdom transfer unparalleled in previous university activities.

The final project report, written by authors living on the traditional territories of the Hasinal and Wichita, Caddo, Comanche, and Cherokee Nations, “From Land Acknowledgement to Place-Based Responsibilities: Enriching University Curriculum and Learning Communities through Indigenous Epistemologies,” summarizes an interdisciplinary, collaborative approach to an integrated land acknowledgment through place-based activity for the whole learning community.

The impacts of the kinds of initiatives the ‘IKE Alliance supports are assessed in two research reports.

“Listening to Learn: Using a Talking Circle Approach to Understand the Indigenous STEM Student Experience” describes the results and recommendations from a qualitative analysis of a series of online forums with Native STEM students and the staff who support them. The research questions were designed to better understand the experience of Indigenous STEM students. The method was modeled on the Indigenous tradition of Talking Circles.

The educational impacts of weaving cultural, civic, and social justice issues faced by the Native

American people of California’s Klamath River into first year STEM student curriculum are described in the article “Integrating Indigenous Science, Culture, and Social Justice Concerns into First-Year STEM Curriculum: Improving Intellectual Growth, Psychosocial Factors Associated with Retention, and Academic Achievement of Students from Racially Minoritized Groups Historically Underrepresented in STEM.”

The forum concludes with a science education and public policy article.

“Centering Indigenous Knowledge in Undergraduate Student Research: Strengthening Cultural Resilience in Resilience Hub Planning on O’ahu” describes the “Action 15 Resilience Hub Project,” launched in 2022 to establish a network of resilience hubs that include cultural resilience in disaster management. The exemplary large-scale and comprehensive public policy project supporting resilience is also a science education project. Aside from being local and Indigenous informants in their own right, the participating undergraduate students are active in both research, analysis, and implementation of the Resilience Hub Project. Their contributions to the article, their learning outcomes, and their reflections demonstrate the educational and change-making power of creating opportunities for students to participate in addressing capacious community issues linked to climate change.

The ‘IKE Alliance hopes this forum will be useful to others interested in supporting Indigenous STEM students by establishing genuine, reciprocal, and long-lasting relationships with Indigenous communities. We look forward to future dialogues with you, the readers, and hope you will consider joining the ‘IKE Alliance.

*Your Forum Editorial Team,
Hökūlani Aikau
Ulla Hasager
Amy Shachter
Amy Sprowles*

References

- Aikau, H., Hasager, U., Shachter, A., & Sprowles, A. (2024). "The Indigenous Knowledges, Encouragements, Engagements, and Experiences (IKE) Alliance for Transforming STEM Education." *Science Education and Civic Engagement: An International Journal (this issue)*.
- Cajete, G. A. (1999). "The Native American Learner and bicultural science education." In K. G. Swisher & J. W. Tippeconnic (Eds.), *Next steps: Research and practice to advance Indian education* (pp. 135-160). ERIC Clearinghouse on Rural Education and Small Schools.
- McClellan, G. S. (2018). *Beyond access: Indigenizing programs for Native American student success*. Stylus Publishing.
- Risling Baldy, C. (2018). *We are dancing for you: Native feminisms and the revitalization of women's coming-of-age ceremonies*. University of Washington Press.
- Ward, C., Demetropoulos, J., Horan, H., Rainock, M., Tatham, L., & Wixom, J. (2019). "Native college student STEM experiences." In M. M. Jacob & S. Runninghawk Johnson (Eds.), *On Indian Ground: The Northwest* (pp. 179). Information Age Publishing.

FROM THE
EDITORS

The Indigenous Knowledges, Encouragements, Engagements, and Experiences (‘IKE) Alliance for Transforming STEM Education

HÖKŪLANI AIKAU

University of Victoria, Canada

AMY SHACHTER

Santa Clara University

ULLA HASAGER

University of Hawai‘i at Mānoa

AMY SPROWLES

California State Polytechnic University, Humboldt

Abstract

Written by the SECEIJ Special Forum editorial team, this Project Report summarizes the interdisciplinary, collaborative, and inspiring research journey and theoretical background leading to the creation of a strategic plan for the ‘IKE Alliance for Transforming STEM Education. ‘IKE, which stands for Indigenous Knowledges, Encouragements, Engagements, and Experiences, means knowledge in the Native Hawaiian language. This article outlines the importance of honoring Indigenous epistemologies in STEM education and across institutions and communities as we work to increase the presence of

Native American, Alaska Native, Native Hawaiian, and Pacific Islander students in STEM. Our goal is to build authentic and durable partnerships locally and nationally through respecting, honoring, engaging, cultivating, and consulting with Native Nations and communities.

Introduction

Indigenous science, knowledge, and traditions are essential for tackling some of today’s most crucial and long-standing problems, yet Indigenous communities continue

to be widely under-represented in traditional (“Western”) academic institutions, particularly in the fields of science, technology, engineering, and mathematics (STEM). In 2013, members of the Science Education for New Civic Engagements and Responsibilities (SENCER) community began a conversation about how to transform STEM education to honor Indigenous epistemologies. This led to a series of grant-funded initiatives aimed at identifying how to improve participation challenges for Native American, Alaska Native, Native Hawaiian, and Pacific Islander (NAAN-NHPI) STEM students.¹ The first was the “Transcending Barriers to Success: Connecting Indigenous and Western Knowledge Systems to Tackle Grand Challenges” (TBS) project which spanned three years starting in 2017 and was funded by the W. M. Keck Foundation. TBS included the University of Hawai‘i at Mānoa and Kapi‘olani Community College (both part of the University of Hawai‘i system), the University of Alaska, Humboldt State University (now California State Polytechnic University, Humboldt), Northern Arizona University, and Salish Kootenai College (Montana). The lessons learned from the TBS work provided the foundation for an NSF INCLUDES Strategic Planning grant, which enabled faculty, staff, students, and Indigenous leaders to continue the work by focusing on developing a shared vision for an alliance: a collective of institutions, organizations, people, and programs committed to achieving a shared vision. The University of Hawai‘i at Mānoa; Kapi‘olani Community College; California State Polytechnic University, Humboldt; Texas Woman’s University; the University of Arkansas; and George Mason University participated in the planning process.

From these efforts emerged the Indigenous Knowledges, Encouragements, Engagements, and Experiences (‘IKE) Alliance to address STEM participation challenges faced by NAAN-NHPI students. ‘IKE, the acronym for the Alliance, is the Hawaiian term for knowledge. It also means to know, understand, experience, and recognize. Its use grounds the ‘IKE Alliance in the distinct Indigenous worldviews of the NAAN-NHPI students it supports. Our planning process was inspired by the importance of the number 4 in Native American belief systems: four worlds, seasons, directions, life stages, and

¹ Throughout this article we use the terms Native and Indigenous interchangeably to refer to this group as a whole.

personages. We devised four dialogic elements: 1) talking circles, 2) listening circles, 3) convenings, and 4) gatherings (Hultranz, 1980; Williamson, 1989; Mooney, 1982; Waters, 1977). Talking circles with faculty, administrators, staff, and students anchored the project at participating campuses. With NAAN-NHPI student experience and knowledge central to this work, listening circles were conducted with students, designed to understand their needs, desires, and insights (see for example Risling Baldy et al., “Listening to Learn: Using a Talking Circle Approach to Understand the Indigenous STEM Student Experience” in this issue).

We also held regional convenings of groups with special knowledge and interests, as well as larger national gatherings. One of the convenings, for example, was focused on identifying population data, which has implications for funding and programming. The Cal Poly Humboldt team showed how they worked with the California State University Institutional Research teams to utilize both racial self-identification and tribal affiliation (e.g., Karuk, Maidu, Cahuilleno, Mojave, Yokuts, Pomo, and Paiute) on application data to provide a more accurate IPEDS (Integrated Postsecondary Education Data System) counting of Native students (National Center for Education Statistics, 2020). By recognizing “political status” they showed how they raised awareness state-wide of the need for honoring dual citizenship, which is a more accurate representation of Native enrollment. Likewise, the University of Hawai‘i system team showed how it enables Native Hawaiian and Pacific Islander students to identify with their specific island affiliations (eg. Hawaiian, Samoan, Tongan, Chamorro, Marshallese, Chuukese, Palauan, etc.). The University of Hawai‘i Community Colleges team also showed how allowing students to check one primary and one in-combination racial category resulted in total counts as much as four times larger for each islander group. When the University of Arkansas and Texas Woman’s University teams adopted these strategies, the results were Native population counts four to five times larger than the IPEDS numbers. For example, in the fall 2021 semester, University of Arkansas’ NAAN undergraduate student population was reported federally through the IPEDS system as 247 students comprising 0.8% of the total student population. When including NAAN students who selected “two or more races,” the

population increased to 831 students, making them 2.9% of the student population. Such convenings shaped the shared visioning process.

As part of our strategic planning process, we identified the mission, shared vision and values of the Alliance. The 'IKE Mission is to fully transform STEM by building reciprocal relationships with Native Nations and communities and with Indigenous knowledges, now and for future generations. The 'IKE Alliance's Shared Vision is to increase the presence of NAAN-NHPI students in STEM by respecting, honoring, engaging, cultivating, and consulting in order to build durable relationships and partnerships with Native Nations and communities that honor Indigenous knowledges. Our values are built upon a shared understanding that Indigenous knowledges, practices, and visions for the future are held in an Indigenous sense of place, kinship networks, and languages. We value a sense of Belonging, a sense of Place, a sense of Reciprocity and Responsibility, a sense of Becoming, and durable relationships based on respect, humility, trust, and honesty.

The 'IKE Alliance's overarching goals are to:

1. increase Native student representation in STEM to reflect the population of the nation;
2. achieve systemic change by Indigenizing STEM education in 'IKE Alliance institutions; and
3. establish a durable 'IKE Alliance for institutional transformation with a sustainable collective infrastructure.

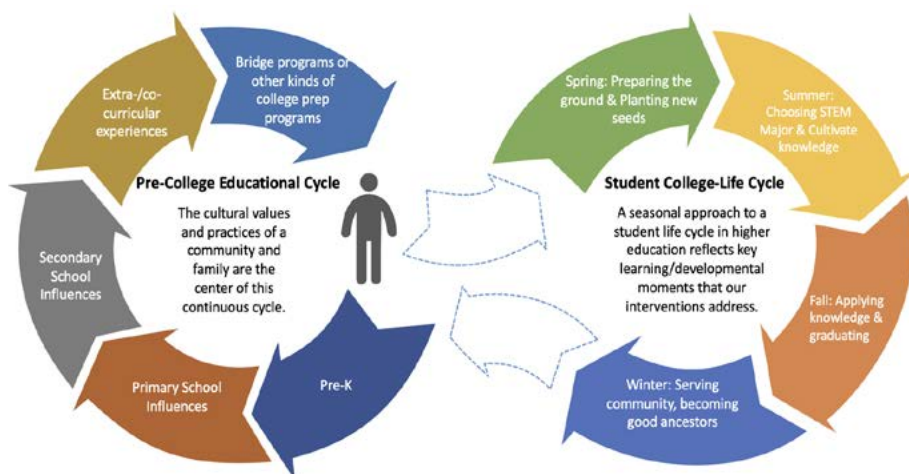
The 'IKE objectives are to:

1. take full advantage of both Indigenous and traditional academic knowledge systems to tackle grand challenges;
2. weave Indigenous science, culture, and community into best practices in STEM education;
3. support STEM NAAN-NHPI student leadership through the 'IKE Alliance Student Corps;
4. create a collective infrastructure to support an Indigenized Networked Communities (INC) model; and
5. develop innovative and culturally appropriate assessment instruments.

We fine-tuned our intellectual approach during the planning process. Supporting NAAN-NHPI students along the path to degree and then to career will require cultural, community, and curricular innovations. One distinctive aspect of our approach is for campuses to collaborate with the Native and Indigenous communities of their service areas to tailor institutional practices such as student identification/data collection, recruitment, mentoring, advising, admissions, and financial aid, as well as systems to address basic needs like food, housing, and physical and mental health services. NAAN-NHPI students often are part of very close communities with extended family and deep relationships. Leaving home is hard, and the transition into higher education can be alienating and isolating. While our approach attends to activities identified in the college life cycle (right half of the student life cycle diagram, the undergraduate experience [Figure 1]), our shared vision acknowledges that students need a strong sense of Belonging and Becoming to

succeed in their educational journey. "Belonging" means that students need to feel that they are legitimate members of the academic community, rather than strangers in a strange land (McClellan, 2018). "Becoming" means they need to have a clear vision of the path in front of them, so that they know where they are going and how they will get there (Ward et al., 2019). While the means of creating a culture supporting these needs will be

FIGURE 1. The 'IKE Alliance Student Life Cycle Model (Aikau et al., 2024)



dependent on individual institutional contexts, we start with a shared vision for integrating Indigenous knowledge, cultural practices, and cultural wealth with Western knowledge systems and frameworks to improve STEM success for NAAN-NHPI students.

Creating a sense of Belonging and Becoming can be envisioned as two strands of a four-strand braided rope that provides a net of support for NAAN-NHPI STEM students: a sense of Belonging, a sense of Place, a sense of Responsibility and Reciprocity, and a sense of Becoming. Indeed, a strong institutional net will provide a well-designed environment for success that more than meets the basic needs of NAAN-NHPI STEM students.

To achieve the four strands of an institutional rope of support, our “Belonging to Becoming” model (Figure 2) brings community and higher education together in ways proven to produce positive results (Tuck & Guisard, 2013). The values of Responsibility and Reciprocity have deep cultural meaning for Indigenous communities and can be translated into the Native vernacular providing even deeper meaning, specificity, and resonance for everyone. This strand of the braid acknowledges that Indigenous students do not necessarily pursue higher education for their own individual advancement. Rather, they see higher education as a means by which they can meet their familial, community, and cultural responsibilities (Whyte, 2018). An Indigenous worldview also recognizes that one’s sense of responsibility extends beyond human relations and is imbued with a sense of reciprocity to the

other-than-human world in the present moment and into the future. Our model for institutional transformation attends to these complex webs of responsibility and reciprocity.

Sense of Place is the final strand of the institutional rope. Being Indigenous today is to be in constant struggle to protect one’s “own internal capacity to cultivate, transmit, remember, and exercise Indigenous knowledges despite what persons and organizations of other heritages and nations do” (Whyte, 2018, p. 76). Indigeneity as an analytic requires at least two analytical lenses, one reflecting settler colonialism and another seeing Indigenous views of land and nature as kin (Gilio-Whitaker, 2019). Speaking to a sense of Place means recognizing that being Indigenous is a political identity formed by colonization and its ongoing effects as well as the unique relationship autochthonous peoples have to specific places and the complex, interdependent societies that emerged from this original relation. A sense of Place fundamentally acknowledges the sovereignty and self-determination inherent in the relationship between place and peoples, and each institutional rope must attend to that specificity. Further, equity, inclusion, and diversity require truth-telling. Thus, a sense of Place must also attend to the history of settler colonialism and to how structures of removal, dispossession, assimilation, racism, and sexism continue to impact all Indigenous communities in the United States, albeit differentially (Gilio-Whitaker, 2019). Ultimately, a strong institutional net of Belonging to Becoming

is reliant on the strength of all other strands as it leads to life success, revitalization of culture, durability in the continuum of flow, and respect between institutions of higher education and Native communities.

The ‘IKE strategic planning process led to an Indigenous Networked Community (INC) and to a theory of change for the Alliance (Figure 3), building on the Networked Improvement Community (NIC) model developed by the Carnegie Foundation, which has been a model

FIGURE 2. ‘IKE Alliance Four-Strand Model for Student Success (Aikau et al., 2024)

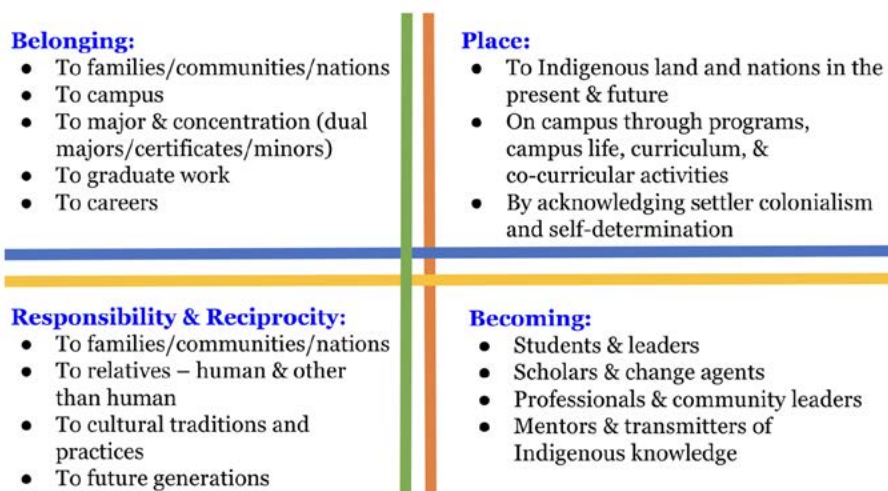
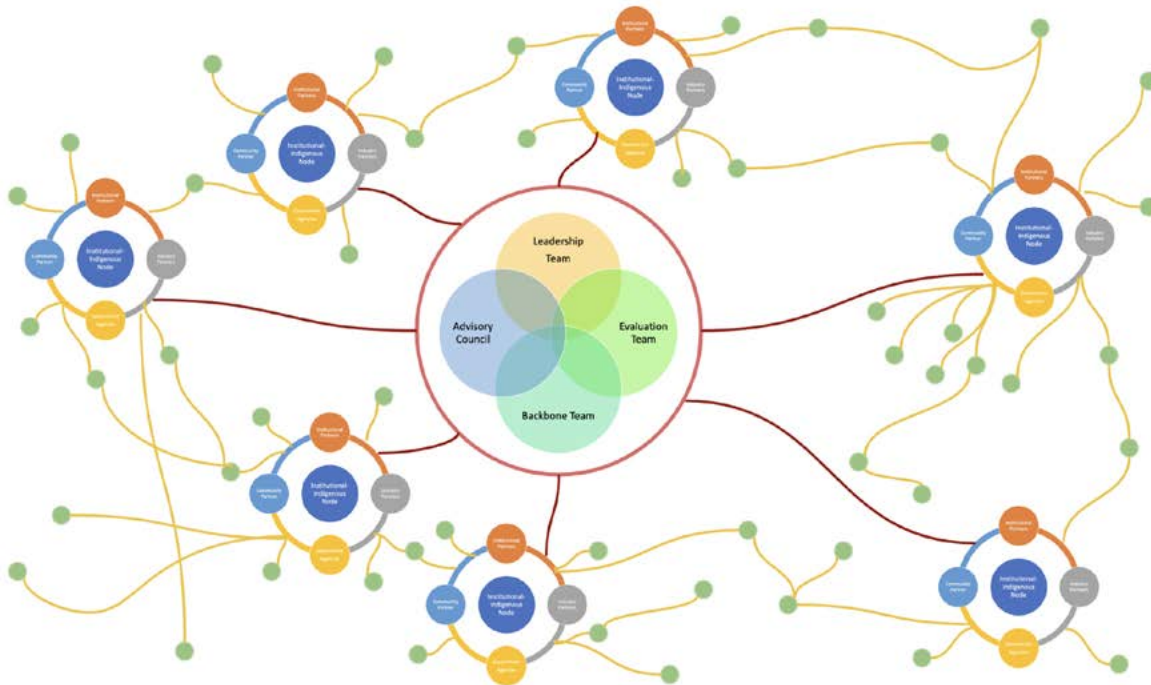


FIGURE 3. Draft 'IKE Alliance Indigenous Networked Communities Model

Concentric center circles: leadership, backbone, and evaluation teams plus advisory council; institutional-indigenous node (dark blue) with community (light blue), institutional (orange), industry (gray), and governmental (orange)



for change in STEM education for over a decade. The essential characteristics of NICs include

1. a focus on a common aim,
2. “deep understanding of the problem, the system that produces it, and a shared working theory of how to improve it,” and
3. a network structure “to accelerate the development, testing, and refinement of interventions, their rapid diffusion out into the field, and their effective integration into varied educational contexts” (McKay, 2017).

The 'IKE Alliance network structure serves as network nodes or hubs that we must address to accelerate Indigenization within higher education. The Alliance is focused now on the further development and implementation of the INC model.

The strategic planning process outlined in this brief overview coupled with our expertise, experiences, and the scholarship of others (see Suggested Readings below) provides a deep understanding and foundation for this work. We invite you to join the 'IKE Alliance (ikealliance.org) and to be part of this work.

References

- Gilio-Whitaker, D. (2019). *As long as grass grows: The indigenous fight for environmental justice from colonization to Standing Rock*. Beacon Press. <https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1844249>
- Hultrantz, A. (1980). *The religions of the American Indians*. University of California Press.
- McClellan, G. S. (2018). *Beyond access: Indigenizing programs for Native American student success*. Stylus Publishing.
- McKay, S. (2017, February 23). *Quality improvement approaches: The Networked Improvement Model*. The Carnegie Foundation for the Advancement of Teaching. <https://www.carnegiefoundation.org/blog/quality-improvement-approaches-the-networked-improvement-model/>
- Mooney, J. (1982). *Myths of the Cherokee and sacred formulas of the Cherokee*. Charles and Randy Elder.
- National Center for Education Statistics. (2020). *Integrated Post-secondary Education Data System (IPEDS)*. US Department of Education. <https://nces.ed.gov/ipeds/>
- Tuck, E., & Guishard, M. (2013). Uncollapsing ethics: Racialized sciencism, settler coloniality, and ethical framework of decolonial participatory action research. In T. M. Kress, C. Malott, & B. J. Porfilio (Eds.) *Challenging status quo retrenchment* (pp. 3–27). Information Age Publishing.

Ward, C., Demetropoulos, J., Horan, H., Rainock, M., Tatham, L., & Wixom, J. (2019). Native college student STEM experiences. In M. M. Jacob & S. RunningHawk Johnson (Eds.), *On Indian Ground: The Northwest*, pp. 179–206. Information Age Publishing.

Waters, F. (1977). *Book of the Hopi*. Penguin Books.

Whyte, K. (2018). What do Indigenous knowledges do for Indigenous peoples? In M. K. Nelson & D. Shilling (Eds.), *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability* (pp. 57–81). Cambridge University Press.

Williamson, R. A. (1989). *Living the sky. The cosmos of the American Indian*. University of Oklahoma Press.

Suggested Readings

Aikau, H. 2016. *Interview on the relationship with Science Education for New Civic Engagements and Responsibilities (SENCER) and Indigenous ways of learning and knowing* (Film). <https://www.youtube.com/watch?v=ILW14Aqjz7o>

Alkholly, S. O., Gendron, F., McKenna, B., Dahms, T., & Pontes Ferreira, M. (2017). Convergence of Indigenous science and Western science impacts students' interest in STEM and identity as a scientist." *Ubiquitous Learning: An International Journal*, 10(1), 1–13. <http://digitalcommons.wayne.edu/nfsfrp/16>

Amaral Buskirk, P. 2016. *Science education & civic engagement in Hawai'i* [Film]. <https://www.youtube.com/watch?v=RSPF2coOQoY&t=2s>

Biden, J. (2021, January 26). *Memorandum on tribal consultation and strengthening nation-to-nation relationships*. White House Presidential Actions. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/26/memorandum-on-tribal-consultation-and-strengthening-nation-to-nation-relationships/>

Bowman, N. R. (2018). Looking backward but moving forward: Honoring the sacred and asserting the sovereign in Indigenous evaluation. *American Journal of Evaluation*, 39(159). <https://doi.org/10.1177/1098214018790412>

Bowman, N. R. (2020). Nation-to-nation in evaluation: Utilizing an Indigenous evaluation model to frame systems and government evaluation. *New Directions for Evaluation*, 2020(166), 101–118.

Bowman, N. R., & Dodge-Francis, C. (2018). Culturally responsive Indigenous evaluation and tribal governments: Understanding the relationship. *Indigenous Evaluation, New Directions for Evaluation*, 2018(159), 17–31.

Bowman, N. R., C. Dodge-Francis, & M. Tyndall. (2015). Culturally responsive Indigenous evaluation: A practical approach for evaluating Indigenous projects in tribal reservation contexts." In S. Hood, R. Hopson, & H. Frierson (Eds.), *Continuing the journey to reposition culture and cultural content in evaluation theory* (pp. 335–360). Information Age Publishing.

Cajete, G. A. (1999). The Native American learner and bicultural science education. In K. G. Swisher & J. W. Tippeconnic (Eds.), *Next steps: Research and practice to advance Indian education*, ERIC Clearinghouse on Rural Education and Small Schools.

Community-Campus Partnerships in Health (CCPH). (2013). Position statement on authentic partnerships. CCPH Board of Directors. <https://ccphealth.org/partnering/principles-of-partnering>

Confederated Salish and Kootenai Tribes of the Flathead Reservation. (2016). *Climate Change Strategic Plan*. <https://www.adaptationclearinghouse.org/resources/confederated-salish-and-kootenai-tribes-of-the-flathead-reservation-climate-change-strategic-plan.html#:~:text=The%20CSKT%20Climate%20Change%20Strategic,and%20funding%20mechanisms%20for%20each.>

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, 95(2), 256–273.

Education Northwest. (2015, June). *Indigenous culture-based education rubrics*. <https://educationnorthwest.org/resources/indigenous-culture-based-education-rubrics>

Education Northwest. (2020, May). *Scaling out-of-school time STEM programming: A national scan*. <https://educationnorthwest.org/sites/default/files/overdeck-ost-stem-report.pdf>

Estrada, M. (2014). Ingredients for improving the culture of STEM degree attainment with co-curricular supports for underrepresented minority students. *National Academies of Sciences White Paper*.

Gewin, V. (2021, January 12). How to include Indigenous researchers and their knowledge. *Nature*, 589(7841), 315–317. doi:10.1038/d41586-021-00022-1

Gilio-Whitaker, D. (2019). *As long as grass grows: The Indigenous fight for environmental justice from colonization to Standing Rock*. Beacon Press.

Hanleybrown, F., Kania, J., & Kramer, M. (2012, January 26). Channeling change: Making collective impact work. *Stanford Social Innovation Review*. <https://doi.org/10.48558/2t4m-zr69>

Hultrantz, A. 1980. *The religions of the American Indians*. University of California Press.

Johnson, M. D., Sprowles A. E., Goldenberg, K., Margell, S., & Castellino, L. (2020). *Effect of a place-based learning community on belonging, persistence, and equity gaps for first-year STEM students*. *Innovative Higher Education*, 45, 509–531. <https://doi.org/10.1007/s10755-020-09519-5>

Johnson, M. J., Johnson, M., Goldenberg, P., & Sprowles A. E. (n.d.). *Impact of a first-year place-based learning community on STEM students' academic achievement in their second, third, and fourth years* [Manuscript submitted for publication].

Justice Institute of British Columbia. (n.d.) *Indigenization Plan 2015-2020*. https://www.jibc.ca/sites/default/files/main/pdf/Indigenization_Report.pdf

Kezar, A., & Gehrke, S. 2015. *Communities of transformation and their work scaling STEM reform*. Pullias Center for Higher Education. <https://eric.ed.gov/?id=ED574632>

LaValle, F. F., Camvel, D. A. K., Thomas, F. I. M., Aikau, H. K., & Lemus, J. D. (2019). Interdisciplinary research through a shared lexicon: Merging 'Ike kupuna and Western science to examine characteristics of water. *Hulili: Multidisciplinary Research on Hawaiian Well-Being*, 11(8), 167–185.

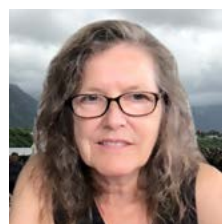
- Lowe, J., Liang H., Riggs, C., Henson, J., & Elder, T. (2012). Community partnership to affect substance abuse among Native American adolescents. *American Journal of Drug and Alcohol Abuse*, 38(5), 450–455. <https://doi.org/10.3109/00952990.2012.694534>
- Malcom-Piqueux, L. (2020). Transformation in the U.S. higher education system: Implications for racial equity. Commissioned paper for Symposium on Imagining the Future of Undergraduate STEM Education, convened virtually by the Board on Science Education, November 12, 13, and 19 with support from the National Science Foundation.
- McClellan, G. S. (2018). *Beyond access: Indigenizing programs for Native American student success*. Stylus Publishing.
- McGee, E., & Bentley, L. (2017). The equity ethic: Black and Latinx college students reengineering their STEM careers toward justice. *American Journal of Education*, 124(1), 1–36.
- McKay, S. (2017, February 23). Quality improvement approaches: The networked improvement model. *Carnegie Commons Blog*. The Carnegie Foundation for the Advancement of Teaching. <https://www.carnegiefoundation.org/blog/quality-improvement-approaches-the-networked-improvement-model/>
- Meador, A. (2018). Examining recruitment and retention factors for minority STEM majors through a stereotype threat lens. *School Science and Mathematics*, 118(1-2), 61–69.
- Mooney, J. (1982). *Myths of the Cherokee and sacred formulas of the Cherokee*. Charles and Randy Elder.
- National Center for Education Statistics. (2020). *Integrated Post-secondary Education Data System (IPEDS)*. US Department of Education. <https://nces.ed.gov/ipeds/>
- National Science Foundation (NSF). (2003). *Culturally responsive educational evaluation workshop*. <https://www.nsf.gov/pubs/2003/nsf03032/nsf03032.pdf>
- National Science Foundation-National Center for Science and Engineering Statistics (NSF-NCSES). (2021, April 29). *Women, minorities, and persons with disabilities in science and engineering*. <https://nces.nsf.gov/pubs/nsf21321>
- Nicholls, J. G. (1984). Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review*, 91(3), 328–346. <https://doi.org/10.1037/0033-295X.91.3.328>
- Postsecondary National Policy Institute (PNPI). (2020). *Factsheets: Communities of students and types of institutions*. <https://pnpi.org/category/factsheets/>
- Raymond, S. (2020). Best practices for participatory leadership in higher education. The Indian Tribal Educational & Personnel Program (ITEPP). [Master's thesis, California State Polytechnic University]. https://itepp.humboldt.edu/sites/default/files/participatory_leadership_itepp.pdf
- Russo Carroll, S. R., Garba, I., Figueroa-Rodríguez, O. L., Holbrook, J., Lovett, R., Materchera, S., Parsons, M., Raseroka, K., Rodriguez-Lonebear, D., Rowe, R., Sara, R., Walker, J. D., Anderson, J., & Hudson, M. (2020). The CARE Principles for Indigenous data governance. *Data Science Journal*. <https://datascience.codata.org/articles/10.5334/dsj-2020-043/>
- Russo Carroll, S. R., Herczog, E., Hudson, M., Russell, K., & Stall, S. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data futures." *Sci Data*, 8, 108. <https://doi.org/10.1038/s41597-021-00892-0>
- SENCER Hawai'i. (2016–). [YouTube channel]. <https://www.youtube.com/channel/UCgwYMedNuabJ8aobeEOJTNw/videos>
- Snyder, T. D., & Dillow, S. A. (2015). *Digest of education statistics 2013*. National Center for Education Statistics. NCES 2015-011. <https://eric.ed.gov/?id=ED556349>
- Sprowles, A. E., Johnson, M. D., Margell, S., Malloy, K. J., Hillman, L., & Hillman, L. (n.d.) *Integrating culture and social-justice issues of the Native American people of our place preferentially improves academic achievements of racially minoritized first-year STEM students*. [Unpublished manuscript].
- Sprowles, A. E., & Malloy, K. J. (2017, October 26). Klamath connection and critical histories/activist futures: The role of interdisciplinary discourse in addressing racism and inequity in STEM education. *Somatosphere*. <https://somatosphere.com/2017/klamath-connection.html/>
- Sul, D. A. (2021). Indigenous assessment developers on elements of the disjuncture-response dialectic: A critical comparative case study (Publication No. 571) [EdD dissertation, University of San Francisco]. University of San Francisco Scholarship Repository. <https://repository.usfca.edu/diss/571>
- Thoman, D. B., Arizaga, J. A., Smith, J. L., Story, T. S., & Soncuya, G. (2014). The grass is greener in non-science, technology, engineering, and math classes: Examining the role of competing belonging to undergraduate women's vulnerability to being pulled away from science. *Psychology of Women Quarterly*, 38(2), 246–258.
- Tuck, E., & Guishard, M. (2013). Uncollapsing ethics: Racialized sciencism, settler coloniality, and ethical framework of decolonial participatory action research." In T. M. Kress, C. Malott, & B. J. Porfilio (Eds.), *Challenging Status Quo Retrenchment* (pp. 3–27). Information Age Publishing.
- United States Census Bureau. (2021, August 12). 2020 Census illuminates racial and ethnic composition of the country. <https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html>
- Voyageur, C. J., Calliou, B., & Brearley, L. (Eds.). (2015). *Restorying Indigenous leadership: Wise practices in community development*. Banff Centre Press.
- Ward, C., Demetropoulos, J., Horan, H., Rainock, M., Tatham, L., & Wixom, J. (2019). Native college student STEM experiences. In M. M. Jacob & S. RunningHawk Johnson (Eds.), *On Indian Ground: The Northwest* (pp. 179-206). Information Age Publishing.
- Waters, F. (1977). *Book of the Hopi*. Penguin Books.
- Wehipeihana, N. (2019). Increasing cultural competence in support of Indigenous-led evaluation: A necessary step toward indigenous-led evaluation. *The Canadian Journal of Program Evaluation*, 34(2). <https://doi.org/10.3138/cjpe.68444>

- Whyte, K. (2018). "What do Indigenous knowledges do for Indigenous peoples?" In M. K. Nelson & D. Shilling (Eds.), *Traditional ecological knowledge: Learning from Indigenous practices for environmental sustainability* (pp. 57–81). Cambridge University Press.
- Wilbur, J. R., Wilbur, M., Garrett, M. T., & Yuhas, M. (2001). Talking circles: Listen, or your tongue will make you deaf. *Journal for Specialists in Group Work*, 26(4), 368–384.
- Wilkie, S. R., Lenentine, M. M., & Hiser, K. (2022). *Final Report: Weaving Indigenous and Western knowledge systems*. Center for Resilient Neighborhoods. <https://cerenehawaii.org/weaving-indigenous-and-western-knowledge-systems/>
- Williamson, R. A. (1989). *Living the sky. The cosmos of the American Indian*. University of Oklahoma Press.
- Windchief, S., & Brown, B. (2017). Conceptualizing a mentoring program for American Indian/Alaska Native Students in the STEM fields: A review of the literature. *Mentoring & Tutoring: Partnership in Learning*, 25(3), 329–345.
- Wolf, P. R., & Rickard, J. A. (2003). Talking circles: A Native American approach to experiential learning." *Journal of Multicultural Counseling and Development*, 31(1), 39–43.

About the Authors

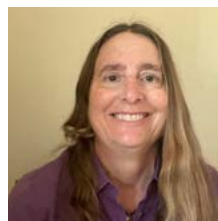


Hökūlani K. 'Aikau (Kanaka 'Ōiwi) is Professor and Director of the School of Indigenous Governance at the University of Victoria. She is the author of *A Chosen People, A Promised Land: Mormonism and Race in Hawai'i* (University of Minnesota Press, 2012). With Vernadette V. Gonzalez, she coedited *Detours: A Decolonial Guide to Hawai'i* (2019) and they edit the *Detours Series* with Duke University Press. And with Heidi Kiiwetinepinesiiik Stark and Aimée Craft she is co-editor of *Indigenous Resurgence in an Age of Reconciliation* (University of Toronto Press, 2023). Dr. Aikau is also the editor for the Pacific Islands Monograph Series (University of Hawai'i Press).



Ulla Hasager is Director of Civic Engagement for the University of Hawai'i at Mānoa's College of Social Sciences. She oversees academic community engagement for students and faculty and leads engaged curriculum creation, as well as professional and program development across communities, institutions,

and disciplines. At the university level, she serves as a leading engagement scholar. An anthropologist, Dr. Hasager teaches Ethnic Studies and general Social Sciences courses and combines her research with active engagement in human and environmental rights issues. As SENCER Ambassador, co-director of SENCER Center for Innovation West, and SENCER Hawai'i leader, she is involved in several joint research and educational reform projects with researchers and practitioners across the US. Dr. Hasager was raised in Denmark, has a large Native Hawaiian family, and lives on the Island of O'ahu.



Amy Marie Shachter is an Associate Professor of Chemistry at Santa Clara University (SCU). She earned a PhD in Inorganic Chemistry from the University of Colorado Boulder and a BA in Chemistry from Knox College. She has been at Santa Clara University since 1990. Dr. Shachter also served as a Senior Associate Provost for Research and Faculty Affairs, Senior Associate Dean of the College of Arts and Sciences, and Founding Director of the Environmental Studies Institute. In addition to progressing the field of chemistry, Dr. Shachter has been working to improve Science, Technology, Engineering and Maths (STEM) as the National Director of Regionalization for the science education reform project SENCER (Science Education and New Civic Engagements and Responsibilities) by fostering the development of new course curricula, as well as innovative, inclusive and engaging academic programs.



Amy Sprowles is a fourth-generation educator, Professor of Cellular and Developmental Biology, Director of the Humboldt CIRM Bridges Program and the Humboldt-CIRM Shared Resources Laboratory, and Faculty Representative for two California State University initiatives in STEM education: CSUPERB and STEM NET. Dr. Sprowles is an 'IKE Alliance Founding Member, SENCER Ambassador, was the director of the Humboldt INCLUDES Planning Grant, and is a guest editor of this special edition. She has also served the university as Faculty Associate Dean of

Undergraduate and Graduate Studies and Department Chair. At the time of this study, she served as Co-Principal Investigator and Co-Director of the CSU STEM Collaboratives award and the Cal Poly Humboldt DHSI STEM grant; Director of the Cal Poly Humboldt HHMI Inclusive Excellence Award; and Principal Investigator and Director of the Humboldt Transcending Barriers to Success grant.

SPECIAL SECTION

Conversations With Indigenous Academics And Elders

1

SUMMER WILKIE AND DR. MARTY MATLOCK

This transcript represents a conversation between Summer Wilkie and Dr. Marty Matlock, two Cherokee scholars at the University of Arkansas. Dr. Matlock is a tenured faculty member in the University of Arkansas Biological and Agricultural Engineering Department. He is also an advocate for Native American and Indigenous students. Wilkie is a staff member of the Indigenous Food and Agriculture Initiative at the University of Arkansas and is pursuing a master's degree in biological and agricultural engineering. Wilkie interviewed Matlock, her advisor and mentor, on March 14, 2024, discovering more about his educational and career path. This interview offers insights into how institutions have changed and must continue to adapt, especially within STEM education and careers, to further encourage and support Indigenous scholars in these fields of study.

Educational Journey

Dr. Matlock (M): I'll start with my name and credentials. How's that?

Summer Wilkie (S): OK, sounds good.

M: PhD, PE Board certified environmental engineer, etc., etc., faculty professor of biological and ag engineering at the University of Arkansas. And you've got all that from my email. Those are my credentials.

S: And you're also a founding member of the 'IKE Alliance and a member of Science and Education for New Civic Engagements and Responsibilities, and this is an interview for our special publication on highlighting our work through the 'IKE

Alliance. And you also just recently returned to the University from serving as Senior Advisor for Food Systems Resiliency at USDA.

M: That is correct. All of that.

S: Taking it back to the very beginning, would you just tell us about the story of your educational journey?

M: Certainly. Grew up in Osage County, Oklahoma, the Osage Reservation. I'm a member of the Cherokee Nation and grew up on a very small farm, about 7 acres. We had goats and chickens, and it was a quasi-subsistence lifestyle, because my dad was a machinist and was unemployed for about half of his career because of AFL-CIO strikes and other disruptions in the 60s and 70s.

I learned the value of education, of good education, from two good teachers, and I learned the disproportionate allocation of good education across rural communities by seeing just how underprepared I was for college and how underserved my colleagues and peers in my cohort group were for life based upon ZIP code, and frankly, underfunding of education for rural communities. So that made me particularly sensitive to the inequity of educational preparation for college, and that carries through with my passion for giving young people chances to grow and aspire in academia, as well as in other parts of their lives.

Actually, my college career began at Oklahoma Baptist University, because I didn't know what else I wanted to do, and so I was convinced by a Baptist minister that I ought to become a Baptist minister. I spent two years at Oklahoma Baptist University. I was a licensed Baptist minister at 16 and preached in the local church in my community.

I had two paths: I could go the path of what I consider to be drugs and just self-absorption, or community service, and in my world community service was limited to the church. It's a very narrow view of the universe pre-Internet, and that's just what I saw in front of me. I can tell you my parents weren't happy about that religious trajectory, but two years in Oklahoma Baptist University purged that out of me, and I realized I didn't want to be part of the religious community, and so I transferred to Oklahoma State University to complete my academic journey.

But at that time, I saw the transformation of the world through the first mass media coverage of the famine in Ethiopia. The first famine that the world witnessed real time, and I wanted to fix it. So I went to Oklahoma State University, transferred there, received a bachelor's degree in agronomy, and that's where I met Norman Borlaug. And he taught me that famine was not only an agronomic problem. It was an economic, social, and political problem, and Borlaug suggested that if I wanted to spend my life making things better for humans on the land that I needed to learn everything about how humans live on the land. I had great mentors at Oklahoma State University.

I finished my bachelor's degree, pursued a master's degree in plant physiology and botany because I wanted

to understand the challenges of production and yield and disease and toxicity from plants. I had a bit of a gap where I didn't know how to pursue that goal because as a first-generation college student I didn't understand my options. I didn't know what to do, so I got a job working for an environmental engineering firm. Three years later, I was a vice president of that firm, and had 32 employees. Four years later, I turned 30 and realized this isn't what I want to do for my life and got back on track.

So I left the engineering firm and started a PhD in ecology focusing on ecotoxicology. I had lunch with Norm [Borlaug] after I finished all my coursework and was working on my dissertation. He said, "You've got the tools to document the decline of ecosystems. How are you going to make things better?"

Restoration ecology wasn't yet a thing at that time, and so I had a conversation with Bud Burks, my mentor at Oklahoma State. He introduced me to the Department of Agricultural Engineering at Oklahoma State. They were becoming the Department of Biosystems Engineering. They needed me to help introduce biology into their curriculum. I needed them because I needed to learn how to fix things. I'd worked for an environmental engineering firm for eight years, so that was easy enough of a transition.

So I pursued a bachelor's equivalent in biosystems engineering, and then got my PhD in biosystems engineering. That's how I got here. That's my educational background.

S: Very interesting. I learned some new things about you.

M: I bet it wasn't too different from yours, was it?

S: Ah, well, I don't have a PhD yet.

M: Well, that's on you.

S: I do feel like you're kind of my Norman Borlaug, so thanks for being that kind of a mentor.

M: Well, that's an honor. Thank you.

Service and Cultural Connection

S: And so, you served as a chairman of the Cherokee Nation Environmental Protection Commission for 16 years. And it sounds like you always, kind of early on, at least saw yourself seeking out service and a way to give back using your

education and to address issues in communities. But did you always see using your education to serve the Cherokee Nation specifically or Native American community specifically? When did that interest arise?

M: Part of the reason we, my wife and I, moved our family back closer to Oklahoma was to be closer to our kin, our relatives, and those include our Cherokee extended cousins and the Cherokee Nation. And that's what made Arkansas so attractive as a location for us to raise our family and have a career.

I wanted to bring my kids closer to their cultural heritage and Cherokee country, but also my wife is Muscogee (Creek), and [we moved] closer so that she could participate in the extended family activities and Muscogee culture. That happened when our children, our oldest daughter, was four. That's when we made that decision. That was a conscious decision to relocate, change our path of our career. Moved from a top 10 university to a smaller university. At that time, we had less than 14,000 students at the University of Arkansas.

We were tiny. Almost a third less than what we have now.

So that was the intention, and then, just by engagement with our Cherokee leadership at the time, they got to know me. I got to know them, and then I was nominated by the [Tribal] Council to serve on the Environmental Protection Commission. I served on the Commission for three years and then was elected to be the chair and served in that position for 16 years.

So 19 years on that Commission I think, total, with the Council's renewal every four years. I was just looking for ways to serve, but we worked with tribal communities in other ways. As we all know, it's not always easy to find traction and service with tribal communities because they're governmental organizations, they're not NGO's. They're not set up to take volunteers. That took some time to come to understand. And let me tell you, after almost 20 years of working with tribal government, I still don't really understand how it works.

And I would say that's probably true for everybody. It's just a wonderful, wonderful community—but my best analogy is thinking about the big extended family Thanksgiving dinner, raucous and chaotic, and then you

try to make a decision. And during that chaos, that's what we do, because we are in the midst of celebrating life every day, and we have to come together and calm down a moment to make a decision, to find a common path. And it's not easy.

S: That makes sense. And as soon as administrations change in tribal governments, priorities change. And it's a whole new landscape for each tribe.

M: We have a tendency among all tribal governments, not just Cherokees, to burn down the house and start over. And you know, the federal government used to do that, and then the federal government implemented civil service programs. And we've tried, and we have now a civil service program with the Cherokee Nation, and that has made transitions a lot more smooth. So we're making progress.

S: That's good to hear. I agree. And getting back to your career in academia, how have you enjoyed being a faculty member? It sounds like you were instrumental in getting our biological and agricultural engineering program established. What has your time as a faculty member been like?

M: We've seen a lot of changes over the years I've been at Arkansas—I'm now in my 23rd year. I came here in 2001. It's 2024. Boy, it slips by fast. It's been the passion of my life to do the work we do. I am often criticized by my colleagues and peers for being involved in too many different things. That's what I love to do. I could not imagine spending a life, a career, doing a very narrow set of things every day. It's the best job I could imagine for me. I suspect other people are not suited for this kind of what we consider to be professional chaos. I revel in it.

It motivates me, and frankly, and you know, our universities are changing too. The demands of society on our universities are creating pressure for them to transition to something else. In spite of what the media landscape may tell you, universities are not progressive places. They're incredibly conservative. Decision-making at universities is incredibly slow. Change occurs usually only through disruption, not through strategic investments or transitions. That's just the nature of our institutions.

One of the most exciting things I have been involved in at the University of Arkansas and across our land grant

university landscape—which is my passion: the public universities, especially land grants—is this recognition that we have to become something different to meet the needs of the 21st and 22nd century, and COVID was that disruption in many respects that I just spoke about, that thing that made us change. I've been working in distance education, that is, technology-based delivery of education, since 1995, as a PhD student where we videotaped lectures, and then put them in a FedEx box and shipped them to other campuses across the nation to share lectures pre-internet.

Now all universities are addressing this fact that the brick-and-mortar institutions that we serve are not necessary for our goals. They are supportive of our goals, but we're not bound by them anymore. Technologies free them, free us.

So how do we now bring technology to our rural communities? Remember my discussion about the inequity of rural education? How do we now use technology to bring equity to primary, secondary education, and access to higher education to those communities who no longer have, who historically have not had access? And I think that our tribal communities, our tribal governments, provide a vehicle for achieving that because we have governmental, nation-level infrastructure in our smaller communities that can amplify these efforts, can motivate these efforts, can govern them, govern them in a way that they're not exploitative of the people.

So we don't have just-for-profit, paper certification generators out there exploiting our young people saying "here, pay us \$5000 and we'll give you a certificate which you can't get a job with." That happens, and that's what we're up against. In any emerging technology you have the hucksters out there. And so how do we overcome that? That's another part of our role, to protect our citizens from exploitation and to enhance their ability to make better decisions.

So that's what I've been up to these last 23 years.

Native American and Indigenous Student Support

S: That's amazing. I agree that the universities, especially our land grants, are being called on to evaluate and change and adapt. And I love the vision of tribal governments, tribal

communities being able to benefit from that and have education be more accessible for a Native American, Indigenous people.

M: That is my vision for what you and Greg are going to do with our Tribal Leadership Council on our campus, because our Tribal Leadership Council now is our foot in the door to tribal governments to take this vision back home.

S: Yeah, we're making great progress on our campus in that direction. I'm really proud of that work too. And it's worth mentioning here that we got a Tribal New Beginnings grant over the summer, which is for land grant universities to fund services for Native American students. And that was a historic creation of a position on our campus, our Native American Student Services Director. Thanks for that, and it's part of the 'IKE Alliance work we built towards this.

M: Absolutely. The 'IKE Alliance gave us the vision, and our discourses with tribes gave us the vision, that frankly, made us aware of what we're not doing. We weren't doing enough.

Made us aware that that there was work in front of us. That's funny. Until you've cleaned your house, you can become blind to the clutter and the dysfunction of your house. Once you clean your house, usually for a party, you think, why didn't I do this a week ago? My house is so much nicer. That's my sort of metaphor here.

The 'IKE Alliance taught us where, in our house, where we had piles of dirty clothes in our living room, and that we needed to change that.

S: And that speaks to kind of the reason why our 'IKE Alliance is so critical, and even universities who don't have high numbers of Native American students, especially if they're a land grant, have a responsibility to Indigenous, Native American people.

And how do you know what the resources are? How do you know, without those kinds of examples and cleaning house and doing laundry like you said, you know, without some kind of inspiration to do that then how will they really know what all the opportunities are? And we're just learning those as we go ourselves.

M: So now what is incumbent upon us is to help our cousins out there at the other public and land grant universities

to see their opportunities and help them develop their internal visions for how they can better serve.

Because as we know, many of our land grant universities were founded, were created, were constructed from land taken by the government from our Indigenous communities, our tribes, and sold. And that wealth was transferred to states to start their land grant universities. And the grant wasn't public land. It was in many cases, tribal land that was yet another taking.

And so yes, there is an unrecognized obligation from our land grant system to tribal communities, unrecognized and unspoken. We need to speak that truth loudly, and we need to proclaim our obligations, and then we need to work towards meeting them.

S: Yeah, and I'm thankful for some universities who are courageously addressing and speaking and learning and acknowledging around that topic. Thankful for the article published in High Country News, "Land Grab Universities," that made that information a lot more accessible for people.

M: That's the power of knowledge. That was a transformational article.

S: And the impacts are still rippling out. Their effect is happening.

Navigating a Career in Higher Education

S: So going back to your career as a faculty member, I would love to hear about what your experience was like. Achieving tenure and you know, if you found a support around your Native American identity and service that you were doing for your tribe and Native communities at that time. Did that help support the tenure process? Did the university acknowledge that? What was your tenure process like?

M: Tenure at the university is not complicated. In fact, it's fairly mechanistic. In the sciences and engineering our metrics are unambiguous.

The problem we have—and so many universities still have legacies of this—these very subjective criteria where basically it meant that the young faculty were exploited by the elderly faculty, the tenured faculty, in order to curry

favor. That process, through effective management of human resources and policy, has been ferreted out. I was at the tail end of that, that culture in engineering. And so our criteria were fairly straightforward.

To get tenure, you needed to have at least 10 peer reviewed publications during your period of service pre-tenure, and that's typically five years. That's two publications a year. At that time it was just \$100,000 of expenditures. Now it's \$1,000,000 of research. You needed to have graduated at least one PhD and a handful of master's students at that time, and those are the criteria now.

I met those criteria easily, but the problem I had was, I am a very diverse scholar because I work on ecosystem-level problems that have human, economic, and ecological and physical elements to them. And because I'm interdisciplinary, I had to be tenured in two different colleges at the time: ag and engineering.

You know, several folks asked me afterwards, "Why do you publish in so many different journals? Why don't you just pick one and stick with it?" Because the mindset was very narrow, that the way you become a scholar is you do your one thing, and you put your head down, and you do that for 40 years, and you become the world expert in that very narrow thing. And that's why that's called a tower of knowledge, right? And it's isolated, and it's often called an ivory tower because it sits on the hill isolated by itself, like a monument to knowledge, without relevancy to humanity. Fortunately, in my 20 years, that's all changed.

But I was sort of the one at the front at the University of Arkansas and at Texas A&M in that interdisciplinary push because my Cherokee heritage taught me that everything is connected. My identity as a human was understanding the world through all those interconnections, and I saw that vast network that has been described by some of our previous elders as a web of life and a web of humanity, interconnected all.

And so that was a challenge. My Native, my Indigenous culture and heritage was an asset. It wasn't a liability because, frankly, I present as a white guy. But it wasn't an asset, wasn't recognized, and the University of Arkansas didn't even start recognizing Native American faculty

and students until 15 years ago. So I was well past tenure when that happened.

S: Yeah.

M: And by the way, I'm an excellent scholar. I exceeded all expectations and still there was resistance because of my diversity of scholarship.

S: Wow. That's interesting to hear, and hopefully we continue to move towards a more interdisciplinary understanding of the world.

M: Oh, now it's an expectation. Now, if you only publish in one journal, that's a negative. It only took 15 years, but the institution can grow.

S: That's good to hear. My last question is just, do you have advice for people considering careers in academia? That would be my last question.

M: If you love exploring the unknown, if you love expanding knowledge, if you love the scientific method, the creative process, the design method, any of those expressions of expanding human consciousness. If you find passion in that, and if you have the discipline to be your own boss. And you love working with young people, because ultimately, we're teachers first, mentors second, scholars third. That's the order of real activities, not the order of award. The order of award is reversed, but that's another thing we're working on.

The institution, if you can, if you have the confidence not to care what other people think, to find your path and to walk your path without regard to affirmation from others. Then it's an incredible job.

It's the only job I could do, because I put the affirmation from others part last. The affirmation that we get, the affirmation that matters, is from our students. That we're teaching them, and usually that comes well after the classroom experience. Usually it comes after they've applied the classroom experience in life and they realize, "Oh, that crap I hate, hated, actually is really important, and that thing, those exercises I had to do that I hated really do serve me well." Now that's the human experience.

So there's no affirmation immediately in the classroom. Often student evaluations are quite low on rigorous instructors. And so the real affirmation we get is through

our proposals that are funded from our peers. We have to understand how to communicate a problem and a solution for that problem, or a method to better understand a complex system in order to get funding, because we have to sell the idea and then we get funding. And then we have to create a team of scholars, undergraduate and graduate students, peers who can work together on those problems. So there's a managerial element to that too, which I absolutely love, and you've been a part of that. It can be robust and it can be, you know, we're still coming out of COVID. We're still trying to figure out how to put that back together, but prior to COVID that was the water I swam in working with my graduate students and with my peers as well.

The opportunities for academic scholarship and academic careers are growing. There are bigger opportunities out in the private sector. They pay more, but none are more freeing than what I do. So yes, I'm a big advocate if you can do it. If you have the characteristics for it. Some people just want a job where they can clock in, do the work, clock out, go home, have their weekends, their holidays, and not worry about things.

This isn't that job. Remember I started my career as a Baptist minister. This is my calling and for most faculty they would characterize it the same way. It's the culture of the mind. This is what we think about all the time. It's our job, our passion, our hobby, these things we do, and somebody pays us to do it, too.



Marty Matlock PhD, PE is a faculty member in the University of Arkansas Department of Biological and Agricultural Engineering. He recently served as Senior Advisor for Food Systems Resiliency at the United States Department of Agriculture and previously held the position of Executive Director of the University of Arkansas Resiliency Center.

Dr. Matlock received his PhD in biosystems engineering, MS in botany and BS in agronomy from Oklahoma State University. He is a licensed professional engineer, a board-certified environmental engineer, and a certified

ecosystem designer, and his research focus is measuring and managing complex ecosystem processes at local and global scales. Dr. Matlock is the recipient of the 2018 Cast-Borlaug Agriculture Communication Award. He has served on the United States Environmental Protection Agency Science Advisory Committee for the 21st Century and as a sustainability science advisor with conservation organizations and agriculture producer groups. He is a citizen of the Cherokee Nation and served as Chairman of the Cherokee Nation Environmental Protection Commission for 16 years.



Summer Wilkie is a Cherokee tribal citizen and the Next Generation Manager for the Indigenous Food and Agriculture Initiative, a program of the University of Arkansas School of Law. In this role

she also plans and leads the Native Youth in Food and Agriculture Leadership Summit each July. Summer Wilkie has a BS in civil engineering from the University of Arkansas. She is pursuing a master's degree in biological and agricultural engineering. Other honors include participating in the Udall Congressional Internship Program and the Cherokee Environmental Leadership Program.

DELANEY SCHROEDER-ECHAVARRIA AND DR. CUTCHA RISLING BALDY

*"The thing that is missing, and has always been missing,
from Indian education is Indians."
– Vine Deloria Jr., 1991*

**This transcript represents a conversation between
Dr. Cutcha Risling Baldy and Delaney Schroeder-Echavarría.**

It was a cold and rainy day in Goudi'ni on March 4, 2024. It was a Monday, so people were coming back from the weekend and were moving slowly throughout the campus of Cal Poly Humboldt. Located on the Traditional unceded land of the Wiyot people, the university is small, but within its scope is the largest population of Indigenous scholars within the California State University system. On this day, I [Delaney] attended my decolonizing methodologies course, participated in a graduate council meeting, and interviewed one of our most esteemed Native scholars, Dr. Cutcha Risling Baldy. I have been fortunate enough to have Dr. Risling Baldy as one of my mentors and educators throughout my time as an undergraduate and now as a graduate student, and we have had many conversations about what it means to have Traditional Ecological Knowledge [TEK] as a foundation within our work. These conversations usually focus on the relationship between Indigenous peoples and knowledges and universities built on stolen Native land. The following interview is one of those conversations.

Delaney (D): *I think we should start with introductions. Can you introduce yourself the way that you feel comfortable?*

Dr. Risling Baldy (C): I'm Dr. Cutcha Risling Baldy. I am Hupa and an enrolled Hoopa Valley Tribal member, and I am an associate professor of Native American Studies at Cal Poly Humboldt.

D: *What has your experience been within STEM academia as an Indigenous person and as a Doctor of Native American Studies?*

C: I can start from being very, very young, in really thinking about the role that science and scientific inquiry has played throughout my life. I do think that Indigenous peoples have some different experiences within Western science from the time that we're very young, because we are often growing up in communities that have been studied, and we are often being approached or included in ongoing scientific research. We would always talk about how we could identify the scientists at places that we were at, and this is sort of extending STEM into what

happens with anthropology and ethnography. Growing up as a Traditional gatherer, I worked with a lot of my relatives on land restoration, and we thought about what it meant from the perspective of being an Indigenous person who's trying to do things with the world around us. I remember learning about environmentalism in school and what it meant to be an environmentalist, and I kept thinking, that's just how we live our lives. As a researcher, I was very invested in the sciences. I wanted to do work that I thought would be important to my community. In my mind, being able to scientifically prove things would help my community in the long term as we were trying to push what has been happening with our salmon and the lands we work with. I thought being a scientist was going to be the most helpful way for me to do those things. And I really wanted to be a doctor. I mean, I am a doctor, [laughs] but I originally wanted to be a medical doctor within my community. My grandfather when I was young was diagnosed with early-onset dementia which was caused by alcoholism and PTSD. He had been a

boxer when he was younger, and I thought that I was going to do work on the human brain. I really wanted to work with our elders, and looking back I was trying to look at how we medically intervene in trauma and what it looks like to address trauma issues from the medical standpoint. I was at Stanford University and immediately started with STEM classes, because I was always told that I had to major in a STEM field to go to medical school, so I majored in human biology. This was the only plan I could see and there is just so much value in the world associated with being a "scientist." People are more likely to trust in your words, right? And I had sort of grown up in this way, that if Western science proves something, that then becomes reality. So my experience in STEM as an undergraduate was...I think I would use the term of "dehumanizing" almost. I couldn't see a connection between what we were learning and what was going to become part of my work that I wanted to do in the future. It was very like "If you can't memorize these fifty things then you can't do anything," and I didn't come from a place where people were able to give me the tools to be able to say, "This is how you would memorize this." And for some reason, I had internalized that asking for help was a negative thing. I felt like everybody who was in STEM already knew what they were doing and I was the only person that didn't, which made me believe I didn't belong there, that the people who belonged there were the people who were having, in my mind, an easy time. I had a lot of really negative experiences; failing tests and classes. Then there was an incident where I had a TA who told me that I was obviously an affirmative action student and that I probably only got in because I was Native and that it was giving me a disadvantage because all these other kids were already there and I would be playing catch up. And that was a crazy moment now that I think back on it, because it really was just sort of like "you don't belong here" and then really feeling kind of pushed out. When people ask me to share my experience about STEM, I always say, "*I was pushed out of STEM. I wasn't invited.*" I ended up majoring in psychology. I guess if you buy what psychology is selling, you're thinking, well, that's still STEM, right? But you're also dealing with people and human beings. What I started to see is the

complexity of what needs to happen as you're thinking about what science is and what it means to do research in a scientific field. Especially if you're somebody who does any research with people but also with our more-than-human relatives (animals and plants). I still don't feel like I was ever invited back into the STEM fields. I kind of found my own way through graduate school and getting my PhD, but because I had this experience and I had done so much growing up, I became invested in how I could build a bridge between these multiple disciplines that I had studied. I always thought of myself in this way: "I'm in Native American Studies and I'm doing Native American Studies but am I thinking about what science could be." And what Native American Studies is saying is, we don't separate these disciplines, actually they're very intertwined. And you can't say to yourself, "I'm a scientist but not a humanist or I'm a scientist but I don't think about what that means for the more-than-human world." Because all those things matter to what you're trying to find out about the world. I read a book by Vine Deloria Jr. called *Red Earth, White Lies*, where he's talking about the myth of scientific fact. He's asking people to have critical conversations about what science is and what role it plays in trying to make us believe that there's an infallible group of people who have all the answers. He's a leading Native American Studies scholar, but he's also a religious scholar and theorist. And I think what he adds to this discussion is saying, "You're trying to separate spirituality and religion and culture for what you're doing as a scientist and that's not what real science is. That's not what we should be doing. That is making you think that there's some kind of infallibility that science can reach, where you don't question its findings and you don't question the methodologies, you just accept it because someone has proven it to be a fact." Those were the moments where I had critical conversations about the things that we were doing, and watching how uncomfortable that made a lot of the Western science professors and researchers. And then I thought maybe that's what I'm doing now. I can walk into a Western colonial institution and have that conversation because of the way I've been trained both at home and in educational settings.

D: We talk about the fact that Western scientists are now super interested in Traditional Ecological Knowledge and Indigenous science and they want to incorporate it into their research, in their classrooms, and I think a lot of the reason why they're doing that is because scientists are starting to realize that Western science is lacking in its interdisciplinary approaches. It wants to be its own thing, you know? As you were saying, I felt the same way growing up. I never felt like I was smart enough to engage in science. All the kids in class were really good in biology or chemistry. I always felt that they had a natural gift and I was just constantly struggling to get by. In reality, it's because it tries so hard to be only one thing, and if you try to approach it in any other way, it's considered wrong. But now that whole ideal is becoming so outdated—it always has been but I feel like now it's gotten even more to the forefront in people's minds. Now scientists are being asked by their students "What about Traditional Ecological Knowledge? And these Western scientists are saying, "I don't know." Well, maybe you spent so long focused on one kind of science, one way of looking at the world that now you're realizing you are falling behind in your thinking and your process. And you know, I think that that can lead to a lot of struggles for a lot of people.

C: I do think I've been having to work through this with myself, but also I think with students that I work with, figuring out how we can break down and decolonize. Frankly, this idea about science, how it was a natural part of life to be someone who is observational and experimental, and to think about how I see the world around me and then how do I apply that and then how do I test it and then how do I make sure it works. We do that in our everyday lives, and we have done that for countless generations. So this idea of this thing that you carry with you wherever you go, well, my grandma told me, "I do it this way because of these things," and then someone says, "Well, that's not a scientific fact." But I just want to tell them, "Well, that's the elitism of what it means to be a scientist." I would say that my grandmother and my great aunts were also scientists, because they would say, "I just figured out that if I put this thing closer to the fire, this thing happens better. But if I don't do that, then I don't get this kind of effect, you know?" And so I constantly push myself to not be caught up in this kind of elite conversation. It's not about this elite conversation.

It's about how we all come together. To come up with things that we want to test and what we want to see. What that means for the world functionally. And I think if science opens itself up to community-based work and how we learn from people, that's where you get the ideas of how you are going to build climate resiliency. How are you actually going to solve these big major problems that we're facing? How do you approach the ongoing issues? And if you invite more people to that conversation, you have more diversity of experience, and then I think you get better ideas.

D: Yeah, absolutely. And we talked about how you decided to move away from pursuing a doctoral degree in biology and becoming a neurobiologist. You kind of already touched on this but my second question is **what caused you to leave Western STEM in your educational pursuits?**

C: I think really it was finding out that there were people who really liked going to class and they really liked all the stuff we were reading. They were energized by the way they were learning, and I felt none of those things. So I wondered, is that because I'm not the right kind of person to be here? Or is it that I'm in the wrong sort of place with people? Do I need to switch? I took a social psychology class at the same time that I was doing all these STEM classes, and that was the part that I really liked. At one point, a woman approached me and told me that I was a really good writer. She said, "You should be writing. You've got an amazing voice and not everybody can do that." And I said, "No, I'm a scientist. I write lab reports. I'm not a writer." And she said, "No, you have a voice that you need to share." And she was trying to encourage me to take a writing class. And I remember telling her, "No, I'm going to be a doctor." And she said, "Well, you can be a doctor, but you should think about pursuing this." So I took a social psychology class and really liked it, and then I talked to an advisor and she told me, "Well, you know, a lot of people go to all their classes and they really like them. They like being here, and they think it's really exciting, and they have teachers that they get excited about and professors they want to work with." I had experienced none of that, and then she said, "Well, maybe you're in the wrong major." It was really hard to hear that, because in my mind what I was being told was

that I was not smart enough to be in this major. I've had to really rethink that, especially with students when I tell them, "No, it has nothing to do with 'I'm not smart enough.' You should major in the things that you love to be around and do." And it's ingrained in us to think about how it has to give you a job, or it has to have a straight path outward, or it has to be something that other people can understand. I always tell people, "You'll always be able to get a job. You'll always be able to do these things, but it is also important to be engaged, happy, and passionate about what you're doing." It took me a long time. After she told me, "Oh, other people like their classes," I realized that I had to figure out if I wanted this. And I think that's something I do want to tell people, that we need to be really open with students. There are so many ways to do this kind of work, to really be a scientist.

D: I feel like I was in similar shoes. My parents told me that if I didn't get a science degree, it'd be really hard for me to get a job; I was kind of scared into pursuing a degree in the hard sciences and I was encouraged to go into environmental law. I was taking those classes and I couldn't stand to be in them. I changed my major so many times, and while I was in community college, I took horticulture science as my biological science requirement, and I fell in love. Working with our plant relatives opened my mind and I wouldn't change anything. I'm really glad I ended up going down that road. I feel like we've touched on a lot of these things, but I want to ask, what barriers have you faced in your pursuits, and what barriers do you think youth are at risk of facing today?

C: I think a lot of the barriers when I was an undergraduate student were really around learning how to learn, but also being okay with the fact that sometimes it's not you, sometimes it's systemic. It's the systemic issues that were obviously present within the disciplines when I was a part of STEM disciplines. I didn't have the terminology or the words at the time, but now that I've done all this work, I think, what does it really mean? To encourage Indigenous students to participate in these STEM fields when there are still a lot of colonialistic things that happen there. I'm at a point in my career where I'm sitting down with people who keep asking the same question, "How do you decolonize? How do you decolonize STEM? What does it mean to decolonize my syllabus or decolonize this and

that?" I've been doing the work for a long time, and I tell them, "Okay, here are these things that I would suggest about what it means to think about reconfiguring STEM so that it isn't a practice that upholds settler colonialism, capitalism, and imperialism. Ask 'What are we actually trying to do here, what does that mean for us long term?'" And then I remember once when someone asked, "What do we do to decolonize STEM?" my answer was, "There's stuff we could do, but do we want to?" Is that where we want to spend our energy, helping Western STEM to be a slightly better version of itself? Maybe that's not the thing we should have been doing. Maybe there are other things that we should really spend our time on. Instead of trying to help them. Maybe we have to work in these spaces and not keep trying to say, we can be part of STEM too, because maybe that's not a thing we want to be a part of. Maybe there's something else we could do with our lives, and do we want to spend all that time trying to help the STEM fields to catch up?" I think about this a lot. When I was little, my great uncle was an educator his whole life, and he was one of the founders of Native American Studies at UC Davis. When I would hang out with him, he would constantly be doing work with academics, researchers, and scientists. I would watch him do that work and put his whole self into trying to help them to truly understand, "Sure you think you're asking this question, but actually that question is informed by these things and that has a lot to do with colonialism." So every time a scientist comes in and says, "What's the highest temperature that a salmon's eggs can survive?" My uncle's job then would be to come in and say, "Okay, you're asking that question, but the reason why these things have changed is colonialism. What you're actually measuring is the impact of colonialism on salmon." He would start talking about history, and they would get very uncomfortable, because they wanted to believe that they could go into an area of research or discipline where politics, history, and culture didn't matter, and in reality, it's all super political. Your findings, no matter what they are, are going to have political implications, and sometimes these implications matter to the very lives of the people that you're working with. You have a responsibility to that. My uncle would point these things out, and I would watch him struggle with this conversation when he

engaged with scientists. They would sometimes get really mad at him. I have since learned that it's part of what I call the settler stages of grief. They would just say, "I can't believe that you are telling me all this stuff and I didn't know this before." They sometimes got really sad, and they would reject outright the things that he was sharing with them and say, "We're not going to do that." And I have to think, how arrogant are you that you come into a space and say, "We need your help with whatever it is, but we're not going to do that because we don't like it." And so I sat with him one time and I asked, "Why do you work with these people?" And what he said to me, I'll never forget and I have shared it with many scientists and scientific audiences that I speak with. He told me, "Western science is very new to this place. This place where we came into being, this place where we have been for time immemorial, this place where we have been for countless generations that we have thousands upon thousands of years of knowledge about. We have so much knowledge about this place based on so many scientific experiments; imagine that you created a theory 10,000 years ago and you've been testing it ever since to see how it changes based on what's going on and the environment around you. This is your life. That's Indigenous peoples. We have a lot of really deep scientific knowledge. Western scientists are new here. Western science is like a toddler in the development of what it means to be a science." My uncle said that Western scientists are like toddlers. And so I always figured that our job is to be the elders of this place and to help them so they don't burn the house down. In his view, we're guiding them in the hopes that they grow up and they grow into themselves. We're helping them to grow up. Telling a Western scientist that he is like a toddler to Indigenous peoples is really funny, because they get it right away. I've heard so many Western science folks say, "I totally understand. Yes, we are. We are new here. We are figuring all this out for the first time. We are like toddlers." I told one group this story: imagine you're a mom and your two-and-a-half-year-old kid comes up to you and you say, "You see that stove? That stove is hot. Don't touch it." And they ignore you and they go up to the stove, and they're still going to try to touch it. Maybe they touch it and then they turn around and look at you

and they say, "Oh, it's hot." And you say, "I know it's hot." And they insist, "No, no, no, I discovered it was hot." [laughs] Western scientists come in and they do a bunch of experiments and then they go, "Hey, did you guys know trees talk to each other? Hey, did you guys know that birds are really smart?" We know that, but good job. We're surrounded by all these people going, "Hey, did you know that sage cleans the air and is good for you?" And then we say, "Yeah, we know that." And then they insist, "No, no, but we proved it. We proved it." And that's what my uncle was trying to tell me: don't ever believe the elitism. Understand your grounding and then say to yourself, "They're still learning." Our job is to make sure that we hold our ground. Time is such a relative thing, and what Native American Studies scholars talk about is the fact that Native American peoples in terms of their knowledge and their epistemological beliefs and their understandings about the world geologically, historically are very different in time than Western culture in this place. Our time is based on a minimum of 10,000 years. Western culture's time is based on a minimum of 500–600 years. These are very different amounts of time. This is a period where Western theory and Western thought are the dominant culture that is teaching and doing things in education, higher education systems. They're the dominant voices in what becomes expertise. That time of those voices being the primary voices might seem very long. Actually, it's pretty short. And we don't think of this as forever, this period of time where this is happening. We have to prep for the next period of time. I love that about Native people, you can come to them and say, "Take the dams down, but it'll take 150 years for the environment to be back to where it should be." And I'll say, "Yeah, take the dams down! Take them down today because then we can start our 150 years of progress, but we are ultimately thinking about 150 years from now." I really love knowing that we are going to be a participant in that, even though we won't be alive when it happens. We know we are participating in 150 years from now because of what we're doing right now. That's what Native people mean when they say you should be thinking about the next seven generations when you do something because you are participating in those next seven generations just by the

decisions and the things that you're doing now. Those things are long-term. I feel like Western science is always looking at things as short-term in a vacuum, not thinking about how it all adds up to something, and how that data should contribute to become a bigger discussion about what it all means. I would say to people, "I can tell you they did a Western scientific experiment to prove that trees talk to each other," but then the Indigenous peoples would say, "Yeah, they do, why do you think we talk to them? Why do you think that we do these things?" If I had just come into this space and said to you, "Did you know that Indigenous peoples know that trees talk to each other? And they're interconnected in these ways." Then you would say, "Oh, that's cute." [laughs] But if I say, "A new Western scientific study came out which proved that trees talk to each other," just watch as people are internally more comfortable with that statement and think, yeah, okay, now it must be true. As if it wasn't just as true three sentences ago when I said Indigenous peoples know that trees talk to each other. So why do we have to be reaffirmed by Western science? Why does Western science feel like it can't just take that knowledge as it is and then ask the next question. That's why I think we get this disconnect, because we're constantly proving things that we already know and then it doesn't move to the point of asking the next question. What's the next question after that? Now that we've proved that. Now we know that that's true, right? I think what happens is that the more you start to get into this idea of what you are able to prove, what you are showing, that always kind of re-proves things, and Indigenous peoples say, "Yeah, that's what we've been trying to help you to understand." You very quickly realize that after you get through that process, your position in the world becomes less. I've been able to prove this thing and now what am I responsible for, now that I know this? I think that those are the kinds of things I see Indigenous peoples continuously trying to do. What we have been able to do, and where TEK is really important to what STEM is moving towards, is to be able to solve some of the largest problems that we face as a world right now. It's really a philosophical, a community-based conversation that I think Indigenous peoples are having because we have gone through 10,000 years with these

questions and have come out the other side saying, "We're responsible for these things, which is why we have set up our culture and society to be responsible to the world around us. We have done enough scientific experimentation to figure out that's how you have to live your life." It becomes a philosophical, spiritual, cultural conversation that I think a lot of Western science is still very uncomfortable with.

*D: I absolutely agree. I took an environmental ethics class and a lot of the theories and the things that we talked about really change your way of thinking about the world. When you tell people, "No, that's not how it works, just because your knowledge works for you, doesn't mean it works for everybody. That's not how the world works." You point out the fallacies in a lot of people's ways of thinking, and even though people spend years in academia getting these degrees, you can shut them down really quickly with just a philosophical question, and it really bothers them. I've had many conversations with people like that. A friend of mine went to Berkeley, and I had a conversation with her about animal ethics that really upset her. I just always think that if you're not allowing yourself to look at the bigger picture and ask yourself these hard questions, you're really setting yourself up for failure in a lot of ways. Failure is not always bad. I think that what a lot of Western academics don't realize is that failure allows you to learn and humble yourself and take into account other knowledges and other ways of thinking about the world. That doesn't mean that you have just wasted your life getting this degree or something, but maybe it's okay to realize that there's failure in your positionality. There are flaws, and that doesn't mean that you're a bad person or that the world's going to crumble around you, or that your research methodologies are incorrect. I think that a lot of people take it really personally. As you mentioned earlier, though, it's not necessarily the people, it's the system. Maybe people need to start looking to the system as what has failed them and not necessarily the philosophical questions that are failing them. The big questions aren't failing. Maybe it's the institution that has failed. That leads to my next question which is **what do you believe we need to consider when exploring TEK and STEM?***

C: When people come to me, they'll say, "I really want to bring TEK into my work or I want to think about how I introduce and engage with TEK in STEM pedagogically," especially in the Western sciences. Now I'm starting to say to people, "That's great, are you able to also engage with what that means for upholding the sovereignty of Indigenous nations? Upholding the determination of Indigenous nations. How are you going to engage politically with tribal folks?" You don't get to come in and say, "I like your knowledge, but I don't want to have to politically engage with what that means for me and you." Because the thing about tribes is we are political status peoples. We are nations within this nation. There are over 500 nations within this nation. It is a political thing that you are engaging in by engaging in our knowledge. There was a period of time—and in fact, this still happens on occasion—when it was illegal to engage in TEK. Indigenous peoples were arrested for that. They were put in jail. They were having their children taken away from them. They could get charges that politically affected their entire lives. There have been instances where scientists have come in and really exploited tribal communities and created situations where tribal communities are faced with exploitation all the way down to their DNA, the very things that make them human beings. Experimentation was done on Indigenous women, experimentation was happening with Indigenous folks, and I think it is really important that if you want to engage with TEK, you also have to engage politically with what it means to protect, uphold, uplift. And if you're not willing to have that conversation, I would say, "Cool, you want to do TEK, are you ready to fight for Land Back?" And if people say, "I don't even know what that is," I say, "Well then don't engage with TEK until you've done the work to figure out where we're at politically and what we need and how you're going to engage with that." We don't need people to just come in and use our knowledge; we need people to understand that our knowledge is there because of the political engagement work that we did to avoid being erased and eradicated and dismantled by this colonial system. So you owe it to that knowledge, to us, to the future, that you also engage with this politically, because the settler state exists to this day to dismantle and disappear Indigenous peoples. If you're not willing to sign up for that part of

it, then you shouldn't concern yourself with TEK. The exploitation of knowledge should be at the forefront of anybody's mind as they're starting to think about what it means to engage with TEK. It's not a cute story. You hear people say, "Oh, isn't it nice that they have a way to make an offering to plants or to think about plants in this way." It's not a story, it's not like something that we can present and people want to do it too. It is the political thing that we had to do. I actually wrote an article a while ago, when I was in graduate school. Actually, it was the first article I ever published, "Why We Gather," and it's about bio-cultural sovereignty. Some students of one of my colleagues read it in their class, and they talked about coming into a space as a scholar and saying to people, "Sure, we can engage in Traditional Ecological Knowledge, and we can learn more from each other," but the scholar also needs to say, "What you're doing here needs to be about bio-cultural sovereignty." I want you to think about the fact that when we used to go gather, we could get arrested. So if we're sharing this knowledge with you, how are you going to make sure that they write a policy that does not leave us out of this conversation? How are you going to make sure we're in the room? How are you going to make sure that we're the ones who are leading the conversations? How are you going to make sure we get the money? Because so much of the money goes to Western science and Western scientists. How do you push back and say, "Why aren't Indigenous peoples leading these endeavors? How are you going to make sure that doesn't become an issue again?" We will constantly come up against these issues with colonial laws and policies and agencies. We have to prove that we're able to be there, even though we're the most sought after for the knowledge of what they're going to do there. You can ask people, "What does political engagement with sovereignty mean for you?" If they haven't done the work to actually politically engage in sovereignty, they need to take a Native American Studies class, read a book, go to the events. Figure out what's really going on with Indigenous peoples and then understand their connections to that. When I talk about engaging with TEK and STEM, I also talk about bio-cultural sovereignty. I talk about what it means to think politically about why it's acceptable for somebody who's in a STEM field to go out and gather marine resources or into the

forest and decide what a forest is supposed to look like. Indigenous people have been engaging in those places for a minimum 10,000 plus years, and they continue to do that even if they're not invited into those places. Why are they not the ones who are invited first? Where aren't they the first ones considered? Why aren't they the ones who are leading that initiative? Why aren't they the ones running the forest? Why don't they own that land? If you're not asking those questions, if you're not willing to have that conversation, if you're not willing to be the person who says, "I'm learning from TEK and I'm upholding biocultural sovereignty," then I don't think you know what you're truly signing up for.

D: When I attended the IAC [Intertribal Agriculture Council] Pacific Summit, I was able to attend a talk with the California Indian Museum Youth Ambassadors, and one of the first things that they talked about was how they and people that they know have been threatened at gunpoint for being on their lands and gathering, and how they were yelled at by just random people in the park or were being stopped by police. When they (non-Indigenous peoples) encounter Indigenous people and Indigenous perspectives they don't think critically about what the history of this land is and where we stand and what we're doing here and the fact that the Indigenous person is sitting in an illegally occupied space. I don't think people realize that we are still living in occupation. And I don't think that is a conversation that ever crosses the minds of non-Native people and people in academic spaces. I think that they also believe that you can own land and you can own relatives. You can own a tree. You can go to a nursery and buy one and just plant it wherever you want. It's violent, and I think there are a lot of people who from childhood to adulthood continue to think that they can just own wherever their feet are. That there's no knowledge and there were no people here and this was just empty wilderness, empty space to take. And it always bothers me because that's how I grew up. I grew up in these public schools and the sections on Indigenous people were two or three pages long, and that was it. That's the only thing non-Native people know. And then we spent weeks talking about George Washington or the Revolutionary War. I literally didn't have any knowledge about actual Indigenous people until I came to college. Until I started listening to the stories that my nana shared with me

*and I started learning about my family history. That really ties into Western STEM. We're constantly teaching people that this is knowledge. This is the only thing that matters. Sorry, I'm like going off on a tangent, [laughs] but I think about that a lot, and what you had to say really resonated with me and this leads into the next question, **what is your opinion surrounding the rise in TEK implementation by non-Indigenous agencies, such as the White House memorandum in 2021 and the utilization of TEK in higher education, specifically in the universities you have been a part of?***

C: Being a part of Cal Poly, I think it's much like anything that has to do with Western institutions. There's a lot of cost. There are often many benefits for the institution and the people who participate in the institution and there are a lot of costs for the Indigenous peoples who participate in this sort of integration. It's the job of the folks who want to embrace, envelop, and bring in TEK to empower Indigenous peoples to be the leaders and at the forefront of that. They can't embrace TEK and also remain the most powerful voices in those spaces. It's up to us to say, "How are you dismantling your role here and uplifting Indigenous voices in those spaces?" Because what you see is that our knowledge is a key component of what needs to happen next, and it needs to come from a perspective of humbleness instead of just extraction. We can see repeats of colonialist institutions extracting from Indigenous spaces and peoples and minds and bodies, and what we have now is a bunch of Indigenous folks who do not want to see that happen with TEK. I think it's the job of the non-Indigenous folks trying to do this work to be the first to say to themselves and then to everybody around them, "We will not repeat a process of extraction from these communities and these peoples, and instead we will dismantle this system and uplift those voices." I see it as a possibility, but what I'm also seeing is the work of constantly asking those questions and pointedly demonstrating that it's not just a matter of extracting knowledge and methodology. That has been left up to Indigenous voices. It's fallen to the Indigenous people who are in these spaces to constantly be the person who says, "But are you thinking about biocultural sovereignty? How are you working with Land Back? What does this mean for the

bottom line of our natural resources? What are we going to do with these resources that we're developing?" We should no longer be the ones to bring it up, because it's exhausting, it's difficult, it's disheartening, and it makes people hyperfocus on you because they think of you as the problem, when what they really want which is just free rein do whatever it is they'd like to do. The thoughtfulness by which you do that should also be a thoughtfulness for the fact that you should be the first person to ask the tough questions and slow down. People want there to be an easy solution that can be offered for all of these very complex, horrific problems that have been created by colonialism. And people think, okay, well, maybe TEK is an easy solution to that. I always say there's a lot of stuff we could do right now if people would just get out of the way. We could do cool stuff, and we could watch the world change. But they're asking us to solve super complex problems with an easy solution, and when it's not easy we say, "We should do this. But that's going to take this amount of time, and you'll also have to change all these laws to make that happen. You're going to have to do this, and also, we want all the land back." You know what I mean. [laughs] Then they say, "I don't want to do that. It's too complicated." They want an easy way out of this really complicated thing that they created. And now you're having people tell you, "We can bring TEK into our science. We can bring TEK into our department. We can teach you." It's just a repeat of the colonial extractive mentality. The thing that I really find interesting is that TEK is on the cusp of being this thing that everybody's really talking about. There have been some huge initiatives that have developed in the United States in the last few years, specifically naming TEK as key to some of the things that people are doing. But then you also watch as people are still arguing about whether or not Indigenous people should have full control over arresting people who commit crimes on their lands. There's a huge missing and murdered Indigenous people's issue, and we don't have the legal system to protect us when extractive industries are coming into our lands and taking everything that they can and destroying it and then thinking it'd be really great if they could have all of our knowledge too. But how can you expect us to take the time to do the work that you

need to do to truly learn from TEK if we are facing on a very fundamental level everyday threats to our bodies and our futures and our children? Threats to our very existence. And if you're not willing to say that that exists, if you're coming to me without that, then you're also repeating a historical pattern. A scientist saying, "I want to talk to you about all your plant knowledge. I don't want to acknowledge that you have lived through a genocide when I'm talking to you about this. I don't want to talk about what it means that you're talking to me. Or that your whole family was killed in a massacre just a few years ago." They're talking to people post-gold rush in California and asking them for plant knowledge. They're not writing about the fact that these people had to live through a genocide and are coming out the other side with knowledge and are still trying to protect their future generations. We are doing it for the future generations. I feel like no Indian people in all of history sat down with an anthropologist or scientist and shared some knowledge they had because they were hoping that the guy would get tenure. I don't think they cared if that guy got tenure. I think these were things they willing to engage with because they saw the importance of this knowledge holding on for another 150 years. What I always imagine about Native people navigating this genocide is what it took to be in the middle of genocide and to be able to say, "I have to remember these things and I will make sure that this gets written down or I tell somebody else or I pass that on in my family." The way that we pass on knowledge in these ways, I'm now finding to be such beautiful ways of us saying, "This is how important this is. We're going to make sure that it gets through even if nobody believes us and they won't accept it." We're passing this on. The things I learned growing up came to me from family members who would tell me, "This is a song my grandma used to sing," and then they'd sing it to me as a lullaby and then I'd find out later it's instructions for something that you're supposed to be able to make out of certain plants or ferns. You know what I mean? These are the kinds of things that they were doing. They're passing on knowledge because this has to hold on. We went through all of that. And we are still fighting to be able to just go into public parks and get things that we need for our culture

and regalia and futures. We still fight with people to just be able to use areas that are sacred to us. We still have to throw a big fit because they come in and just build these giant windmills on this ridge and completely destroy a sacred site. No biggie! We have to be the ones who come in and say, "A hundred years ago, you guys came in and you said, 'What's the big problem with blowing up mountains and pouring mercury into the water?' And it obviously is a big problem, and we don't want another big problem." Then people compare Indigenous peoples doing that political work to what they call Nimbyism [Not in My Backyard]. And then we get talked down to, and we wait for scientists to say what they're supposed to do. Then the state gets to make decisions about how our community lives. And unless the state sees what's truly at stake, then I can't see them engaging with TEK in a way that isn't just extractive. So I would say to people, "It's great that Joe Biden says you should consider TEK on the same level as you do Western science. That's great. I think that's important. That's an important statement." But that doesn't mean we're not in there every single time that they ask, "Does this thing from a museum belong to you?" It's always a fight. They never ask, "How can we participate in this process of uplifting you? And your voices and your futures?" It's the same thing with all these people wanting TEK in their classrooms. One time I had somebody get in touch with me and say, "I'm going to do TEK in my physics class. Can you send me what I need to know so I can teach TEK in my physics class? Just whatever I would need to read?" And I literally sat there and I was this close—I didn't do it, but I was this close—to writing back and saying, "Yeah, sure, here's some stuff. And can you send me the four or five readings I need to do so that I can teach physics in my Native American Studies class?" Because that would be just what the other person does, right? And then you watch as the person tells you, "Well, no, I can't just give you four things that you read and then you can teach physics" and then I want to say, "I can't give you four things that you read so that you can teach TEK." These are the kinds of conversations we need to have, a real humbleness to what it means to invite TEK into your spaces. This is why I think a lot of Indigenous peoples are really cautious about that. They

are very thoughtful about how they approach that and they are constantly asking really tough questions. It's not just because they're difficult. It's not just because they don't know what the benefits would be if all Western scientists started doing TEK. It's because of these ongoing issues. I think if scientists are really interested in how they can bring TEK into STEM fields, they have to start with, "What does that mean for me politically and the way that I am engaging with Indigenous sovereignty?"

*D: Yeah, the way that you describe that just makes me think of constantly living in survival mode, just trying to survive. I really liked that you mentioned humbleness. I always talk about humbleness when I talk to non-Indigenous people who want to work with Tribes or want to engage with TEK or want to take NAS classes or such. I say, "If you want to work with Native people, you better humble yourself, and when you walk into these spaces and realize that you don't know anything, maybe that's okay." It's all about just realizing that the knowledge that you have, you can't bring that knowledge into Native spaces and act like that's gospel and treat Indigenous knowledge as if it's beneath yours. I also want to hone in on the rush mentality you mentioned. You talk about California with the gold rush, the timber rush, the fish rush, and then with Dr. Reed's book [Dr. Kaitlin Reed, *Settler Cannabis*], the green rush, it kind of sounds like there is a TEK rush. A knowledge rush, wanting to extract from these communities. Continuously, over and over again. And it's just this horrible cycle that has continued for so long and has caused all of these people, yourself included, to be constantly living in survival mode. What can I protect? I have to protect my culture, my children, and my knowledge. I have to survive. I need to be able to have this place, to be on my land. I think about this rush mentality and how it's another face of colonization, another face of genocide. And I think that statement goes well into our next question about staying connected to traditions and culture while working within STEM. And so **how do you stay connected?***

C: I think the biggest way is just to be as active and involved in my community as I can. I take inspiration from the community work that I do, and I think about it from the perspective of what that means for the work I do in this STEM field or with my own research or when I am

working with STEM researchers. I'm very fortunate to live in my homelands and really be near my Tribe, but also near the Tribes that I'm ancestrally connected to and near the Tribes that I grew up with and around. There's something really important about the fact that there are Native peoples now who have been able to complete their degrees and become a part of these areas of research and are doing this work. There has to be a kind of understanding of being a Native person who's doing that work from their home. It is so important. And I don't know if I have not seen a lot of value that comes out of institutions and organizations that really say, "What else we have here is Indigenous peoples from this place who are doing this work." One, we have a long-term connection with this area and that gives us a sort of an affection for all the other things that you have to put up with when you are involved with institutions. But two, it also highlights an opportunity for an institution to think beyond, "We are hiring or engaging Indigenous peoples, so that we can up our diversity numbers." To say instead, "What does it mean to really support Indigenous peoples of the region that we occupy? To elevate them and actually really feel good about the work that they do. That's part of what we need to do. That's part of what has to happen because we illegally occupy these lands." We are part of this system. I'm fortunate to do work from home. I'm fortunate to be in my homelands doing this work. I think that I can't sever a connection because it's here. I'm from here. My grandmothers told us growing up, "This land made you. You are the soil. The water from this place runs through your veins. This is you." To know that and then to come here and be here, knowing that I want to do good work for my community. I also think that it's been really important to understand that I'm not a part of an institution to make the institution stronger and better. I'm not thinking about how we make this institution the best version of itself, just as I'm not thinking about how we make STEM the best version of itself. I think what I say to myself is, "How do I make sure that other people who are doing work like this are able to do this work and get out the other side, ready to do whatever the next thing is." If we do the process and we help do that work, we are dismantling colonial institutions. That's okay. And if in the

process we're doing that work, we are pushing against systems. That's okay. But if we're also doing the work simply because we have a love for our people, our communities, and our futures. That's okay. So I constantly remind myself that I'm not here to be a warrior for the institution and feeling a little bit like it's okay to be here and not be caught up in what's happening institutionally but instead thinking about my connections to my community. That's what matters the most. It gives me a good perspective, because you can get caught up in the everyday sort of bureaucracy of what it means to exist in a colonial institution. It's very easy to get caught up. I always say to people "Indigenous peoples, Indigenous disciplines, Indigenous points of view, TEK, none of those things were invited into the university. None of those things were invited to be a part of these disciplines. We demanded our way in. Students protested to make sure that these things were available. This was a movement to tell institutions that they have to change." When you are the uninvited guests in this ivory tower elite space, you are constantly navigating what it means to be in an institution that truly doesn't feel like you need to be there. It wouldn't be so sad if you were gone. "We let you in and now you keep asking for other stuff, and you keep expecting us to do things, and you keep coming into rooms and demanding Land Back. Why do you think you can do that?" They think we should be grateful that we just get to be a part of this elite institution. The beautiful thing that I keep reminding people is, remember that's not what your life is about. You're not that institution. You are part of a community and you're a people who have a history and a culture. You have survivance and you have resilience running every day through your body, alongside this water and this soil and these fish and these more-than-human relatives that have been a part of you and continue to be a part of you. You have something bigger than that. That means that you don't have to take seriously all that stuff that they are arguing and fighting and grasping over. I don't have to participate in that kind of culture, because I have this over here that reminds me that in the end that's what we're doing here. We're trying to make sure that we get through so that we can do the things that we need to do to really uplift our community. In the meantime, can we have

different conversations? Can we talk about land return and protecting the fish and better water? Let's do that too! And I think we should all work together to do that, versus working together to figure out who gets the most accolades or who's the favorite of some administration. Who's the best at the bureaucracy? That's where I think we get a disconnect. And that's what I think happened when I was an undergraduate. I could memorize fifty things about mitosis and meiosis. But I couldn't understand why we weren't having a conversation about what it meant to be doing that kind of scientific work and how we could ask questions that actually really pertain to the world that we're facing today. What does it mean in the long term and what kind of person are we going to be coming out the other side? I needed to see those types of larger connections. I think what Humboldt's doing that not a lot of universities are doing is they're having their STEM majors in their first year take Native American Studies classes. They're saying to STEM majors, "Alongside these first-year classes that you need to take so that you can be ready to do STEM, you need to take Native American Studies." That's amazing. That's also really key to helping students to understand what they're doing. In Native American Studies, they learn the connections between the critical approach to understanding the history of science and Indigenous knowledge and what that means politically. They start to get very invested in science. Science for them is an investment in things that they can do to truly affect the world around them. They see that they can actually be a functional participant in all of these things. That to me has been something that has really helped the University to increase its retention rates and really think about how to help students say to themselves, "Maybe I did bad on this multiple choice quiz that was given to me in my chemistry class, but I can see that at the end of this really tough work, I'm gonna start having conversations about what it means when I do this kind of work. There will be a space in which I understand those kinds of connections across disciplines." So back to me, I get the most excited about the work that we could do. But I also think it's still asking a lot of marginalized professors to be those voices. I do think that there should be a lot more of us if you're going to say, "I also want to

make it so all of our freshmen have to take science classes" at your school. Think about what that means politically in terms of the work and people needed to really help these students out. The fact that most of these departments that you would be engaging with, like Native American Studies, are some of the least-funded departments on the campus. They have the smallest budgets, with not a lot to work with. They are some of the first to have their courses cut; these are the kinds of things you're participating in an academic political process. So how are you an ally for these departments that you will be relying on to really push your curriculum? That's the question I keep asking: what does it mean for you to be a political actor and an ally to the work that we do?

D: We talk about it all the time. It's just a matter of putting your money where your mouth is. If you're going to tell these students that they have to take NAS classes, if you're going to continuously profit off of Indigenous labor—because they are making a profit by these students taking these classes—if you're going to continuously make a profit off of Native instructors and off of this knowledge, then how come that money is not being allocated properly? I have a lot of friends who work in the heavy STEM disciplines here on campus and a lot of those students are so overwhelmed. There are so many classes they have to take and a lot of them can't graduate on time because of all these classes they have to take. I think, well, maybe if you didn't burn these students out, they'd be more interested in taking these classes, like advanced NAS classes, because if you take a 100-level class, you're only going to be able to get a semester's worth of knowledge. I think the real questions that you need to ask yourself as a person in STEM come to you over time, over periods of taking these courses. I feel if I had engaged in just one NAS class, it wouldn't have offered the real in-depth knowledge that you need in order to seriously take into account what Native American Studies is, what TEK is. How cool it would be if there was an interdisciplinary STEM program, a major or a discipline where you are able to engage in this work and actually learn something? I feel that a lot of kids take these classes because they're supposed to, but they don't really want to or they don't really engage in the healthiest way, in a way that is actually an upliftment to Native communities. I feel that if we took a step back and said, "If you're interested in

NAS, you should take more NAS classes. You're an engineering major. You should do that!" We were talking about that earlier. I don't think Western STEM leaves enough room for learning other knowledges. They say, "Oh you won't have room in your schedule, or you won't have time for that, that's not important to your career." I think that's absolutely ridiculous. As we said earlier, if you are passionate about something, and it is an interesting topic to you, that should be something that an advisor encourages you to do. The whole 120-unit cap thing and all the requirements seem to be another way of saying that your interests and the classes that are important to you and the NAS classes are not as important as your requirements. It's really frustrating, because I think that people can really do some serious damage with that mentality of not allowing people to engage in what they want to learn and what they're passionate about. This is kind of a weird deviation from that, but this is more of a fun question for you, **who is an Indigenous scientist that has inspired you?**

C: I think first and foremost, my family members and elders and folks that I always worked with growing up, who really taught me about Indigenous science from the perspective that it's an everyday lived experience and knowledge. I don't think you could have told me when I was growing up that we were doing science, because I was in a Western education system. I was in elementary school. But I look back now and realize, I didn't know that people grew up and didn't know the names of ferns, the different things they could be used for. I didn't know that they didn't grow up with people who would tell you, "That's this kind of tree and the way you can tell that is by this kind of leaf." You know what I mean? I didn't know that, oh, these trees are related and the way you know that is this. I thought that's how people inhabited the world. So it was really interesting as I was getting older to figure out that not everybody knew that. I didn't know everybody didn't have a dad who just would go driving sometimes on the weekends and just be spotting plants. I was spotting things that we might be looking for later. He would say things to me like "I'm just seeing how the manzanitas are doing." And I would ask, "What do you mean? And he'd say, "You know, if it's doing well, if it's happy." I just thought that's how the world functioned. So now I look back thinking, they were scientists who were

teaching me about how you view the world as a scientist. And when you can see what's going on, you can look at the way these leaves are acting differently and know that it must have been because of this thing that happened. You look at the way this animal is acting, and you know it must be for this reason. You see the interconnections of the world around you. I'm grateful that you can be a kid in a Western education system. You can be in elementary school and junior high, and you can internalize very easily that Native teaching and knowledge is not necessary for your everyday life. It's very easy to think, I don't understand why my relatives are talking to me about this and to sort of throw yourself into the belief that somehow the Native people are not teaching right because they don't wear a lab coat and they didn't graduate from a university. I'm grateful to my relatives who worked with me even though I think there were times as a kid that I would just say things like, "Well this isn't important or nobody cares about this or why would I have to," even though as a young Indigenous kid in school, I was struggling from what I was being told and taught and then what was happening in my family. As if that wasn't just as much knowledge and just as important. I have my own daughter now and she's great. She's lived her whole life having to do the same kinds of things, because it's been very important to us to pass those things on. I think because I've been very open with my own experience, she's never been at the point where she has said to me, "Well this doesn't matter, this isn't important." But I remember that from when I was a kid and I'm very grateful that we have these people now who I would say are big-time scientists. They're people with so much knowledge that other people would come from miles around to learn from them. And they were willing to work with me as an ungrateful little kid who was just trying to figure out what that meant. They were very thoughtful about how they responded to me and would explain what they were talking about. And they never stopped! I would think, that's not important, because we don't need acorns anymore. But they would say, "No. It is important. And I'm going to keep telling you," and I love that about our elders. I do a lot of work on the revitalization of knowledges and practices, and I will tell you, it was because of the visionary practice by

which our elders—as our knowledge holders, as our scientists—were making decisions that they would pass all this knowledge on, even if it meant we told them they were being crazy or that there was something wrong with what they were teaching us. They were going to do it anyway. Now, I look back at these instances where they would come to our school assemblies and they would do presentations on things or they would come when we were hanging out and sit down and say, "Let me teach you about this thing." And the fact that it survived and got passed on, I'm so grateful for that. That's inspirational. That's an inspirational science. I have to make sure that this science carries on, no matter what. My great aunt, who I'm named after, she was a basket weaver, but what that really means is she was a deeply knowledgeable plant scientist. To be a basket weaver, you have to be a deeply knowledgeable plant scientist. What it also means is she was a fire scientist because she had to understand fire and she had to understand how fire worked for the things she was doing and how to enact it. She also had to understand patterns of fire, because you start to see massive forest fires in the regions that we would normally use for gathering what we would use for basket weaving. So if there is a large forest fire, we have to understand on a large scale what it means for these things. What does that mean we have to do if we want to restore the forest for the things that we're trying to use it for. But she was also a political activist and she was a political scientist. She was writing policy and she was going to testify before legislatures about what this meant as a deeply knowledgeable plant scientist. She did that up until the end of her life. And yet she also taught kids how to be basket weavers and she also did workshops. She also went to women's groups and talked about the importance of connection to culture and art to help you through some of the most difficult times of your life as a woman. She talked about what that meant for how we could empower ourselves so that we didn't have to be caught up in relationships that were bad for us or a political system that would only define us by who we were married to. She was a political activist and a political scientist. She was a psychologist and would say, "You have to think about these things in the context of what it means when you weave baskets." Now I'm able to put those kinds of words together as a

much older person. When I was a kid, I was fortunate enough that they would do it even if I couldn't understand all those connections. So I'm still very, very, very grateful. I think some of the Indigenous scientists are a little bit younger than me. Elders would say to me, "You're very young," [laughs] I don't think so, but some of the ones who are doing work now, the people who are coming up and have been doing both Native American Studies and science are some of the most amazing folks that I have seen and I'm very excited about these new voices. What I also think is really interesting about them is that they are very tied to community. They are really thinking about the role of community in the science that they want to do. They are willing to have those conversations right out loud and upfront. And I think that they've seen the benefit to their science, where their science is actually ahead of other people's approaches to things because they are thinking about it in this way. I really admire Jessica Hernandez's work, the work she's doing on Indigenous science. Melinda Adams, who does fire science and environmental science—I'm a really big fan of her upcoming work. It has been really clear to me that a lot of Indigenous scientists have the experience that they have been kind of pushed out or rejected from Western STEM, and then they turn and say, "What do I really want to do?" and in this way they've been able to then come back into STEM and make something out of that. I really admire that about them, but also the way that they are unapologetically demonstrating that it is important to have those interdisciplinary connections, that you really can't do science without them. And there are other Indigenous folks who are doing the work to engage with Western science and looking at it from the perspective of representation. Nicole Mann is a California Native who is a NASA astronaut. Just imagine what it takes to get all the way there and still to have messages and understanding of what it means to be a Native person in these places and to have those conversations and to understand what that means for her as a representation for folks. And then I think about the people who are doing work in our communities. I really admire Kim TallBear, who is a scientist and does a lot of work around genetics and DNA, deeply, deeply understanding Western science but also a Native Studies faculty. I think about what it means politically to navigate

academia and then engage TEK within STEM. When you see a Native scientist who is also still very active and a part of Native American Studies or Indigenous Studies, that to me is so important because they are functionally demonstrating that it's not either/or. It's also not that because I did this big science thing and I'm a scientist, I don't engage. That's where I engage. That's what's important to me. I think that Kim TallBear is a really great leading voice in this public discourse saying, "I'm a scientist and I'm also a Native Studies scholar and this is what that means for my science." And so I want to encourage people to do that too, because sometimes it feels like you either go into the STEM disciplines or you don't, and if you do, you have to say, "I'm in chemistry, I'm in physics," but you can't say, "I'm in Native American Studies, but I have my background in chemistry." People won't view it the same way. I actually think the scientists that I really admire are the people who were, "I do Native Studies and my background is in genetics." You know what I mean? Because that shows a foundational understanding of why Native Studies is such an important part of what you're doing and the work that you're doing.

D: Thank you for sharing that. My last question for you is what advice do you have for young Indigenous people pursuing a career in STEM?

C: I would say, find your people, find your voice. Learn what you can learn, but don't make it be anything that defines you as a person, because the thing that will truly define you is the work that you want to do and the things that you want to engage with, whether or not you can pass a 150-question multiple choice test on a chapter that you read about the way the eye functions. Not that that's a specific example from my life, but whatever, maybe it is. [laughs] But you know what I mean? That doesn't define you and if you don't do it the first time and you want to try again, do it the second time. But if you decide, "I can't learn this way. I have to learn a different way," then that's okay too. In the pockets of spaces of STEM that make sense to you, you will find a way to grasp the totality of what you're trying to learn in that instance. Sometimes it's just that somebody's not teaching you the right way. Sometimes it's that the material isn't written well. Sometimes it's that you're coming up against a social or

a political thing that you can't reconcile. "If I answer this question this way, then it's asking me to believe this, and I can't reconcile that. I don't actually think that that's the case." The best scientists are actually the ones who will ask those kinds of deep, meaningful questions and not the ones who just can pass a 150-question multiple choice test. So don't let that be the thing that selects you out. That's what I would say. The best scientists are the ones who will actually push for those kinds of discussions, versus "But I memorized 150 facts about the eye!" The other thing I'll say is to remind yourself to care for yourself within all of the things that you do. Understand that institutionally, a lot of things are happening politically, and sometimes what you're up against is structure—it's actually a function of the structure that you're a part of. It's not you. I also tell people—and this is just sort of my own way that I engage in life—don't take it so seriously that you can't see all the ways that you could just make fun of what's happening to you in these moments. The ridiculousness of colonial institutions is something that Native people figured out a long time ago. They really just sat back and said, "On top of everything, there's the violence and the genocide and the capitalism and the ignorance, and on top of all of that there's the ridiculousness of these institutions, and what they're trying to do here." Ridiculous. There was a period of time when there was a colonial belief that they could eradicate queerness in Native cultures. I always tell people, you can't eradicate queerness at all. Because no matter what it will always exist. So really your goal is to kill everybody, right? That's not a good plan. So try to see the ridiculousness, the ridiculousness of disciplines, the ridiculousness of their foundations of belief. They want to be elitist: "We have come to this conclusion and now we're the great knowledge holders," or whatever. But I think even Indigenous peoples will tell you that the only way to truly learn is through a positionality and humbleness all the time that you don't know. There's always something else to learn, and what you learn will always be changing based on where you're at. A lot of times if I was doing something as a young scientific person, I was doing an experiment, I was helping a professor. I would say to an elder, "I'm frustrated because I'm trying to do this thing with this data that I found, and it's not

coming out, and this is what's going on" and they would say, "Well, did you learn something?" and I would say, "I learned that everybody answered this question wrong." And then they'd say, "Why?" and I'd say, "I think I asked it wrong" and they'd say, "Well then, there you go. You learned something." It's about you, how you are going to learn and change and adapt. It's not about this grander knowledge that you could find, because it's always very individualistic and it changes depending on the weather or something. And Vine Deloria Jr., you know, says, "You can't create knowledge in a vacuum. Knowledge is informed by everything around you and it can change at any time so we're in a constant state of change in learning." And that's the best thing you can remind yourself of. It's ridiculous what's happening. The best thing you can do is say to yourself, "This is not what defines me. What defines me is my community, my people, my history, my family, the things outside of this institution." Don't let the institution define you. Don't let the institution define what you major in, what you study. Don't let the institution tell you that one thing is more valuable than another. Because you will find that in your life as you explore the things you want to do, the true value comes from those moments where you connect with yourself through that learning, and then what you want to do with that.

D: Wow. Thank you for that. I needed some of that wisdom, because you know it's hard, it's really hard to separate. We've talked about it. It's hard to realize that I am not this institution. I can't change what I can't change. And it's always good to get that wisdom, to get that Indigenous knowledge of just realizing that's not going to define you. I remember you telling me a few months ago that in 20 years I will laugh about all these problems that I'm having right now. [laughs] They're not going to define me. And I just have to keep telling myself that, and I think that a lot of Native youth could really use that wisdom. Change is nature and we can't let these institutional systems, these colonial systems, define what it means to be us and how we arrive here and what we do here. So I appreciate that wisdom. That was the last of the questions, is there anything else that you want to say?

C: I will say that Humboldt has done a lot to try and document the experiences of Indigenous students, especially

those in STEM. I think listening to their voices and responses is really important. One of the things that was really highlighted for me is that learning about Native peoples, the things that we're doing right now, the ways that we're engaging in knowledge building, the history, those moved-beyond moments—"I felt good about learning about that" to "That actually empowered me enough to stay in school, because I was learning about things that really demonstrated to me the empowerment of my cultural and social background." And this is why I think even as people are saying, "Well, there aren't very many Native kids in higher education." or "Native people are the least likely to graduate from high school in the United States, they're the least likely to go to college." Then I think, well, if you could demonstrate for them the importance of Native American Studies and Native Knowledges in their higher education, they would all start thinking, maybe I could go there and learn about this and do this. Right now what they're being told is that they don't have a place there. And if they do, they have to accept the institution's way of thinking. I think that representation matters, and that's what I would tell people who are wondering what can really help Native students to succeed in STEM. They talk about support programs, about how money is a big issue. They talk about housing, and about being able to feel safe where they're living. Then they talk about those moments when they finally were able to feel empowered by their education. People say, "Oh, you're coming to college and you have to major in one of the major disciplines in order to succeed." But if they started saying, "This is how we empower our Native American Studies Department and curriculum," more Native people would start to feel really invested in how they can participate in that higher education system. And I think it's the bare minimum that we have to do. Because you come in, you occupy all the land and build the stuff on it. But here we are, still here and you want to work with us, then how do you empower our young people to feel like they can also succeed in this institution? Bringing TEK in is not just about how all students will benefit from that, because they'll start to see connections to community and how they work, how they do their science. We should also make sure that we remember that Native students will

benefit from that. Maybe that's what we should be doing, because historically and temporarily speaking they are not benefiting from higher education. And a higher education institution should step back and say, "What is wrong, that of all the people, these folks are not benefiting from higher education? What do we have to do to invite them?" instead of getting to the point where again the Native students have to demand space at the institution.

D: Yeah. When we were talking earlier about being a champion for the university, I think about myself, and I think about the fact that I'm here because of people like you and people like Marlette in ITEPP [Marlette Grant- Jackson, Academic Advisor for the Indian Tribal & Educational Personnel Program (ITEPP), and local Yurok artist] and Marlene' [Marlene' Dusek, Traditional Land Steward, Payomkawichum, Kumeyaay and Cupa artist and scientist] and all of the Native people who have decided, "I'm going to be here, and I'm not going to let this institution define me." I think that what inspires a lot of Native youth to continue to be here is the fact that you and people like you are here and you're continuing that fight. And I always think about what will happen if I decide to go down this road of higher education and become a professor myself. The goal of becoming a professor is to continue to inspire Native youth like myself to be here. That's the most important thing to me, because I feel that if you were not here, then who would be? I know who would be here teaching NAS classes and I don't want to learn from those people. [laughs] I think that that's a lot of the reason why Native youth think that higher education isn't for them. I think about that and it makes me emotional, because I wouldn't be here if it weren't for you and if it weren't for the continual inspiration that you bring by just being here and not letting the system, not letting this institution, beat you down. I hope to not let it beat me down someday. [laughs] So I thank you for that. And I thank you for your last words.

C: Thank you, Delaney. I appreciate it. And I'm looking forward to what we come up with on the other side of this.



Dr. Cutcha Risling Baldy, Associate Professor of Native American Studies at Cal Poly Humboldt, researches Indigenous feminisms, California Indians, Environmental Justice, Indigenous Natural Resource Management, mental health and cultural interventions, and decolonization. She is the Co-Director of the NAS Food Sovereignty Lab & Traditional Ecological Knowledges Institute and Co-Principal Investigator, National Science Foundation FIRE-PLAN grant, in collaboration with the Karuk Tribe. She is also one of the Guiding Leaders for the State of California Native American Studies Model Curriculum project.



Delaney Schroeder-Echavarria is a student at Cal Poly Humboldt with a major in environmental studies, and a minor in environmental policy. Delaney's particular areas of interest are Indigenous food sovereignty, food politics, Traditional Ecological Knowledges, and justice-oriented food systems.

ANAYA BARRERA, MARIKO NOJIMA-SCHMUNK, AND DOMINIQUE HANNON

This transcript represents a conversation between Anaya Barrera, Mariko Nojima-Schmunk, and Dominique Hannon.

Two George Mason University undergraduate students, Mariko Nojima-Schmunk (Red Lake Band of Chippewa Indians) and Dominique Hannon, interviewed Anaya Barrera, an Apache elder and Road Man, when they were in Hawai'i in 2023. At that time, they also attended the Western Region Continuums of Service Conference in Honolulu and spent time with members of the Nation of Hawai'i, an independent group of sovereign Kānaka Maoli who are located in Waimānalo. The trio discussed the connection to and disconnection from Indigenous cultures experienced by Kānaka Maoli as well as Indigenous peoples on the North American continent (also known as Turtle Island), how Indigenous thinking can be respectfully brought into Western academia, and how to create and maintain reciprocal and authentic relationships with Indigenous peoples. The travel and interview were facilitated by Dr. Thomas Wood of George Mason University.

Maintaining Connection to Culture

Dominique Hannon (D): *What are some barriers you are seeing currently for Indigenous communities inside and outside of academia?*

Anaya Barrera (A): When we were talking to [Nation of Hawai'i President] Bumpy [Pu'uhonua Kanahēle], he told us that he has noticed that the children are not as attentive in their cultural things that they do, that children are not as enthused about the old ways. So he has come to understand that having the elders teach the youngsters is a very important part of maintaining the culture.

Mariko Nojima-Schmunk (M): *So thinking of the future and with the youth, do you have any advice for those youths who are maybe not as inclined to follow those old ways? You suggested having elders present in those spaces, but do you have other suggestions?*

A: That's what it's going to take because the elders are the keepers of the knowledge. And they're the keepers of the wisdom. So the grandparents have to be involved. I first suggest that every eighth grader and under interview their grandparents. You know, both of their sets of grandparents. And then they have an idea of their own heritage.

M: *I have a question for those individuals who may have lost that connection. Do you have any advice for those who do not*

have a connection? Who have no family or a blood relation who is present in their lives, that they could go to?

A: In the villages, in Hawai'i in particular, it'd be very hard to find traditional families, Islander families that don't have some relatives that they could learn from, but there are a lot of organizations that mentor, especially for displaced people. And those avenues are available on all of the islands too.

Academia and Indigenous Knowledge

D: *So, thinking back to our time in Hawai'i, especially when we were on O'ahu, were there any moments where you observed or felt that tension between the Indigenous knowledge and the more traditional academic ways of learning while we were engaged in the conference?*

A: The only thing I can think of was that the setting was not very culturally sensitive, and the way that things were scheduled. There was a big difference in the ambiance, and everything related to that—so I think that the welcoming ceremony and beyond should have been done with more Kānaka Maoli peoples' input. For instance, highlighting issues and having the Kānaka Maoli and other Indigenous peoples discuss these issues and conflicts would have centered Indigenous voices more.

M: In your years of experience, have you noticed a change in the relationships between Indigenous people and academia and other institutions?

A: In the past, you know, people would come and try to get the elders to share spiritual secrets and what-not, instead of sitting down with them and helping the elders establish an archive of history and cultural traditions and beliefs. But now, one of the things that I know is that elders are getting more involved, especially since almost losing the language. There used to be so few who really knew and spoke the traditional languages the old way. So the language resurgence is one example, and it has really gotten a lot of elders involved. I think they always wanted to be involved, but they didn't know how to approach and not offend, and they didn't want to bring shame on somebody that they were offering help to. I think that nowadays it's getting easier and easier on both sides.

Communication and Understanding: A Bridge Between Two Worlds

M: I know that lack of understanding is something my father struggles with. Working in the Western world as an Indigenous person highlights the lack of understanding. People who say they want to help have a difficult time listening to the words that he shares. Do you have any suggestions for how to teach or encourage people to truly listen? To make sure that those Indigenous voices are heard?

A: One of the first things that I try to do, I try to create some type of group activity that is going to show off what the Indigenous group is bringing to us. Whatever the activity is, it's based on what they do and aims to get them to want to teach us the way they do things. And then usually, I get a lot of good work out of asking them how they see what they are already doing, and asking them if they want to change something that they either haven't asked about, don't know how to ask, or haven't identified.

So we're always trying to teach non-Indigenous people how to do things like address an elder and certain customs and ways of engaging, and oftentimes they think they understand, but they're so far off, they're out in left field. So it's education in order for them to properly

develop a relationship with Indigenous people and understand ways of living.

D: Are there any suggestions you have for building and maintaining the relationship between Indigenous peoples, knowledge-keepers, and academia?

A: The relationship is actually like a heart transplant and the complexity of it. If you're going to bring Indigenous peoples into academic culture without educating them and without giving them some life support system, they're going to struggle. It's important to maintain those relationships you build with them. These interpersonal relationships are important, especially when you're trying to present and work with them in a reciprocal way.

The interviewers, Mariko and Domi, are grateful to have the opportunity to jointly remember and discuss their experience with Anaya. They both feel that this interview allowed them to gain precious insight into the work that Anaya has done with Indigenous communities across Turtle Island and how it has shaped his perspective when interacting with groups of Indigenous activists and educators like the Nation of Hawai'i, as well as with the numerous Indigenous and non-Indigenous scholars, educators, and activists that they met at the Western Region Continuums of Service Conference. Having the insight and ability to communicate with an Indigenous knowledge-keeper about these topics is important, not just for these students personally, but also for those looking to build relationships with Indigenous peoples and to decolonize their academic work.



Anaya Barrera, Apache Elder



George Mason students **Mariko Nojima-Schmunk** (Red Lake Band of Chippewa Indians) and **Dominique Hannon**

PROJECT
REPORT

Media Arts on a Marine Research Station: Reflections on a Storytelling Course in Support of Native Hawaiian Communities

PATRICIA A. KĀWELU AMARAL

University of Hawai'i at Mānoa

REANNA D. SALVADOR

University of Hawai'i at Mānoa

LISA C. MCMANUS

University of Hawai'i at Mānoa

Abstract

Storytelling via digital media can effectively spotlight pressing societal and environmental concerns. In Hawai'i, these issues encompass addressing climate change impacts and amplifying Indigenous viewpoints within academic contexts. This report discusses "Communicating Creativity," a course offered by the School of Communication and Information at the University of Hawai'i at Mānoa. This four-week summer intensive course was part of Nā Ko'oko'o, a Hawaiian leadership program for Native Hawaiian students and other students with strong commitments to Native Hawaiian communities. Students enrolled in the course spent one week at the

Hawai'i Institute of Marine Biology (HIMB) on Moku o Lo'e, Kāne'ohe Bay, O'ahu. The course aimed to guide students in creating media content (filmmaking) rooted in Hawaiian epistemologies and praxis, bridging Indigenous knowledge with Western scientific perspectives through art, creativity, and visual communication in order to promote interdisciplinary dialogue. Additionally, it featured "talk story" sessions with Native Hawaiian cultural practitioners and HIMB faculty and students, exploring the interface between traditional knowledge and conventional science. This report reflects on lessons learned during the course and underscores the potential of experiential learning to drive socio-ecological change.

Introduction: "Communicating Creativity"

The University of Hawai'i at Mānoa's (UHM) College of Social Sciences Native Hawaiian leadership initiative, Nā Ko'oko'o (College of Social Sciences, 2021), offered an experiential learning course in Summer 2022 titled "COM 489: Communicating Creativity." The Nā Ko'oko'o program started in 2016 and is designed for Native Hawaiian students and other students with strong commitments to Native Hawaiian communities. "Communicating Creativity" was the second of two courses chosen for this cohort offered through the School of Communication and Information at UHM—their first time hosting this program—and was open to all College of Social Sciences students. This class aimed to explore the role of creative visual storytelling in cultivating connections to Native Hawaiian perspectives, as a way to effectively communicate alternative means of solving important challenges we face as a society today. "Communicating Creativity" was designed by Professor Patricia Amaral as part of Nā Ko'oko'o's mission to "clarify their *kuleana* (responsibility, privilege) and to see their education in the context of uplifting the land and people" (College of Social Sciences, 2021).

To incorporate diverse perspectives, the author list for this report includes Patricia Amaral, the instructor for "Communicating Creativity" and Program leader of Nā Ko'oko'o 2022, Reanna Salvador, a graduate student participant of the course, and Lisa McManus, the Hawai'i Institute of Marine Biology (HIMB) faculty sponsor. "Communicating Creativity" was developed and taught by Prof. Amaral, while Dr. McManus facilitated connections with HIMB researchers and provided guidance on course logistics. As an associate professor of Communication and child of the Hawaiian diaspora, Prof. Amaral intended for students to incorporate communication practices within the field of Media Arts in order to support Native Hawaiian causes. Her pedagogical goals were to shift prevailing Western paradigms towards Indigenous frameworks that prioritize relationships with the land (*āina*-based learning) through visual communication theory and practices. Prof. Amaral views film as a form of visual and oral storytelling that is in alignment with the Native Hawaiian oral tradition, and she also believes that experiential learning is in alignment with Indigenous sensibilities. The Hawaiian proverb, *Ma ka*

hana ka 'ike (in working one learns) encapsulates this experiential course philosophy (Pukui, 1983). Dr. McManus, an assistant professor at the Hawai'i Institute of Marine Biology (HIMB), conducts research to understand the impacts of climate change on marine ecosystems. She also aims to make marine science more accessible in support of the University's commitments to Native Hawaiian place-based learning. Reanna Salvador is a graduate of the Communication MA program. She enrolled in "Communicating Creativity" in Summer 2022.

The four-week "Communicating Creativity" course integrated one week of instruction and video/audio recording at HIMB, a marine field station on Moku o Lo'e in Kāne'ohe Bay, O'ahu. To facilitate an immersive place-based format, the cohort of four students (including Salvador) and Prof. Amaral stayed in HIMB dorms for a total of five nights. All students were part of the College of Social Sciences and one self-identified as Native Hawaiian. Typically, Nā Ko'oko'o programs are hosted at sites where students work closely with community members, including *kūpuna* (elders). However, due to COVID-19 restrictions, HIMB was selected as an alternate site. Students learned about the island's unique history and status as a marine research station that is accessible only by boat. Moku o Lo'e was owned by Hawaiian *ali'i* (members of the ruling class) until the 1930s. The island was then privately owned, and was frequently visited by politicians and celebrities. In 1948, a portion of the island was donated to the University of Hawai'i for use as a marine laboratory and, by the 1990s, the entire island became the site for HIMB (Klieger et al., 2007). Prof. Amaral provided each student with a copy of Paul Christiaan Klieger's 2007 book, *Moku o Lo'e: A History of Coconut Island*, so that they could learn about the island prior to their visit. At Moku o Lo'e, students practiced their media production skills to create short creative films in promotion of civic engagement while incorporating Native Hawaiian epistemologies. The course culminated in a media showcase that was open to the public, mentors, and College of Social Sciences administration.

With some grounding in Indigenous perspectives and emphasis on uplifting Native Hawaiian communities, "Communicating Creativity" provided students with an opportunity to develop technical media and storytelling capacities while discerning their values and

responsibilities as future change-makers. The global media landscape has been heavily influenced by Western countries, particularly the United States and Europe (Turan et al., 2009; Stoddard et al., 2014). Thus, a primary course objective was to encourage students to explore alternative worldviews with digital media tools. Students were encouraged to practice *kilo* (keen observation) through activities such as meditative walks while video-taping and daily journaling sessions to reflect on their recording experiences. Students had the opportunity to showcase the relationship they built with Moku o Loé by creating a short film with the *āina* as its target audience. These activities aimed to prompt students to reconsider prevailing Western paradigms in order to embrace Native Hawaiian perspectives and communicate these perspectives through visual storytelling. The second course objective was to help students clarify their individual *kuleana* (responsibility, privilege) and become open to experiencing new ways of observation through the hands-on application of visual communication theory. An important requirement was that students in Nā Koókoó set *pono* (just, proper) intentions and be mindful in their actions throughout the course.

We include quotes throughout this paper from reflections presented by the students during the course *hō'ike* (final media showcase) in July 2022 and from feedback that was solicited in May 2024 for this report. The authors have permission from the students to use their real names.

Course Successes

"Communicating Creativity" utilized an immersive, creative and skills-based format to connect students with Hawaiian perspectives centered on relationships with the land. Students and instructors alike enjoyed their time on the island, developing personal connections and honing technical filmmaking capacities. The hands-on experiences on Moku o Loé emphasized relating to the land, and through creative visual media production techniques, students were also given a unique opportunity to explore their leadership potential. Students connected with local filmmakers, cultural stewards, and marine scientists on the island to expand their perspectives on utilizing

creativity in promotion of social change relevant to Native Hawaiian communities. HIMB, as a UHM stakeholder invested in Native Hawaiian place-based learning, willingly provided facilities—including lodging and classroom space—for holding the week-long Moku o Loé intensive course. This was significant, because many University of Hawai'i students and local residents have not had the opportunity to visit the island—although we note that HIMB has offered public education programs for over 20 years, with significant investment (e.g., faculty and staff hires) to support this work. HIMB continues to enhance community involvement and education as a core value in their strategic planning. Also part of the HIMB strategic plan is collaboration with other University of Hawai'i units on initiatives that center on Indigenous perspectives; this alignment has been approved by the Institute's administrators. Lastly, the small class size, early summer term scheduling and coordination with an HIMB researcher (Dr. McManus) facilitated planning and logistics.

A key assignment was the praxis activity, an experimental filming assignment where students used *kilo* to explore new ways of seeing through creative gathering of media assets (video and audio recording) and editing. The praxis component challenged students to experience the creative process in a holistic manner—spiritually, emotionally, physically—and to create media works presented to Moku o Loé itself as the intended audience. This assignment was designed to foster stronger observation and visual storytelling capacities, linking creativity with Indigenous science. (To access the videos, see Supporting Information at the end of this report.) While some students were resistant to this approach, all gained new experience in an unconventional media creation method, which they were unlikely to experience on their own or in other media and communication classes. For example, one student shared the following comments:

For me personally the trip to Moku o Loé was very impactful. I've always wanted to go but didn't know the full history until going there. It also brought great sadness to learn how the island was transferred from one *haole* (foreigner) hand to another. So while I was there I felt like I made a bond with the island, and in my video I really felt like

the island didn't want me to go, but understood that I had to. During my *mo'okū'auhau* (genealogy) research, I recently discovered why I felt a strong bond. One of the siblings to Queen Pauahi is my *kūpuna*. I truly believe that our *kūpuna* speak to us in various ways, including through the land. I feel that had I not gone there, maybe my *kūpuna* wouldn't have had a better opportunity than on Moku o Lo'é to speak to me and help me fill the gaps in my *mo'okū'auhau*. Helping me to find out where I came from, my identity, why I am the way I am, and why I feel the need to fight for Hawai'i.

Essential to the course were informal "talk story" discussions with local Native Hawaiian media professionals, HIMB researchers, academic administrators, and cultural experts. These insightful dialogues showcased how different Western and Indigenous perspectives could be presented, discussed, and applied in various careers. The instructors attempted to facilitate compassionate, open, judgment-free spaces for discussing complex, emotionally charged questions of identity and purpose. Specifically, we discussed the relationship between conventional and Indigenous scientific approaches.

Some students gained unexpected but profound clarification of their core values and duties as future agents of social change. Salvador used her experience building relationship with *āina* (land, place) on Moku o Lo'é in her thesis research methods. Partnering with a community organization on O'ahu, she regularly returned to the place of her research and established deeper connections to the area and people working within the organization than would have been possible with a non-collaborative research approach. Another student wrote,

One of my core values in all that I do is to always seek *kanaka* (Native Hawaiian) input and to always open my ears to the knowledge and wisdom the *kūpuna* around me have to offer. This core value has been solidified in me by my experience as a Nā Ko'oko'o student and specifically in our experience visiting Moku o Lo'é.

The course culminated in a *hō'ike* where students presented final works to each other and invited guests, including community members involved in the course and administrators. As part of the *hō'ike* and representing

the final class requirement, students introduced their films and explained their creative process to the audience both in person and over Zoom. This practice of sharing taught the students to reflect, articulate and summarize their own learning journey. Additionally, engaging with the audience to receive constructive feedback and discuss their projects was a valuable experience.

Areas for Improvement

The course "Communicating Creativity" offered students an innovative experiential format that exposed them to Hawaiian perspectives and epistemologies that challenged prevailing notions of media production. However, Prof. Amaral notes certain areas for refinement to better prepare students for engaging with Indigenous perspectives. Most students struggled with the creation of media projects that incorporated relationships with *āina*. Some felt resistance to and were dismissive of adopting an unfamiliar non-Western worldview; some also felt conflicted about their identities as non-Hawaiians. The intention of this course was to move students away from the Western constructs associated with filmmaking towards a more creative and holistic approach. To help the students be more open-minded for these assignments and to ease discomfort, the instructors could have provided more clarity about the intended learning outcomes centered on expanding worldviews and experimenting with different creative perspectives during the pre-production, production, and post-production processes. Furthermore, additional emphasis on the power of media production to amplify Native Hawaiian voices, facilitate civic engagement, and support community endeavors might have provided a better understanding of the potential for this kind of work. To support this, in a future iteration of the class the instructors could prioritize assignments where students view more projects created by Native Hawaiian filmmakers before staying at HIMB. Additionally, having more experiences on Moku o Lo'é before the class started might have allowed more time to build technical and emotional preparedness. Nevertheless, the course cultivated deeper observation and storytelling skills linking scientific observation with creative communication.

While students benefited from the group discussions, HIMB researchers sometimes shared cautiously. There

were a few reasons for this. These meetings were intentionally unstructured to allow the conversation to evolve organically, but there were occasional moments where no one wanted to be the first to share. Having a moderator or a set of prompts for each guest might have allowed for a more fluid discussion. Some hesitation in speaking may have been due to discomfort surrounding some of the topics for the researchers, because they addressed the role of Indigenous perspectives in science; some scientists may believe that Indigenous wisdom and spirituality are incompatible with conventional science (Bassalla, 1967; Makondo & Thomas, 2018). In the future, additional meetings with time for casual conversation with researchers could lead to more open exchange, which is particularly important if a future course's primary objective is science communication. ("Communicating Creativity" was focused more on experimentation with different perspectives.) Additionally, pairing course participants with HIMB students before the official site visit could foster more trusting, familiar relationships.

Overall, greater coordination among UH programs is vital for ensuring that educational offerings support the institution's stated duty to support UHM's Strategic Plan to become a Native Hawaiian Place of Learning (Native Hawaiian Place of Learning Advancement Office, 2019). Administratively, uncertainties surrounding COVID-19 and difficulties in procuring proper media equipment initially delayed recruitment, compressing preparation and resulting in a smaller class size. Furthermore, the ideal set of prerequisite coursework would include an introductory media course to build technical skills and an introductory Hawaiian Studies course to provide background on Hawaiian perspectives. With those prerequisite courses, "Communicating Creativity" could better emphasize creative approaches in support of amplifying Native Hawaiian voices and engaging in civic issues. Moreover, recruitment that targets students eager to apply Indigenous perspectives to their own scholarship could help assemble a group that is motivated to integrate the skills and knowledge that this class provides. Increased logistical support from the College of Social Sciences and HIMB could ease the administrative burdens that fell to the faculty involved in this course; these burdens deter the implementation of similar innovative programming. While HIMB and the School of Communication are

from different UHM Schools, supporting partnerships with other programs is an important way for HIMB to build and maintain connections with colleagues on the main campus, which is located approximately 14 miles away. Additionally, these partnerships allow HIMB to expand public access and awareness of the research and educational programs offered on Moku o Lo'é. In general, structural support through funding, public relations, and curricular mainstreaming of Indigenous methodologies remain imperative if the University is to actualize its commitments to Native Hawaiian communities through student development.

Conclusions

Student feedback indicated that "Communicating Creativity" provided them with a uniquely impactful opportunity for grappling with Indigenous ways of knowing through building a relationship with the land. One student stated,

Being on HIMB, not only did I get to learn from our *kumu* (teacher) and *kūpunas*, but I learned to let the island [itself] tell me its own story... Two years later I hold on tightly to everything I learned during my experience with Nā Ko'oko'o.

Another student shared,

My time working with Nā Ko'oko'o and HIMB stands out as one of the most memorable experiences during my time at UH. It was incredibly rewarding to engage with Native Hawaiian culture in a way that allowed me to express my creativity and passion for media, while supporting these communities and their values.

Overall, by personally engaging Moku o Lo'é's complex history and modern uses, students gained appreciation for Native Hawaiian perspectives while honing technical media skills.

Despite the clear benefits of this approach, offering field-based experiential learning programming with cultural components strains existing staffing models. Providing cameras, editing laptops, other filmmaking gear, and transportation also involves major investments often beyond standard departmental budgets. Moreover, in order

to meaningfully indigenize curriculum, faculty must devote extensive effort to developing innovative courses, which current tenure metrics—at the University, School, and Departmental levels—largely neglect. We note, however, that there are ongoing efforts to revise these metrics across different programs at UHM.

Continued conversations around reforming faculty evaluation systems to reward public scholarship and service more comparably to publications, awarded grants, and other scholarship metrics (e.g., Özkan-Haller, 2021) seem prudent, given the University's stated emphasis on becoming a Native Hawaiian Place of Learning. Actualizing this by diversifying offerings to highlight Indigenous worldviews demands implementing support structures to facilitate the development of similar experiential courses. Until better technical/logistical assistance and value alignment mechanisms take shape, traditional university standards prevent fully delivering the demonstrated potential of enriching Western pedagogies by bridging cultural heritage and scientific insight.

Nevertheless, students gained profound clarity of personal purpose and community responsibility during "Communicating Creativity." This course thus provided a promising template demonstrating that place-based creative media production can help actualize the University's commitments to Indigenous knowledge, provided adequate structural backing allows such programming to substantially expand.

To end this report, we want to share the following *'ike kūpuna mana'ō* (knowledge infused with ancestral wisdom) from Nālani Minton, Director, 'IKE AO PONO at UH Mānoa, gifted to the Nā Ko'oko'ō cohort at the *hō'ike* in July 2022:

Each of us learns from the *'āina* how to go deeper into the understanding of who we are, but also of what the great potential is when spirit is recognized in all living things as speaking to us. And for us to be able to respond, we have to know that truth so deeply within us.

Acknowledgements

We would like to thank Ulla Hasager and Nālani Minton for their valuable guidance and generous support. We would also like to thank Nā Ko'oko'ō 2022 cohort students Tanya "Sweet T" Alana, Elizabeth Pearson, and Alec Tucson for their feedback and permission to include their media projects in this report. We acknowledge educators from Science Education for New Civic Engagements and Responsibilities (SENCER) for helping inspire the creation of experiential courses and supporting new ways of learning, including programs like the Nā Ko'oko'ō Initiative. We also gratefully acknowledge logistical support and participation of researchers from the Hawai'i Institute of Marine Biology.

Supporting Information

Student project videos can be accessed at <https://doi.org/10.5281/zenodo.11168419>.

References

- Basalla, G. (1967). The spread of Western science. *Science*, 156(3775), 611–622. <https://doi.org/10.1126/science.156.3775.611>
- College of Social Sciences. (2021, January 13). *Nā Ko'oko'ō*. College of Social Science; University of Hawai'i at Mānoa. <https://socialsciences.manoa.hawaii.edu/study-at-css/experiential-learning/na-kookoo/>
- Klieger, P. C., Helfrich, P., & Leong, J. A.. (2007). *Moku O Lō'ē: A history of Coconut Island*. Bishop Museum Press.
- Makondo, C. C., & Thomas, D. S. G. (2018). Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation. *Environmental Science & Policy*, 88, 83–91. <https://doi.org/10.1016/j.envsci.2018.06.014>
- Native Hawaiian Place of Learning Advancement Office. (2019). *Aloha'Āina – Native Hawaiian Place of Learning Advancement Office*. University of Hawai'i at Mānoa. <https://manoa.hawaii.edu/nhpol/aloha-aina/>
- Özkan-Haller, T. (2021, May 28). *To help address the climate problem, universities must rethink the tenure and promotion system*. Yale Climate Connections. <https://yaleclimateconnections.org/2021/05/to-help-address-the-climate-problem-universities-must-rethink-the-tenure-and-promotion-system/>
- Pukui, M. K. (1983). *Ōlelo no'ēau: Hawaiian proverbs & poetical sayings*. Bishop Museum Press.
- Stoddard, J., Marcus, A., & Hicks, D. (2014). The burden of historical representation: The case of/for Indigenous film. *The History Teacher*, 48(1), 9–36. <http://www.jstor.org/stable/43264376>

Turan, A. H., Colakoglu, S., & Colakoglu, B. E. (2009). Perceptual differences of international news: Western media influence on non-Western media. *China Media Research*, 5(2), also available in *Gale Academic OneFile*.

About the Authors



Patricia Amaral, MFA (she/her) is an associate professor in the University of Hawai'i at Mānoa's School of Communication. Her research and creative work focus on science communication, civic en-

gagement, oral history, and Indigenous storytelling in all forms of mediated communication, to help make a difference in promoting the quality of life for our communities.



Reanna Salvador (she/her) is a graduate of the Communication MA program at the University of Hawai'i at Mānoa. She currently works as Operations Coordinator for the UH Better Tomorrow

Speaker Series and is passionate about responsible and regenerative tourism.



Lisa McManus, PhD (she/her) is a marine ecologist and theoretician. She works at the Hawai'i Institute of Marine Biology, University of Hawai'i at Mānoa, as an assistant research professor. Her research fo-

cus on the ecological and evolutionary drivers of coral reef dynamics, and she is particularly interested in the effects of climate change on coral populations.

PROJECT
REPORT

A Student Exploration on Advancing Multicultural Science through Ethical Indigenous Engagement

AMY E. SPROWLES
Cal Poly Humboldt

NICHOLAS A. WORONCHUK
Cal Poly Humboldt

JESSICA JONES
Cal Poly Humboldt

NOAH ANGELL
Cal Poly Humboldt

SHAY KONRADSDOTTIR
Cal Poly Humboldt

ELYSE MCKINNEY
Cal Poly Humboldt

XENA PASTOR-NUILA
Cal Poly Humboldt

MARINA ROSE STOREY
Cal Poly Humboldt

The philosophy and perspective of Western science seeks to explain large-scale phenomena with a universal rule in which the observers are isolated from the subject they are studying (i.e., are on the outside looking in). Originating from Greek and Roman practices of creating law and order (Enache, 2010; Huntington, 1996), the Western scientific method has long been society's preferred process for understanding the world and the universe beyond. As issues surrounding climate change and resource

extraction continue to become more urgent, many have begun to question whether this approach is sufficient to address the myriad of concerns facing the natural world. In addition, there is a growing understanding of how Western science's culture can perpetuate harmful colonial systems of oppression, environmental injustice, and loss of human rights. Multicultural science is an all-inclusive and holistic way of knowing that considers the ways people from all backgrounds collect information, create

connections, and expand the range and breadth of their knowledge. It has also been asserted that decentering Western science and adopting a multicultural approach are required to address the grand civic and environmental challenges facing our world (Held, 2023).

We are a group of Western-trained biologists (seven students and one faculty member) from diverse cultural backgrounds, who spent a semester exploring how we might complement our epistemological approach to addressing real-world problems by including possibilities outside the Western-scientific methodology. As our campus sits on the unceded territory of the Wiyot people, and has nearly one dozen contemporary Native American communities in our admissions and services area, our project focused on the ways Indigenous people have utilized Indigenous Science to manage natural resources since time immemorial. Indigenous Science, which includes Traditional Ecological Knowledge (TEK), is relationship-based, grounded in the living understanding of how the world works (Proulx et al., 2021; Lipe, 2023). Human and non-human entities in the environment are considered equal and are reliant on each other in both a pragmatic and spiritual manner (Kimmerer & Lake, 2001; Lipe, 2023). Information and knowledge acquisition is accumulated and transmitted across generations within specific cultural contexts. Not only does this ensure practitioners can build upon the knowledge of others; it is also a form of survivance, as it often uses traditional forms of knowledge such as oral storytelling, which simultaneously resist colonialism and disseminate knowledge to succeeding generations (Vizenor, 2008; Dunbar-Ortiz 2023). In the last decade or so, non-Indigenous Western scientific researchers and management practitioners have increasingly begun to include TEK in their studies, as evidenced by the application of Indigenous knowledge in peer reviewed publications related to the ecological sciences (Jessen et al., 2022).

Our study focused on how to move towards a multicultural scientific approach through the ethical, authentic inclusion of Indigenous Science. Our reflections were informed by literature review and conversations with Indigenous and Western scientists at various stages in their careers. We offer this project report not as experts, but as facilitators hoping to inspire future conversations that will broaden the definition of knowledge in our individual

disciplines and refine professional codes of ethics to ensure respect and the dignity and sovereignty of all peoples. Though still a work in progress, our realizations include the following:

1. Valuable scientific knowledge has been derived from the contributions of scientists prior to the establishment of Western civilization. Roger Hooykass derived a set of criteria of what science is: "Science acknowledges no authorities ... except the authority of nature.... Science is experimental" and is based on the "direct observation of nature" (Hooykaas 1987, p. 455).

Similarly, Arthur Clegg (1979) also constructs a list of criteria that define the key features of what science is: "[Science] is the habit of isolating a problem for observation ... the use of experiment as part of the observational process ... a logical structure of reasoning ... a theory of knowledge ... [and the] belief that something can be discovered and is worthwhile" (p. 186). Additionally, Clegg makes the insightful remark that although there is no evidence of scientific experimentation before the end of the 16th century, the earliest evidence for experimentation and its resulting contributions originated with the apprentices of merchants and craftsmen in medieval Europe (Clegg, 1979, p. 187). Through observation and "copying their masters," apprentices learned through "active experience" and through trial and error (p. 188). The contributions of pre-modern scientists produced valuable knowledge and information that is still used today. The history of science presented by Clegg and Hooykass has direct parallels to TEK and the production of knowledge through trial and error, direct experience, and the acceptance of natural laws.

2. The mere juxtaposition of Western and non-Western cultures for the purpose of comparing and extracting information does not serve as a conducive means for integrating knowledge systems. "Science contributes to culture by energetically proclaiming its own testable knowledge—not by denouncing additional sources of testable knowledge that may in fact have great legitimacy and value" (Gauch, 2009, p. 39). The idea that some knowledge is more valuable than others not only limits the perspectives available to current researchers, it creates engagement barriers for scientifically curious students

of diverse backgrounds. "The failure to appreciate the unique temporal, cultural, economic and political webs of social matrices that make up the immediate lives and environments of students' epistemological views only furthers hegemonic powers" (Zeidler, 2014). Cultural understanding must transcend mere translation of information to establish the equitable collaboration between cultures required for innovation and advancement.

3. The creation of a multicultural science requires Western scientists to acknowledge that all knowledge, no matter its origins, is relevant (Barsh, 2000). Scientists must unlearn the central fallacy taught to all Western-scientists-in-training—that the Western scientific method is infallible, unbiased, and unconcerned with identity and culture. Western science is deeply rooted in the notion that objectivity is a universal monolith, completely insulated from outside bias. The notion of objectivity, however, can be influenced by Western-based cultures, and therefore cannot be the main driving factor of science. Scientific convention is also a product of subjective cultural influence and can therefore not claim to be totally rational. This means that non-Western science and Western science are equally valid methods of knowledge production, and that both are inherently valuable.

4. To achieve multicultural science, Western scientists must first interrogate the multicultural aspects of themselves. Feminist philosophers were some of the first to argue that the standards for judging who deserves credibility and authority are social constructs that help to reinforce the political and economic status quo, and that when the perspectives of others are excluded, critical questions and perspectives are missed (reviewed in Meyers, 2014). As Western scientists, we must acknowledge the importance of how our personal identities as members of different communities and cultures are inherently molded by a Western worldview. We must think critically about parts of our perspective that we firmly believe to be true and must authentically challenge our own beliefs and understanding. This is easier said than done, as it requires each of us to behave with humility and to allow doubt to enter into our practice of science. Though it may be challenging, practicing humility and acknowledging our areas of personal bias and ignorance allows for us to interact

with other people, whether they share our cultural identity or not, with increased authenticity and empathy. It is this humility that allows us to consider other perspectives and solutions that may work better than our own, where we truly have the opportunity to learn and solve problems in a more meaningful and hopefully more ethical and equitable way.

5. We must abandon the practice of extraction or "helicopter research," where researchers come to an area, conduct research, and leave without engaging the community. Engaging and actively sharing knowledge with local and Indigenous communities in research projects will deconstruct the disconnection and mistrust towards scientists. Engaging communities in research also carries the responsibility of integrity with regard to the knowledge that was gained from local peoples. What is often seen by one group as scientific knowledge may be the coveted cultural heritage of another. Therefore, preserving and respecting that knowledge in the wake of scientific studies is incredibly important if we are to avoid exploitation. Take the time to establish personal relationships. Take the initiative to learn about those you interact with, and unlearn reductive Western ideologies, if only to avoid inflicting further emotional turmoil onto others (Adame, 2021).

6. Remove and avoid scientific names that have discriminatory or exclusionary origins. Trying to categorize and classify the universe is deeply rooted in the practice of Western science (Gillman & Wright, 2020; Rummy & Rummy, 2021). Whether it be intentional or not, the creation and use of certain terminology has facilitated the colonization of language and culture. For example, binomial nomenclature, the practice of classifying organisms using a descriptive two-part name (i.e., scientific names) is useful to differentiate species but has historically been used to elevate the influence and prestige of white men. Interwoven with the history of scientific names is the erasure of Indigenous language and culture. The connection an Indigenous group has to a species, along with their values, knowledge, and the natural history of that species are lost in Western science (Rummy & Rummy, 2021). Just as research can be done with Indigenous input from start to finish, so can naming new species. This collaboration

between cultures and sciences will benefit science overall and expand our knowledge of the natural world.

7. As educators, we must value the knowledge and diverse experiences of our students and empower them to include their cultural capital in their approach to science. It is important to make connections between what is learned in school and life outside of the classroom. Information presented in a Western science classroom often lacks applicable meaning because it is presented at a global scale. Understanding through direct connection is an Indigenous practice that helps foster the idea of interconnectedness. For example, living in the same place as numerous generations of your ancestors emboldens the connection of a community with the land on which they live. Having knowledge of the land not only holds a profound cultural significance, but also holds a practical significance that is rooted in survival. Elder McDermott refers to the process of how elders teach the next generation about identifying medicinal plants: "...introduce them to the medicine tree...Hug it, taste it, smell it... spend some time with it" (Iseke & Desmoulin, 2015, p. 41). Elder McDermott continues by describing the process of making information directly relevant: "The ones who know what they are doing, ... they didn't learn it from the book" (Iseke & Desmoulin, 2015, p. 42). Making direct connections with information helps learners understand the relevance of the task through firsthand experience. As we educate the next generation of scientists, we should empower them to include this cultural capital in their scientific approach.

8. To increase STEM interest among communities historically underrepresented in Western science, it is crucial to establish outreach programs that provide resources, information, and opportunities. By tailoring outreach efforts to the specific needs, values, and contexts of different cultural groups, schools can create a more inclusive and practical approach to promoting STEM education (Ong, 2011). It is essential to encourage the integration of cultural values and traditions into STEM fields to create a greater appreciation and understanding of the relationship between cultural heritage and STEM knowledge. This can be accomplished by initiating discussions on the harmonious coexistence of STEM

knowledge and cultural heritage. Doing so can bridge the gap between these seemingly disparate areas and create a more holistic and inclusive approach to education and knowledge sharing. Schools can integrate cultural values and traditions by studying Native American history and by learning from Native American people and visiting their communities. Promoting the use of Indigenous languages and terminology in STEM education can strengthen inclusivity and cultural awareness (Ong, 2011).

In summary, considering either Western or non-Western systems as superior reduces our ability to understand the natural world. As individuals, we must explore the multicultural aspects of ourselves, abandon the idea of taking without engaging in a community, and reassess paradigms of scientific naming conventions that originated from discriminatory or exclusionary practices. As researchers and educators, we must acknowledge the voices, knowledge systems, epistemologies, and values from diverse perspectives and cultures and ensure they are included in our observations, experimental designs, analyses, and interpretations.

This project encouraged us to evaluate the ways we think, the kind of information we seek, the voices we include, and our approach to education and research. We find ourselves at various stages of increased awareness, understanding, intentionality, and implementation. The trajectory is non-linear, as each step elicits reflection and refinement of our approach to science. We are hopeful that through continuing conversations with scientists, cultural experts, and Indigenous communities, we can make progress towards advancing a multicultural approach to scientific exploration through ethical engagement with Indigenous people.

Acknowledgements

We are grateful to those who took the time to share their perspectives with us: Dr. Daniel Lipe, Dr. Laurie Richmond, Dr. Micaela Szykman Gunther, Dr. Frank Shaughnessy, Dr. Patricia Dawn Goley, and the other students in the seminar course. Our work would not have been possible without their thoughtful contributions.

References

- Adame, F. (2021, June 29). Meaningful collaborations can end 'helicopter research.' *Nature*, 10.
- Barsh R. L. (2000). Taking Indigenous science seriously. In S. Bocking (Ed.), *Biodiversity in Canada*, 153–174. University of Toronto Press.
- Clegg, A. (1979). Craftsmen and the origin of science. *Science & Society*, 43(2), 186–201.
- Dunbar-Ortiz, R. (2023). *An indigenous peoples' history of the United States*. Beacon Press.
- Enache, B. C. (2010). What is the West? *The Independent Review*, 14(3), 450–453.
- Gauch, H. G., Jr. (2009). Responses and clarification regarding science and worldviews. In M. R. Matthews (Ed.), *Science, worldviews and education* (pp. 303–325). The Netherlands: Springer.
- Gillman, L. N., & Wright, S. D. (2020). Restoring indigenous names in taxonomy. *Communications Biology*, 3(1), 609.
- Held, M. (2023). Decolonizing science: Undoing the colonial and racist hegemony of Western science. *Journal of MultiDisciplinary Evaluation*, 19(44), 88–101.
- Hooykaas, R. (1987). The rise of modern science: When and why? *The British Journal for the History of Science*, 20(4), 453–473.
- Huntington, S. P. (1996). The West is unique, not universal. *Foreign Affairs*, 75(6), 28–46.
- Iseke, J. M., & Desmoulins, L. (2015). A two-way street: Indigenous knowledge and science take a ride. *Journal of American Indian Education*, 54(3), 31–53.
- Jessen, T. D., Ban, N. C., Claxton, N. X., & Darimont, C. T. (2022). Contributions of Indigenous Knowledge to ecological and evolutionary understanding. *Frontiers in Ecology and the Environment*, 20(2), 93–101.
- Kimmerer, R. W., & Lake, F. K. (2001). The role of indigenous burning in land management. *Journal of Forestry*, 99(11), 36–41.
- Lipe, D. (2023, October 9). Lecture in the Graduate Seminar Course Exploring Western Bias in Science
- Meyers, D. T. (2014, September 8). *philosophical feminism*. *Encyclopedia Britannica*. <https://www.britannica.com/topic/philosophical-feminism>
- Ong, M. (2011). Broadening participation: The status of women of color in computer science. *Communications of the ACM*, 54(7), 32–34. <https://doi.org/10.1145/1965724.1965737>
- Proulx, M., Ross, L., Macdonald, C., Fitzsimmons, S., & Smit, M. (2021). Indigenous traditional ecological knowledge and ocean observing: A review of successful partnerships. *Frontiers in Marine Science*, 8. <https://doi.org/10.3389/fmars.2021.703938>
- Rummy, P., & Rummy, J. T. (2021). Recontextualising the style of naming in nomenclature. *Humanities and Social Sciences Communications*, 8(1), 1–6.
- Vizenor, G. (2008). Aesthetics of survivance: Literary theory and practice. In G. Vizenor (Ed.), *Survivance narratives of Native presence*, 1–23. University of Nebraska Press.
- Zeidler, D.L. STEM education: A deficit framework for the twenty first century? A sociocultural socioscientific response. *Cult Stud of Sci Educ* 11, 11–26 (2016). <https://doi.org/10.1007/s11422-014-9578-z>

About the Authors



Amy E. Sprowles is Associate Professor of Cellular and Developmental Biology at Cal Poly Humboldt and served as the facilitator for this course. A fourth-generation educator, her career has focused on inclusivity in STEM education. She currently serves as the Faculty Associate Dean for Undergraduate and Graduate Programs, the Director of the Cal Poly Humboldt HHMI IE'17 Award (Howard Hughes Medical Institute Inclusive Excellence Award), and the Director of the Humboldt/California Institute for Regenerative Medicine (CIRM) Bridges Training Program. Dr. Sprowles was the director of the Humboldt INCLUDES Planning Grant, is an 'IKE Alliance Member, SENCER Ambassador, and is a guest editor of this special edition.



Nicholas A. Woronchuk is a master's degree student at Cal Poly Humboldt studying the disease transmission of novel Rickettsial pathogens. During the summer of 2023, he worked with the Trio Upward Bound program, teaching microbiology to local high school students in Humboldt County. Seeking to bridge some of the gap between broad scientific theory and real-world applications, he designed a course to provide students with a deeper understanding of microbial life, as it relates to everyday situations. While teaching a class to a diverse group of students from different cultural backgrounds, Nicholas was challenged to make the course relevant to the experiences of each student.



Jessica Jones has a master's degree from Cal Poly Humboldt. She is studying the behavior of northern red-legged frogs (*Rana aurora*) and northwestern salamanders (*Ambystoma gracile*). Prior to graduate school, Jessica worked at the Loveland Living Planet Aquarium in Draper, UT for six years as an outreach educator and then as a zookeeper. As an

outreach educator, she traveled to elementary schools throughout Utah, teaching science topics and handling all sorts of animals from snakes and tarantulas to parrots and armadillos. She switched careers in 2017 and worked as an academic advisor for undergraduate biology and botany students at Utah Valley University. There, she conducted research on the developmental mortality of brine shrimp (*Artemia*). Besides pursuing the sciences, she enjoys creative writing and has self-published a fantasy duology, *The Wizard's Seal*, through Kindle Direct Publishing, and a poem, "Cosmic Promenade," in Southern Utah University's *The Kolob Canyon Review*.



Noah Angell is a current master's degree student in the Fisheries Department at Cal Poly Humboldt. He earned his bachelor's degree from Colorado State University in fish and wildlife conservation biology. As a Latino with an Indige-

nous background he is very passionate about the representation and empowerment of people of color in science. He has participated and presented at multiple knowledge exchange events with local tribal nations and has been a program assistant with the Scientists in Parks program, which provides natural resource internships for students who have been traditionally underrepresented in science.



Shay Konradsdottir graduated from Cal Poly Humboldt with a degree in computer science and molecular biology. She has a broad range of experience in the intersection of these two fields, from utilizing artificial intelligence for image

recognition of algae samples, to developing 3D models of cells through cellular holography. She presented a paper at the 4S 2023 Conference (Society for Social Studies of Science) titled "Rural Education's Impact on Children's Perceptions of Computer Science and Artificial Intelligence in Public Services."



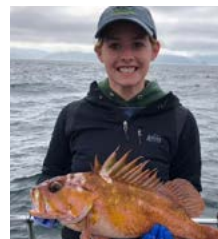
Elyse McKinney graduated from California Polytechnic State University, Humboldt with a Bachelor of Science degree in biology with an anthropology minor. She has a solid foundation in biological science and laboratory techniques,

along with time management skills cultivated through college athletics. Elyse's accomplishments include Dean's List and Presidential Scholar honors, as well as serving as Team Captain for the Intercollegiate Women's Volleyball Team. With a strong passion for healthcare, she now seeks to advance her education in a medical profession, aiming to contribute meaningfully to the field.



Xena Pastor-Nuila is a first-generation Latina who is originally a San Francisco Bay Area native. She has a Bachelor of Science degree in cellular molecular biology and is currently working at Cal Poly Humboldt in emergency management.

She hopes to work with local tribes to strengthen disaster preparedness in the surrounding community.



Marina Rose Storey is a master's degree student in the Craig Lab at Cal Poly Humboldt (formerly known as Humboldt State University) studying marine biology. Her interests are in marine habitat restoration and conservation, focusing

on marine invertebrates. Her thesis examines persisting kelp beds at river mouths in Mendocino County, CA, hypothesizing that the decreased salinity in these areas is negatively affecting purple sea urchin grazing on bull kelp.

PROJECT
REPORT

Awakening Indigenuity at George Mason University

THOMAS WOOD

George Mason University

SHIMA MOHEBBI

George Mason University

DANA ADKINS

Chickahominy Indian Tribe

JEREMY CAMPBELL

Field Museum of National History

Twenty-five years ago, the aspirational vision of a newly formed national SENCER initiative led one of our authors (Wood) to initiate a long-term relationship between the Smithsonian Institution and George Mason University, involving a residential, immersive approach to education focused on biodiversity conservation. Science education reform was in full swing, fueled by reports from the National Academies of Sciences (National Academies of Sciences et al., 2000, 2007) and the Carnegie Foundation on the Scholarship of Teaching (Boyer, 1990) that identified an alarming decline in education in the United States. Active, experiential learning was rightly recognized as a better learning method (Arslantaş & Bavli, 2022), since—unsurprisingly—people develop cognitive and affective learning domains better under the natural conditions in

which the brain evolved. This is something people closely connected to the Earth have always known (Wildcat, 2023). As a result, exposure to the natural world has been reclaimed as healthy; exposure to nature improves mental health and academic success. In the Smithsonian-Mason Semesters, we made progress by transforming the curriculum and incorporating active learning around real-world problems with an interdisciplinary focus. We were aware of the urgency of climate change and the biodiversity crisis then, as we are now. Mason students began discovering ways to become knowledgeable about societies and, consequently, the Earth's capacious problems, through immersion in the complex realities of living in the Anthropocene. However, we now face the reality that the modern approach of extraction-focused resource management

that is promoted by most societies is not likely soon to stem the tide of climate change, biodiversity loss, or deterioration of ecosystems. Today, we are quickly reaching a catastrophic tipping point that will detrimentally impact all life on Earth unless quickly mitigated (Fletcher et al., 2024). Again, revising how we function as a university and society has become necessary.

Considering the magnitude of our global problems, understanding, respecting, and adopting the values and actions of knowledgeable societies with long-standing respect for the living Earth is long overdue. Indigenous people closely connected to the living Earth are keenly aware of the injuries inflicted upon fellow species and the land, water, and air by extractive resource management approaches used by most societies (Wildcat, 2023). Recognition of the wisdom of the Indigenous mind opens opportunities to understand how Traditional Ecological Knowledge can help us all understand, respect, and restore the Earth as informed through thousands of years of close interdependence with our diverse eco-relatives (Alfred, 2015; Cajete, 2000). Indigenous keepers continue to be important stewards of terrestrial land, exercising traditional rights over one-quarter of the earth's surface and stewarding approximately 38% of all protected lands (Sze et al., 2022). They have generally done a much better job of living in concert with other life, terrestrial systems, forests, grasslands, and deserts, and taking care of the air, water, oceans, and soils as part of the living fabric of Earth than modern societies (Taiaiake, 2015). Indigenous communities worldwide exemplify the concept of Natural Law, where living respectfully with other life and natural systems is a cultural foundation (Wildcat, 2023). Respectfully, considering the magnitude of the current global crisis, societies should work to better understand and incorporate Natural Law into our education systems to help promote respect and healing. Our actions at Mason now incorporate these values, starting with recognition, collaboration, and planning with local Indigenous people in the Chesapeake region.

At Mason, we have grown wiser about incorporating TEK (Traditional Ecological Knowledge) and Indigenous thinking and values into education for all students. Using a holistic approach, we have hired Indigenous faculty, built an interactive community with students and local tribes, and collaboratively developed research and education

opportunities. These efforts parallel the improving relationship between tribes and the federal government with the passage of the Thomasina E. Jordan Indian Tribes of Virginia Federal Recognition Act of 2017. This act provided federal recognition for the Chickahominy, the Chickahominy Eastern Division, the Upper Mattaponi, the Rappahannock, the Monacan, and the Nansemond Nations, who joined the Pamunkey Tribe for federal recognition. Virginia's state-recognized tribes and nations include the Nottoway, Chickahominy, Chickahominy Eastern Division, Mattaponi, Upper Mattaponi, Nansemond, Nottoway, Pamunkey, Patawomeck, Rappahannock, and Monacan. The Piscataway, the Piscataway Conoy Tribe, and the Accohannock Indian Tribe have state recognition in Maryland. These recognitions are opening awareness of the 13,000 years of human occupation that existed in harmony with the natural ecology of the Chesapeake Bay region and are leveling the playing field for collaboration. Through respectful collaboration, we are now engaging in education and research reforms with an Indigenous perspective in several programs across the University.

In addition to new federal recognition, state- and University-level changes provide a strong foundation for this transformation. Most recently, in 2024, Virginia House Bill 1157, "Federally recognized Tribal Nations in the Commonwealth; agencies to consult on permits and reviews," was signed into law following many years of hard work by tribal leaders and elected representatives. This law establishes an ombudsman to facilitate communication between the federally recognized Tribal Nations and relevant state and local governments regarding environmental, cultural, and historic permits and programs. George Mason University also has a newly created "President's Taskforce on Indigenous Inclusion and Collaboration," which is actively initiating collaborative programs that include Indigenous faculty, staff, and students. We are also primary participants in the newly developed (2023) Annual Virginia Indigenous Nations in Higher Education Summit, sponsored by the State Council on Higher Education in Virginia, our accreditation agency. Through these actions, Mason has become a leading Virginia educational institution engaging with Tribal Nations, respecting and incorporating their traditions, values, and land rights across research and education programs in the University. Together, we have tribes' participation in the

mutual identification, development, and implementation of new ideas and programs seeking to co-create opportunities for knowledge and value growth for all people. These activities promote responsibility through an understanding of cultural perspectives, Traditional Ecological Knowledge, and Native science concepts among all learners. George Mason is also a member of the 'IKE Alliance, the SENCER-derived collaboration between universities and tribal communities ranging from Hawai'i to Virginia. Focused on STEM education, we seek to know, understand, experience, and recognize Indigenous knowledge that is infused into our institutions and find strengths working together to reform our approach to research and education. Collectively, through these initiatives, Mason is actively pursuing the following general goals (George Mason University Virginia Indigenous Nations in Higher Education Collective, 2023):

- Increasing enrollment, graduation and life success of Indigenous students at George Mason University.
- Creating a campus culture that empowers Indigenous students.
- Supporting collaborative research on environmental, health, and community dynamics.
- Supporting tribal decision-making and tribal priorities throughout the development of new research and education initiatives.
- Decolonizing and indigenizing our curriculum in key areas.
- Listening to the Tribes to learn how to be a trusted and relevant institution that can contribute to the thriving of Virginia's Indigenous communities.

In pursuit of these goals, one exemplary ongoing collaboration is The Indigenous Environmental Mapping & Resilience Planning Project, started in 2022 together with the Chickahominy Tribe. This project exemplifies collaboration as the Chickahominy Tribe re-acquires traditional land and seeks to recover from over 400 years of colonial oppression. The project functions with Data Sovereignty for the Tribe and will collect, organize, and analyze socio-environmental data and environmental decision-making guided by Natural Law and traditional tribal values. Our initial research focuses on wildlife diversity assessments, food sovereignty, and community health. The project utilizes various data collection

techniques ranging from site surveys for biodiversity to GIS and remote sensing modeling for spatial analysis on terrestrial and estuarine sites. It is important to note that the Tribe is prioritizing an understanding of the potential impacts of climate change and rising sea levels on the environment and collective impacts on citizens. An additional ongoing goal of this project is to continue the engaged research methodologies that produce mutually beneficial, just outcomes for all. Indigenous students enrolled at Mason, as well as Chickahominy youth, are active participants in this research.

To date, nine deliverables have been produced and presented to the Chickahominy Tribal Council. These include biodiversity surveys, GIS maps important for planning related to food insecurity and environmental contamination, and cultural information useful for repairing eco-kinship relationships to promote universal healing. Tribal citizens' participation in GIS training was well received, and collaborative education is a hallmark of this relationship. Baseline surveys on the biodiversity of breeding birds and plants have been completed and will continue temporally over the years to come. Environmental Indicator species, including prothonotary warblers (*Prothonotaria citrea*) among others, will be continually observed and monitored for temporal success, exemplifying mutual concern for native animals and people during climate change in this estuarine landscape. Such information will be used by the Tribal Council when considering the conversion of land use reform from modern agriculture to more traditional uses envisioned by the Tribe.

Initiatives between George Mason University and Tribal nation partners represent mutual respect and observance of moral principles grounded in reverence for the Earth and traditional knowledge. We are establishing positive relationships and active engagement throughout our region. Faculty facilitate interactions among Indigenous students, community members, and locally residing elders from many Indigenous communities, promoting mutual respect through knowledge and wisdom transfer unparalleled in previous University activities. This multiplicity of events is a new and responsible approach, and by establishing trusting relationships, it represents a necessary, positive shift away from less respectful research practices undertaken by universities in the past.

References

- Alfred, T. (2015). Cultural strength: Restoring the place of Indigenous knowledge in practice and policy. *Australian Aboriginal Studies*, 2015, 3–11.
- Arslantaş, Ç. N., & Bavlı, B. (2022). School-based outdoor education: A neglected practice at the secondary level. *Journal of Adventure Education and Outdoor Learning*, 24(2), 270–286. <https://doi.org/10.1080/14729679.2022.2143385>
- Boyer, E. L. 1990. *Scholarship reconsidered: Priorities of the professoriate*. Carnegie Foundation for the Advancement of Teaching.
- Cajete, G. (Ed.). (2000). *Native science: Natural laws of interdependence*. Clear Light Publishers.
- Fletcher, C., Ripple, W. J., Newsome, T., Barnard, P., Beamer, K., Behl, A., Bowen, J., Cooney, M., Crist, E., Field, C., Hiser, K., Karl, D. M., King, D. A., Mann, M. E., McGregor, D.P., Mora, C., Oreskes, N., & Wilson, M. (2024). Earth at risk: An urgent call to end the age of destruction and forge a just and sustainable future. *PNAS Nexus*, 3(4), 106. <https://doi.org/10.1093/pnasnexus/pgae106>
- Garnett, S. T., Burgess, N. D., Fa, J. E., Fernández-Llamazares, A., Molnár, Z., Robinson, C. J., Watson, J. E. M., Zander, K. K., Austin, B., Brondizio, E. S., Collier, N. F., Duncan, T., Ellis, E., Geyle, H., Jackson, M. V., Jonas, H., Malmer, P., McGowan, B., Sivongxay, A., & Leiper, I. (2018). A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability*, 1, 369–374. <https://doi.org/10.1038/s41893-018-0100-6>
- George Mason University Virginia Indigenous Nations in Higher Education Collective. (2023). *George Mason University: Leadership and Tribal contacts*. <https://www.schev.edu/home/showpublisheddocument/3757/638526548148830000>
- National Academies of Sciences, National Academy of Engineering, and Institute of Medicine. (2000). *How people learn: Brain, mind, experience, and school* (expanded edition). National Academies Press. ProQuest Ebook Central, <https://ebookcentral-proquest-com.mutex.gmu.edu/lib/GMU/detail.action?docID=3375510>.
- National Academies of Sciences, National Academy of Engineering, and Institute of Medicine. (2007). *Rising above the gathering storm: Energizing and Employing America for a brighter economic future*. The National Academies Press. <https://doi.org/10.17226/11463>
- Sze J. S., Childs, D. Z., Carrasco, L. R., & Edwards, D. P. (2022). Indigenous lands in protected areas have high forest integrity across the tropics. *Current Biology*, 32(22), 4949–4956.
- Taiaiake, A. (2015). Cultural strength: Restoring the place of indigenous knowledge in practice and policy. *Australian Aboriginal Studies*. 3–11.
- Wildcat, Daniel R. 2023. *On indigenuity: Learning the lessons of Mother Earth*. Fulcrum Publishing. Wheat Ridge Colorado. ISBN 9781682754573.

About the Authors



Dr. Thomas Wood is a tenured Associate Professor of Conservation Studies in the School of Integrative Studies at George Mason University. He created the resident Smithsonian

Mason Semester program, where students reside at the Smithsonian Conservation Biology Institute, and was the founding director of the Smithsonian Mason School of Conservation. Wood has extensive experience in funded science education reform efforts, including the NSF-sponsored project SENCER (Science Education for New Civic Engagements and Responsibilities), where he serves as a Senior Leadership Fellow. He helps advise the Native American Indigenous Alliance (NAIA) and American Indian Science and Engineering Society (AISES) student organizations at Mason. He has studied traditional ecological knowledge from his youth and walked with a Mescalero Apache elder for over 20 years.



Dr. Jeremy M. Campbell is a cultural anthropologist who specializes in the relationships between communities and their environments, especially in the context of Indigenous stewardship of landscapes. Campbell has worked with traditional knowledge holders in North and South America to forge reciprocal relationships that support Indigenous environmental management. Dr. Campbell is Director of the Andes-Amazon Research Program at the Field Museum of Natural History in Chicago.



Shima Mohebbi is an assistant professor in the Department of Systems Engineering and Operations Research, and affiliate faculty of computer science at George Mason University. Her research interests include game theory, network optimization, simulation, and interpretable machine learning, with applications in resilient infrastructure systems, sustainable water systems, and smart and connected communities.



Dana Adkins, a citizen of the Chickahominy Indian Tribe, has served as the Tribe's Environmental Director since the establishment of the Environmental Office in October 2019. Since its inception in 2020, Dana has chaired EPA Region 3's Regional Tribal Operations Committee and also represents Region 3 on the EPA's National Tribal Science Council.

PROJECT
REPORT

From Land Acknowledgement to Place-Based Responsibilities

Enriching University Curriculum and Learning Communities through Indigenous Epistemologies

NASRIN MIRSALEH-KOHAN
Texas Woman's University

ADESOLA AKINLEYE
Texas Woman's University

BECKY A. RODRIGUEZ
Texas Woman's University

ALANA TAYLOR
Texas Woman's University

ELISA DE LA ROSA
Texas Woman's University

RAVEN GALLENSTEIN
Texas Woman's University

HOLLY ANN GRIFFIN
Texas Woman's University

GILLIAN HAYES
Texas Woman's University

KYNDEL LEE
Texas Woman's University

RICHARD D. SHEARDY
Texas Woman's University

Abstract

Land Acknowledgements have become a ubiquitous part of universities. They purport to remember, honor, and bear witness to the future of Indigenous nations and to recognize the land and honor local Indigenous communities. While acknowledging the Indigenous peoples upon whose lands we work is an essential gesture, the authors join other scholars who argue that we must go beyond a mere statement. The Land Acknowledgement must also

propel the learning community of the institution to take action, to embrace relationships with the environment (land), and to take responsibility for its care for Indigenous generations to come. Our attempts to recognize the importance of Indigenous epistemologies and commitments to the land have enriched the whole learning environment of the University. This report describes the interdisciplinary, collaborative approach we have been taking as we attempt to go beyond the mere performance

of acknowledgement towards making substantive change. At the time of writing, the authors live on the traditional territories of the Hasinal and Wichita, Caddo, Comanche, and Cherokee Nations.

Introduction

Texas Woman's University (TWU), like all institutions of higher education on Turtle Island, resides on the lands of Indigenous nations. As a university, we are residents on this land as a site of knowledge through investigation, study, and analysis. As scholars and academics, we are aware that "we cannot remove ourselves from our world in order to examine it" (Wilson, 2008, p. 14). In seeking how to better understand the world around us, we have considered our place-based responsibilities to Indigenous communities and environment on the site of the University. In this report, we discuss our initial attempts to embed site-specific, place-based forms of redress (Robinson et al., 2019), such as Land Acknowledgements. Land Acknowledgements are important for recognizing Indigenous peoples, particularly in terms of land they inhabit, learn from, and care for. However, to avoid being performative or merely symbolic, we felt our Land Acknowledgement must be embodied through tangible activity. We have found that although such action might be initiated by altruistic notions of support, in fact, acknowledgement of the knowledge and traditions of the Indigenous people enhances the educational experiences of the whole university (Deloria & Wildcat, 2001). We hope that by converting into actions what could otherwise be rhetorical gestures, we will start to empower students, faculty, and staff from within our midst and create inviting educational environments for prospective Indigenous students, faculty, staff, and collaborators. We recognize and attempt to honor the conviction that there is urgency to this and much work to be done to create equitable learning environments.

TWU's three campuses constitute the largest public university system primarily for women in the United States and is a federally designated Hispanic-Serving Institution (HSI). Our student body includes a range of identities. Over 50% of TWU students are the first generation of their family to attend college. These first-generation (or first-gen) college students are students whose

parents or guardians have not completed a bachelor's degree. Committed to educating female-identifying, first-generation college, and ethnically diverse students, both from the place currently known as Texas and from across Turtle Island, TWU plays a significant role in expanding opportunities for earning advanced degrees to a broader demographic group.

This report outlines our interdisciplinary, collaborative approach to embracing culturally relevant initiatives and fostering strong relationships with the health of the land and Indigeneity of the communities around TWU. The report describes the activities carried out through collaboration between the Division of Chemistry and Biochemistry, the Division of Dance, and the Center for First-Generation Students.

Timeline

We have initiated a number of commitments to the development of a culture of responsibility to the lands we teach and study on. This has meant taking an approach that builds across academic years. Below we unfold a linear timeline of our activity thus far.

Spring 2018: In 2018, TWU's chemistry program was recognized by the American Association of Colleges and Universities (AACU) as a model for how to promote civic learning and democratic engagement [Texas Woman's University, 2018]. Several initiatives led to the prestigious recognition we received. These included our integration of sustainability and green chemistry principles into our courses, alongside our emphasis on how our students enhance their ethical reasoning and engage with their disciplines through a civic engagement. Our Division's shift towards sustainability and green chemistry was also driven by the imperative to responsibly steward the Indigenous lands upon which we reside. Our green chemistry initiatives inspired our students, especially our Chemistry Club, to feel empowered to engage with strategies of care for the environment that also value and respect Indigenous culture and communities.

Fall 2019: Our chemistry curriculum for both STEM and non-STEM majors integrates Indigenous perspectives by providing unique insights that connect

Indigenous culture to environmental issues and sustainability.¹ Through our curriculum, we nurture students to think critically and engage in meaningful discussions about how to address current challenges facing our planet, while considering multiple perspectives.

In addition to our major courses, we have been redesigning courses for all majors (chemistry and non-chemistry majors, SCI prefix), in order to incorporate Indigenous perspectives into our reading objectives, assignments, experiences, and projects. In our Climate Change course, designed for science and non-science majors, students were assigned a group research project focused on Native American, Alaskan Native, Native Hawaiian and Pacific Islander (NAAN-NHPI) communities. Students in the course came from multiple ethnicities and academic pursuits in business, education, psychology, chemistry, and biology. They worked as a team to gain historical knowledge and explore current issues important to NAAN-NHPI communities. The project continued for the entire semester and was presented in a community event. The students also took a field trip to Lake Ray Roberts State Park, where they learned about the Indigenous communities who previously inhabited the land.

Spring and Fall 2020: The Division of Chemistry and Biochemistry and the SENCER Center for Innovation Southwest (SCI-SW) hosted the fifth annual SENCER Regional Symposium at TWU on January 31, 2020. The focus of the symposium was “Citizen Science: The Impact on our Communities by Plastics in our Environment.” In keeping with this topic, we planned the symposium in such a fashion as to minimize the environmental impact, and this led to the inception of the TWU Zero Impact Project (ZIP) under the supervision of Dr. Cathy Middlecamp from the University of Wisconsin and led by the faculty advisor, Alana Taylor, at TWU. From Spring 2020 on, all the events and symposia in the Division of Chemistry and Biochemistry were held in accordance with a zero-impact commitment. This marked the beginning of our effort to embed environmental care principles into our departments’ infrastructures. We fell short by not

¹ Fall 2023 enrollment data reveals that 10% of STEM majors (1000 students) and over one-third of the entire enrolling undergraduate student population at TWU are taking our introductory chemistry courses.

having any presenters at the symposium who discussed Indigenous perspectives; however, this event initiated a conversation about the importance of learning from Indigenous knowledge and including Indigenous scholars and presenters in future gatherings.

Spring 2021: Student leaders from various student organizations and graduate students expressed their desire to establish a meaningful acknowledgement of the Indigenous lands. We recognized the complications of writing a Land Acknowledgement, and so we established a student committee. The student committee created a draft Land Acknowledgement, which was then sent for review to a committee consisting of staff and faculty from across the University who identify as Indigenous. The written Land Acknowledgement is a working document that we continue to craft, as we are aware that it is an important step towards creating a more inclusive and respectful campus environment.

Fall 2021: As a continued acknowledgement of the land, the Division of Dance began an embodied Land Acknowledgement practice in November 2021. Embodied Land Acknowledgement has taken place once a week in the morning from 8:00 to 8:45. It involves picking up litter from the small waterway that runs across the campus. This practice is intended to honor how previous generations cared for the land. It also reminds us to carry on that legacy of being responsible to the land we dance on.

A workshop was organized by the Division of Chemistry and Biochemistry titled “Partnerships to Transcend Barriers to Success for Students and Communities,” to teach us how to build partnerships with the Native communities and learn how to develop these partnerships. The workshop was led by guest Dr. Robert Franco from Kapi’olani Community College in Hawai’i.

Spring 2022: Acknowledging that students come from across the state and beyond, the Division of Dance was interested in how students could use dance to explore how they arrive “here ... in this place ... Denton.” We felt that anchoring dance to local history was key to this. We planned our Dance History course for Fall 2022 in collaboration with the Choctaw Nation, whose recent history includes their relocation to an area an hour’s drive

north of the campus. We collaborated with the Choctaw Nation Cultural Center in Calera, Oklahoma, and with historian Ryan L. Spring. We also visited the Choctaw Nation Cultural Center.

The Division of Chemistry and Biochemistry invited Dr. Mark Griep from the University of Nebraska-Lincoln to discuss how his university is incorporating Indigenous epistemologies into their curriculum. Dr. Griep's presentation was titled "The Sharing Cycle of Science Learning: Connecting Chemistry at Tribal Colleges to Tribal History, Language, and Culture."

Fall 2022: The Dance History course, designed in collaboration with the Choctaw Nation the previous Spring, offered a curriculum that aligned the timeline of dance with the local history of the Choctaw Nation. The class covered the Texas state-required national and international dance history syllabus, but contextualized it within the Choctaw Nation's historical timeline, which also has international significance. On November 2nd, 2022, Ryan L. Spring and Misty Madbull visited the TWU campus to give a guest lecture to the Dance History class. While they were visiting the Dance Department

they also watched a ballet class and met faculty to gain ideas for their Choctaw Cultural Center. Ryan L. Spring also met with 23 TWU student leaders and facilitated a traditional Choctaw decision-making scenario (Figure 1). The student leaders were from across the University and held leadership positions within a variety of student-run organizations. The students were selected by their advisors with the intention of their learning leadership development and community building. An interactive role-playing experience focused on how Choctaw people traditionally made decisions within their community and how we can apply those values to building community today.

During this semester, the Division of Chemistry and Biochemistry joined the Green Chemistry Commitment community, sponsored by Beyond Benign, and pledged to implement green and sustainable chemistry.

Two of our Science core courses, Earth Science and Sustainable Physical Science, were redesigned to incorporate Indigenous perspectives and environmental injustices. Earth Science is a core STEM course that is offered to all majors at TWU. Throughout the semester, students research environmental issues of the Anthropocene and incorporate Indigenous narratives and environmental injustices. They also explore issues surrounding water

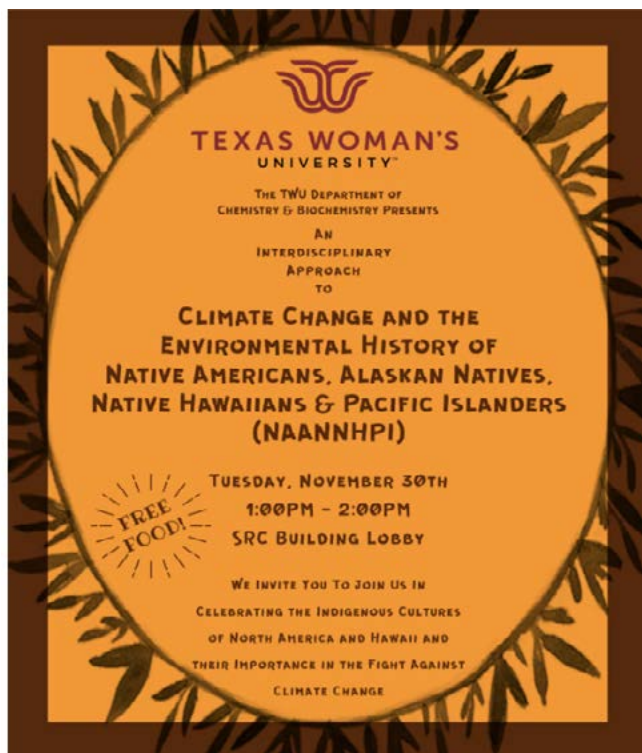
rights through native storytelling by watching Kelsey Leonard's 2020 TED Talk, "Why Lakes and Rivers Should Have the Same Rights as Humans." After watching the video, the students create a presentation that discusses the Indigenous perspective of water in our modern world. Our introductory Sustainable Physical Science course for non-majors includes reading objectives that explore Indigenous struggles and environmental justice. Students are given a platform to explore and discuss the view of Indigenous people and sustainable development as a process that integrates spiritual, cultural, economic, social, political, territorial, and philosophical ideas (Figure 2).

Spring 2023: Using a Creative Arts and Humanities small grant, two faculty from the Division of Dance traveled to Mexico City and San Juan Teotihuacan, Mexico to learn Indigenous (pre-Hispanic) dances for the mountains which filter

FIGURE 1. A flyer sent to student leaders for guest speaker, Ryan L. Spring



FIGURE 2. A flyer advertising the event showcasing Climate Change Students' presentations



the local water. They also collected interviews about the mountains and visual footage of the environment from which the dances emanate. When they returned to TWU, they developed four performance pieces that were presented by faculty and students alongside Danza Chikawa the following semester, April 2023. Ryan L. Spring, Audrey Jacob, and four other representatives of the Choctaw Nations Cultural Center came to Denton from Oklahoma to attend the Friday performance. Reaching out beyond TWU, faculty attended the Indigenous choreographers gathering at the University of California, Riverside, to interview/talk to three Indigenous choreographers about making contemporary dance work derived from traditional Indigenous worldviews. Alongside the April performances, the Division of Dance hosted lectures and workshops at TWU by Danza Chikawa in collaboration with the Division of Chemistry and Biochemistry and the Center for First-Generation Students (Figure 3).

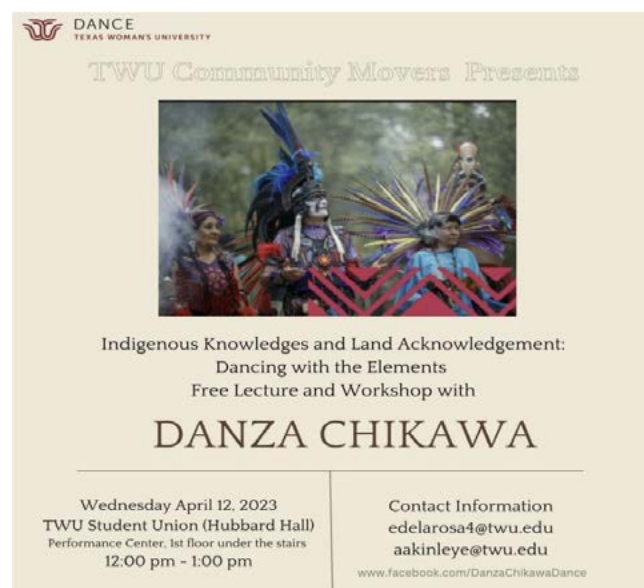
TWU students inaugurated the first "Indigenous Connection Student Organization." The purpose of the Indigenous Connection club is to bring together Indigenous peoples and their allies, to honor Indigenous heritage and create a safe and celebrating space. "The

Organization is for any student interested in Indigenous connections. As a part of the *Indigenous Connection*, we have engaged in Embodied Land Acknowledgement, specifically cleaning up the water source closest to us."

Summer 2023: Concluding the 2022/2023 academic year's work in June 2023 was a community event as part of Global Water Dances (globaldances.org.com), linking sources of water in San Juan Teotihuacan and Denton. This event joined the TWU Denton campus with Teotihuacan: dancers at both sites danced simultaneously and together as part of the global event of Global Water Dances. Three short films were made of this event and accepted by the Global Water Dances Institute as part of the global collection of water dances. We came in July together to write a grant to obtain financial support for future planning, which unfortunately was not successful. This slowed momentum, but we were able to continue to build infrastructure for students and future curriculum. We continue to seek funding while maintaining our activities, including the weekly Embodied Land Acknowledgement and ongoing curriculum development.

Fall 2023–Present: The Division of Chemistry and Biochemistry is part of an NSF-funded project (NSF #2040991), "Transcending Barriers for Success," which

FIGURE 3. A flyer announcing the lectures, workshops, and performance pieces that were performed by faculty and students alongside Danza Chikawa, April 2023.



addresses diversity in STEM fields for the NAAN-NHPI population. We are currently working with eight engaged campuses to identify barriers to the recruitment and retention of NAAN-NHPI students. We continue to develop a sense of belonging to the land on which we study through student activity, ongoing written and embodied Land Acknowledgement, and making strong connections to the communities around us.

We feel our collaborative approach embodies the interconnected worldview and epistemologies of many Indigenous communities. We are sharing this work at conferences and across our academic communities.

Acknowledgments

The authors express their gratitude to the Choctaw Nation, Dr. Mark Griep, and Danza Chikawa, as well as to the TWU students, faculty, and staff in the Division of Chemistry and Biochemistry, the Division of Dance, the Division of Student Life and Center for First-Generation Student Success, and the National Center for Science and Civic Engagement (NCSCE). We are also grateful for funding from the National Science Foundation (NSF #2040991), The Welch Foundation (m-0200), TWU Student Life, TWU Creative Arts and Humanities, and the Spencer Foundation.

References

- Deloria Jr., V., & Wildcat, D. R. (2001). *Power and place: Indian education in America*. Fulcrum Publishing.
- Global water dances*. <https://globalwaterdances.org/>
- Robinson, D., Kanonhsyonne, J. C., Hill, A., Ruffo, G., Couture, S., & Cooke Ravensbergen, L. (2019). Rethinking the practice and performance of Indigenous Land Acknowledgement. *Canadian Theatre Review*, 177, 20–30. muse.jhu.edu/article/716610
- Texas Woman's University. (2018). *Texas Woman's University chemistry program earns top national recognition*. <https://twu.edu/news/2018/texas-womans-university-chemistry-program-earns-top-national-recognition/>
- Wilson, S. (2008). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.

About the Authors



Dr. Nasrin Mirsaleh-Kohan is an associate professor of physics and the Division Head of Chemistry and Biochemistry at Texas Woman's University. She is a Leadership Fellow and Faculty Ambassador for SENCER and holds the position of Director for the SENCER Center for Innovation-Southwest. Kohan's research laboratory investigates the interaction between DNA and platinum-based anticancer drugs and applications of nanomaterials, especially carbon nanotubes, and their use in the capture and storage of carbon dioxide.



Dr. Adesola Akinleye (She/They) is a choreographer, artist-scholar, and assistant professor in the Dance Division at the Texas Woman's University. Adesola has been an Affiliate Researcher in Arts, Culture and Technology, and is a Visiting Artist at the Center for Art, Science & Technology at the Massachusetts Institute of Technology, as well as a Theatrum Mundi Fellow. Their career began as a dancer with Dance Theatre of Harlem Workshop Ensemble (USA). For more about Adesola, please visit www.adesolaakinleye.com.



Dr. Becky A. Rodriguez is the Executive Director of the Center for First-Generation Student Success at Texas Woman's University. She draws on her experiences as a first-generation Latina student to create a sense of community for all TWU students. Her contributions have enhanced student success, retention, and persistence at TWU. Rodriguez's pioneering work has resulted in the development of several successful programs, including First-Gen Pioneers, First-Gen Champions, TWU Go Program, and G-Force Work-Study Mentorship Program. She has received over \$1.9 million in grant funding for mentor programs.



Alana Taylor is a lecturer at Texas Woman's University with a passion for science and innovative teaching methods. She earned her master's degree from the University of North Texas and is pursuing a PhD in education and organiza-

tional leadership. Ms. Taylor's research focuses on community resiliency to climate change and identifying practical solutions for building sustainable communities in areas that are facing environmental challenges. She teaches undergraduate environmental and earth systems courses using a transdisciplinary approach and a dynamic teaching style involving personal responsibility and reflection, multiple perspectives, and critical thinking. Outside of academia, she actively promotes science literacy and environmental stewardship in her community.



Elisa De La Rosa, daughter of migrant farmworkers, and granddaughter of Mexican immigrants; Assistant Professor of Dance at Texas Woman's University, is a choreographer, performer, dance educator, and the founding artistic director of De La Rosa Dance Company. De La Rosa's research is focused on Dance of the Latinx Diaspora: Pre-Hispanic Indigenous, Mexican, and Tex-Mex dance forms. Prior to teaching at Texas Woman's University, she was a dance educator for 14 years in public schools. De La Rosa received a BA in Dance with Secondary Teacher Certification from Texas Woman's University and an MFA in Dance from Montclair State University.



Raven Gallenstein has bachelor's and master's degrees in chemistry from Texas Woman's University. Her professional journey includes teaching as an instructor and teaching assistant. Ms. Gallenstein is attending Boston College, being fully

funded by the Krell Institutes Computational Science Graduate Fellowship. Beyond academia, Raven demonstrates a commitment to environmental stewardship, for example by being a Watershed Protection Intern.



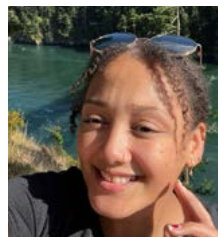
Holly Ann Griffin is a dancer, artist, and musician with a Dance Studies BA and a minor in music at Texas Woman's University. She practices an Indigenous research model, believing that somatic knowledge, spiritual knowledge,

and intuition have a value equal to other forms of knowledge. Above all, she considers dance a form of liberation from oppression through unbridled expression, and a potential and birthright for everyone.



Gillian Hayes is a student at Texas Woman's University, majoring in political science with an emphasis on politics, policy, and public service. She is very involved in student organizations on campus, including as president of Indigenous

Connection, and Student Body President of the TWU Student Government Association for 2024–2025. Through all of this, her main goal is building community with people from all walks of life.



Kyndel Lee is an artist, performer, teacher, and choreographer from Dallas, Texas. She connects environmental psychology to dance to educate and advocate for change by elevating unheard voices worldwide. Kyndel has been performing

dance works for over 15 years, ranging from seven years of drill team and studio training to dancing in the Collin Dance Ensemble, a contemporary modern dance company under the direction of Tiffaniee Arnolds, from 2018–2020. She has a BA in dance from Texas Woman's University.



Dr. Richard D. Sheardy is Cornaro Professor of Chemistry and Biochemistry at Texas Woman's University. He teaches freshman and biophysical chemistry and continues his research focusing on the structure, stability, and ligand

binding properties of unusual DNA conformations to learn more about the molecular basis of cancer. He has mentored multiple faculty, graduate, and undergraduate students at TWU. Sheardy is Conference Chair for the North American Calorimetry Conference and is a SENCER Ambassador. He has organized many symposia at regional and national conferences on nucleic acid biophysics and science education reform.

RESEARCH
REPORT

Listening to Learn Using a Talking Circle Approach to Understand the Indigenous STEM Student Experience

CUTCHA RISLING BALDY

Cal Poly Humboldt

H. EVE ROBINSON

Cal Poly Humboldt

**ADRIENNE
COLEGROVE-RAYMOND**

Cal Poly Humboldt

MARLENE' DUSEK

Cal Poly Humboldt

NIEVITA BUENO WATTS

Cal Poly Humboldt

MELITTA JACKSON

Cal Poly Humboldt

AMY E. SPROWLES

Cal Poly Humboldt

Abstract

Indigenous students often see higher education as a means by which they can meet their familial, community, and cultural responsibilities. Unfortunately, many collegiate institutions emphasize values and social protocols, a way of understanding, and a way of knowing that are unfamiliar and even hostile to Indigenous worldviews. To better understand the experience of Native and Indigenous STEM Students at our institution, we listened

to students, alumni, faculty, and staff through a series of online forums modeled on the Indigenous tradition of Talking Circles. The discussion from participants in the Talking Circles resulted in 464 coded responses characterized as supports, barriers, and ideas in STEM. The results show how Indigenous students benefit from the integration of cultural wealth that resides in Indigenous knowledge, practices, and protocols. We have also gained insights into the importance of an Indigenized campus

culture and have time-tested and effective programs that teach us how to promote such a culture. We review the major themes identified and provide recommendations to others interested in supporting Indigenous students in STEM.

Introduction

“The thing that is missing, and has always been missing, from Indian education is Indians.”

-Vine Deloria Jr., 1991

“If you see an Auntie at your academic desk, you know everything’s going to be okay.” -Cal Poly Humboldt

Indigenous STEM student, 2021

Research on racially minoritized¹ collegiate student success reveals dissonance between pre-college and college cultures that creates barriers to persistence in the study of science, technology, engineering, and math (STEM) at the individual, personal, interpersonal, institutional, and organizational levels (Mallinckrodt & Sedlacek, 1987; Murguía et al., 1991; Tierney, 1991, 1999; DeSousa & Kuh, 1996; Jun & Tierney, 1999; Kuh & Love, 2000; Rendón et al., 2000; Gonzalez, 2003; Guiffrida, 2003; Museus & Quaye, 2009; Alkholy et al., 2017; Malcom-Piqueux, 2020). Indigenous students encounter many of the same barriers as other students from disenfranchised minority populations. For example, Native students are less likely to have family members who have attended college; have less access to college prep and advanced placement courses in high school; and are more likely to be undercounted in college databases due to smaller size and aggregation into “mixed” or “other” categories (Post-Secondary National Policy Institute, 2020; Colegrove-Raymond, personal communication).

A unique aspect of the Indigenous student experience is that Western institutions of higher education, although built on Indigenous ancestral lands, are grounded in frameworks with values and ways of knowing unfamiliar and even hostile to Native and Indigenous students. Indigenous students must contend with colonially fixed learning environments that disregard the deeply complex knowledges of Indigenous people and typically are not inclusive of Indigenous people or their perspectives in daily campus life (Windchief & Brown, 2017; Lipe, 2018; Brown, 2019). Indigenous retention in STEM can be further challenged by a cultural alienation that exists between Indigenous students, their knowledge, and the perspective from which science is traditionally taught in schools (Tierney, 1991; Cajete, 1999; Bissell, 2004; Alkholy et al., 2017). As much of STEM can appear incompatible with cultural ways of knowing, some fear their participation will lead to the loss of traditional values.

The Cultural Wealth Theory suggests that dominant culture biases can be overcome in educational framing through direct translation of the values of each culture in the educational enterprise, from both the instructor’s and student’s perspectives (Sze, 2018). Integrating the cultural wealth that resides in Indigenous knowledge, practices, and protocols, especially related but not limited to ecological and biocultural restoration, is one way to recruit and retain Indigenous students in STEM (Berkes, 2000; Gavin et al., 2015; Kealiikanakaolehaililani et al., 2018; Guenther et al., 2010; Sterling et al., 2017; Ticktin et al., 2018). Though the idea that Indigenous knowledge and culture are important in supporting the success of Indigenous students is spreading across STEM fields (Alkholy et al., 2017; Estrada et al., 2016), the question of how to create in institutions grounded in Western frameworks an educational environment that respects, honors, and includes Indigenous knowledge continues to be a challenge (LaValle et al., 2019).

Study Location

This study was performed at Cal Poly Humboldt,² a mid-sized master’s-granting state university and the

¹ We use the terms racially minoritized to describe “the process [action vs. noun] of student minoritization” (Benitez, 2010, p. 131) that reflects an understanding of “minority” status as that which is socially constructed in specific societal contexts, and persons excluded by ethnicity and race (PEERS; Asai, 2020) rather than the IPEDS term underrepresented minority. The data is derived from the category “minoritized” in our campus and CSU databases.

² Humboldt State University became California State Polytechnic University, Humboldt (Cal Poly Humboldt) in January 2022. While the article refers to the institution

northernmost California State University (CSU) campus. It is located in a rural setting with a predominantly non-Hispanic white population (~73%, US Census, 2021). As the only CSU campus situated amongst a large Indigenous population, American Indian scholar Vine Deloria Jr., recognized Cal Poly Humboldt as “absolutely unique within the California State University system” (Deloria, 1989). The university resides on the unceded territory of the Wiyot people, who have called the Humboldt Bay region of Northern California home from time immemorial. The local admissions and service area³ includes what the Wiyot people call Goudi’ni (over in the woods) and several thriving Native American tribes and communities, including the three largest federally recognized American Indian tribes in California: Yurok, Karuk, and Hoopa. The relatively large number of American Indian personnel at Cal Poly Humboldt (2012–2020x = 3.3%,⁷ Table 1) have formed the Council of American Indian Faculty and Staff (CAIFS). This multi-tribal, interdisciplinary group includes members from across campus departments, programs, and divisions, as well as several local tribal members and Humboldt alumni.

Generations of people from the local tribes have grown up on and around Cal Poly Humboldt and have come to campus as students and/or as faculty and staff. The campus engagement of the local Indigenous people has cultivated spaces, policies, and partnerships with the Indigenous communities of the region to support Cal Poly Humboldt’s American Indian students (Native American and Alaska Natives [AIAN]). Humboldt’s 17-year average AIAN enrollment is 1.49%, 4.18 times that of the CSU (0.4%; CSU Student Success Dashboard accessed August 8, 2020) and well above the national average (National Center for Science and Engineering Statistics, 2021). Cal Poly Humboldt also has a relatively high percentage of Native American personnel (3.3%) (Cal Poly Humboldt Office of Institutional Research and Analytic Reporting). Cal Poly Humboldt was the

first CSU campus to offer a stand-alone major in Native American Studies (NAS). The American Indian Education minor and Social Work BA and MSW with an emphasis in Indigenous and Rural Communities are longstanding academic programs that provide opportunities for AIAN students to connect their education to Indigenous communities and culture. The Rou Dalagurr Food Sovereignty Lab and Traditional Ecological Knowledges Institute is the first and only food sovereignty lab in the CSU system. Recently, NAS has partnered with other departments and colleges to create culturally responsive degree plans. These include a Certificate in Museum and Gallery Practices with an NAS concentration (Art), a Tribal Forestry Concentration (Forestry), and a Master’s of Engineering: Community Practices (Environmental Resources Engineering). In addition, approximately 70% of all incoming first-year STEM students at Cal Poly Humboldt take a NAS course as part of the first-year Place-Based Learning Communities (PBLCs) (Johnson et al., 2017; Sprowles et al., 2019).

Cal Poly Humboldt also boasts two of the oldest Indigenous student support services in the CSU: the Indian Tribal and Educational Personnel Program (ITEPP) and the Indian Natural Resources, Science and Engineering Program + Diversity in STEM (INRSEP). Established in 1969, ITEPP provides culturally responsive academic advising, co-curricular programming, educational planning, and academic support focused on Indigenous methods of learning and community accountability. ITEPP partners with Institutional Research to identify all students who identify as Indigenous and their tribal affiliations. Advisors reach out to these students and provide wrap-around support that offers students valuable leadership skills, access to scholarships and internship opportunities, connection to local tribes, organizations, and other campus resources. INRSEP was founded in 1972 to locate and train American Indian students for professional resource management positions either within American Indian communities or in federal, state, or local organizations. Today, INRSEP supports students interested in all STEM disciplines. The advisors blend community and professional engagement with academic advising and holistic mentorship, provide bridges to key campus resources, foster student-faculty connections,

as Cal Poly Humboldt, throughout the manuscript respondents may refer to the university as “HSU” as the name change happened while the manuscript was being finalized.

³ The Cal Poly Humboldt local admissions and service area is defined as Del Norte, Humboldt, Northern Mendocino (north of Ukiah), and Western Trinity Counties.

TABLE 1. Demographics of Humboldt State University Administrators, Faculty, and Staff 2012-2020 (October of each year)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
A. Head Count										
White	1019	990	961	978	956	914	875	830	765	921
Black/African American	17	24	27	25	34	35	34	37	36	30
Hispanic/Latino	44	52	57	66	74	79	80	86	81	69
Asian	40	44	43	50	49	47	37	48	43	45
American Indian/Alaska Native	47	46	42	38	41	43	44	44	39	43
Not Specified	90	108	111	119	124	139	148	151	138	125
Native Hawaiian/Oth Pac Island	3	2	1	1	1	1	1	1	0	1
Two or More	37	33	34	40	43	47	47	43	38	40
Total	1297	1299	1276	1317	1322	1305	1266	1240	1140	1274
B. Percent										
White	78.6%	76.2%	75.3%	74.3%	72.3%	70.0%	69.1%	66.9%	67.1%	72.2%
Black/African American	1.3%	1.8%	2.1%	1.9%	2.6%	2.7%	2.7%	3.0%	3.2%	2.4%
Hispanic/Latino	3.4%	4.0%	4.5%	5.0%	5.6%	6.1%	6.3%	6.9%	7.1%	5.4%
Asian	3.1%	3.4%	3.4%	3.8%	3.7%	3.6%	2.9%	3.9%	3.8%	3.5%
American Indian/Alaska Native	3.6%	3.5%	3.3%	2.9%	3.1%	3.3%	3.5%	3.5%	3.4%	3.3%
Not Specified	6.9%	8.3%	8.7%	9.0%	9.4%	10.7%	11.7%	12.2%	12.1%	9.9%
Native Hawaiian/Oth Pac Island	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Two or More	2.9%	2.5%	2.7%	3.0%	3.3%	3.6%	3.7%	3.5%	3.3%	3.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Part A is total head count, part B is percent. Information obtained from Cal Poly Humboldt Institutional Research (Analytics and Reporting 4/2022).

and connect students to internship and research opportunities. INRSEP has many partnerships with tribal communities who are leading the way in managing and co-managing their traditional lands, waterways, airways, and natural resources with methods that include traditional values and traditional science. Both programs are located in Indigenized physical spaces available for study, community, and cultural support. The Food Sovereignty Lab and NAS have also recently started remodeling an area on campus that includes the Goudini Gallery (a Native American arts gallery on campus), the Native American Forum, and the Indigenous Foods Garden and cultural area. This area was recently renamed “Wiyot Plaza”⁴ and will be an Indigenized site for hands-on learning in Indigenous Science and Traditional Ecological Knowledge.

⁴ <https://now.humboldt.edu/news/wiyot-plaza-new-name-campus-space>

Despite Cal Poly Humboldt’s unique support systems for Indigenous students, there are significant gains to be made in STEM enrollment, retention, and completion of undergraduate and graduate STEM degrees. Of the 6941 BS degrees conferred between 2013 and 2021, just 0.46% (n=106) were awarded to AIAN students (Colegrove-Raymond and Office of Institutional Research and Analytic Reporting). This study was conducted to document and understand the Cal Poly Humboldt Indigenous STEM student experience. Here we report our findings and provide recommendations for supporting AIAN students on our campus and others.

Methods

The data was collected from Cal Poly Humboldt students, alumni, faculty, and staff through a series of online forums modeled on Indigenous Talking Circles. “A Talking Circle is a group of individuals working together in an

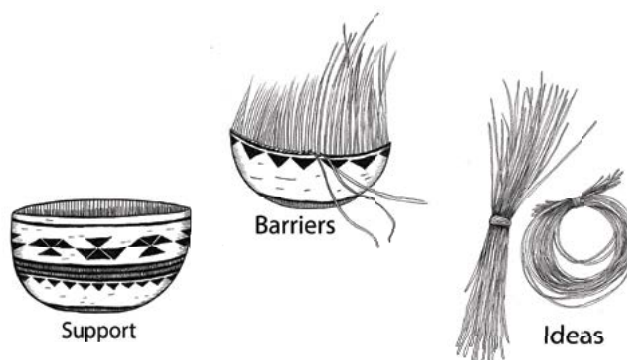
TABLE 2. Talking Circle Participant Groups, Number of People, and Questions

CAIFS (N=2)	Students (N=5)	Alumni (N=3)	Advisors (N=8)
<p>Is there anything you'd say in response to the information you've received about the INCLUDES project?</p> <p>One focus of the report is what HSU is doing well to support Native students. Are there specific things to highlight?</p> <p>Do you see any particular areas of concern that keep tribal students from being successful in STEM at HSU?</p> <p>HSU is already a leader in tribal programs, student supports, language, art, and STEM curricular innovations. In your view/place that you work from, what would make HSU the top tribal-serving STEM institution?</p> <p>Does CAIFS have any particular questions we should ask specific groups of people?</p> <p>What are some ways that we can best approach/interview and interact with specific stakeholder groups?</p>	<p>Tell us a little bit about what your experience at HSU has been like as a Native student. What is something you might tell another student or a potential student about what it is like to attend HSU?</p> <p>What does HSU do well in supporting tribal students in higher education? Are there specific resources/activities/data that should be highlighted? What are some programs or projects that you have been involved in that have been particularly helpful in your success at HSU?</p> <p>Are you currently in a STEM major? a) If yes, why did you decide to go into this major? What has your experience been like in the major? b) If you entered HSU as a STEM major, but are no longer in STEM, why did you switch majors? Was there a reason that you no longer wanted to pursue a STEM major?</p> <p>Tell us a little bit about your STEM major advising experiences at HSU. Have you had other advising experiences on campus that have been helpful in your career at HSU? What resources have been most helpful in making progress towards completion of your science degree?</p> <p>Do you see any particular areas of concern that prevent tribal students from being successful in STEM at HSU? This does not have to just be as a major; consider courses that you take for General Education or for other minor or certificate programs as well.</p> <p>Are there barriers or injustices that you have encountered in your time as a student at HSU? a) If yes, was there anything that assisted you with addressing these issues? Was this helpful for you? Why or why not?</p> <p>What do you think would improve your experience or other student experience in the classroom or with the curriculum that you are being taught?</p> <p>As we work to "reimagine" the STEM fields, what are some areas of opportunity that you could see as a student that would help to make majoring in STEM more beneficial to Native students, Native communities, and Native peoples?</p> <p>HSU is already a leader in tribal programs, student supports, language, art, and STEM curricular innovations. In your view, what would make HSU the top tribal-serving STEM institution?</p>	<p>Tell us a little bit about what your experience at HSU was like as a Native student. What is something you might tell another student or a potential student about what it was like to attend HSU?</p> <p>What does HSU do well in supporting tribal students in higher education? Are there specific resources/activities/data that should be highlighted? What are some programs or projects that you have been involved in that were particularly helpful in your success at HSU?</p> <p>Did you major in a STEM field? a) If yes, why did you decide to go into this major? What was your experience in the major? b) If you entered HSU as a STEM major, but graduated in a different field, why did you switch majors? Was there a reason that you no longer wanted to pursue a STEM major?</p> <p>Tell us a little bit about your major advising experiences at HSU. Did you have other advising experiences on campus that were helpful in your career at HSU? What resources were most helpful in completing your science degree?</p> <p>Do you see any particular areas of concern that prevent tribal students from being successful in STEM at HSU? This does not have to just be a major; consider courses that you took for General Education or for other minor or certificate programs as well.</p> <p>Are there barriers or injustices that you encountered in your time as a student at HSU? a) If yes, was there anything that assisted you with addressing these issues? Was this helpful for you? Why or why not?</p> <p>What experiences or training at HSU do you think would have been useful for your career? What aspects of your education at HSU have been helpful? What was missing?</p> <p>As we work to "reimagine" the STEM fields, what are some areas of opportunity do you see that would help to make majoring in STEM more beneficial to Native students, Native communities, and Native peoples?</p> <p>HSU is already a leader in tribal programs, student supports, language, art, and STEM curricular innovations. In your view, what would make HSU the top tribal-serving STEM institution?</p>	<p>What does HSU do well in supporting tribal students in higher education? Are there specific resources/activities/data that should be highlighted?</p> <p>Do you see any particular areas of concern that keep tribal students from being successful in STEM at HSU?</p> <p>Are there any particular stories or anecdotes that you can share about Native student experiences with STEM majors and STEM fields at HSU? What are some of the reasons that Native students leave STEM majors? What are some reasons that they are successful in STEM majors?</p> <p>Native students who are not STEM majors are still required to take GE STEM courses. What are the experiences like for Native students in these courses? How do you advise Native students in selecting their GE STEM courses? What could improve these courses (curriculum, activity, expectations, etc.) that might help Native students to be successful and/or potentially major or minor in these fields?</p> <p>Considering that we are likely moving in the direction of becoming a Polytechnic Institution, what are some concerns and/or considerations that you would want to highlight for how best to continue to serve and support Native students?</p> <p>As we work to "reimagine" the STEM fields, what are some areas of opportunity do you see that would help to make majoring in STEM more beneficial to Native students, Native communities, and Native peoples?</p> <p>HSU is already a leader in tribal programs, student supports, language, art, and STEM curricular innovations. In your view/place that you work from, what would make HSU the top tribal-serving STEM institution?</p>

intentional way to address a concern or task brought to the circle” (Osborn, 2003). Talking Circles are designed to encourage dialogue and respect so that all voices co-create a learning atmosphere rich in information, identity, and interaction (Brown & Di Lallo, 2020). As the circle is meant to serve as a reminder of the respect and clarity that comes from each individual’s experiences, this culturally appropriate approach can be an effective means of using the group process to address issues of concern for Indigenous people and others (Wilbur et al., 2001; *Talking Circles Overview*, 2009; Bohanon, 2013; Barkaskas & Gladwin, 2021). To take precautions during the COVID quarantine of 2021, the Talking Circles were facilitated online. The raise hand tool in Zoom was used to give each speaker time to respond to a question. The facilitator and participants practiced respectful listening to the experiences of those in the Talking Circle.

Our first Talking Circle was conducted with CAIFS to guide our experimental design, strategy for engaging stakeholders, and interview questions. After incorporating this guidance, the next Talking Circles were conducted with students and advisors. A total of two Talking Circles were conducted to collect student input (one with current students, one with alumni) and a total of three Talking Circles were conducted with advisors. Three facilitators moderated these sessions. The questions that were asked and the number of participants from each stakeholder group are listed in Table 2. This study received approval from the campus Institutional Review Board (IRB# 20-134). Responses from the Talking Circles were recorded, and a transcript was generated automatically (Zoom live transcript function or Otter). The recordings were used

FIGURE 1. Respondents in Talking Circles discussed experiences that supported students through STEM, barriers encountered, and ideas to promote and nurture Indigenous student success in STEM.




to review and cross-check the transcripts to verify that the text represented what the participants said.

Results

An initial analysis of the students’ transcripts by three authors (Baldy, Robinson, Sprowles) revealed 464 responses that fell under three broad categories: “Support,” “Barriers,” and “Ideas” (Figure 1). The basket metaphor symbolizes what each participant carried to this project. The completed basket reflects the woven network of support that respondents discussed. The partially completed basket is unfinished due to lack of resources. The ideas respondents discussed are represented here by the materials used to continue weaving, strengthen existing basket patterns, or make new ones. Recurrent statements in each category were summed and calculated as a proportion of the total responses in each Talking Circle, to standardize

TABLE 3. 464 Responses from Students and Advisors, Categorized As Supports, Barriers, and Ideas

Broad categories of responses	Broad categories of responses	
	Students	Advisors
Support	106	83
Barriers	87	49
Ideas	74	65
Total	267	197

TABLE 4. Themes Discussed in Talking Circles As Providing Support for Indigenous STEM Students


Support	Proportion of responses	
	Students	Advisors
Mentoring and community connections on campus	0.50	0.39
Professional development	0.21	0.29
Course curriculum connections to Indigenous knowledges, TEK, and communities	0.17	0.18
Activities and events with Native communities	0.07	0.12
Indigenized space on campus	0.05	0.06

TABLE 5. Descriptions of Identified Themes from Talking Circle Transcripts of Respondents Discussing Supports for Indigenous Student Success in STEM

Culturally affirming advising, mentoring, and on-campus community connections	Respondents referred to advising by supportive faculty, staff, and advisors that honored cultural and family commitments. Respondents identified specific people connected to campus who provided support. This also includes mentions of flexibility in pursuing interdisciplinary majors or pathways.
Course curriculum connections to Indigenous knowledges, Traditional Ecological Knowledge, and communities	Respondents referred to course curricula that brought together natural resources and Traditional Ecological Knowledge (TEK).
Activities and events with Indigenous communities	Respondents referred to events or activities with off-campus Indigenous communities or community members.
Professional development	Respondents referred to opportunities for career, job, or internship placement and research. Activities include building skill level and confidence.
Indigenized spaces on campus	Respondents referred to the supportive role of having physical, Indigenized spaces on campus in which to connect with culture, feel welcomed, build community, and connect to services.

between the different numbers of participants and responses in each focus group (Table 3). The basket metaphor symbolizes what each participant carried to this project. The completed basket reflects the woven network of support that respondents discussed. The partially completed basket is unfinished due to lack of resources. The ideas respondents discussed are represented here by the materials used to continue weaving, strengthen existing basket patterns, or make new ones.

Supports

There were five themes related to existing student supports revealed from the Talking Circle transcripts. Proportions of responses were calculated by dividing the total number of times the theme was mentioned by the number of responses (Table 4). Descriptions of the

identified themes are found in Table 5. Quotes from the students provide additional context.

“If you see an Auntie at your academic desk, you know everything’s going to be okay.”
– *Student response A*

“I think Native Indigenous students ... really need that connectivity, not only to family but to place, to place-based identity, those cultural practices that we do whether it’s collecting roots or mushrooming or catching salmon or being part of ceremony.”
– *Student response B*

“I think Cal Poly Humboldt does a great job of supporting Native and Indigenous students through ITEPP [Indian Tribal & Educational

Personnel Program] and through INRSEP [Indian Natural Resources, Science & Engineering Program], specifically. I think the resources and the people who work in those two places are really dedicated and engaged and create an atmosphere of caring and community, which is really wonderful for students to find ... away from home. And I think there's an emphasis on not only fostering a sense of belonging, and a sense of 'you're here with us, we've got you,' but also a sense of guidance and facilitation of academic success.... If I hear [a student is] struggling, I make sure that [these programs] know so that we are all an extra support team for that student. I think having professional staff on campus who can simply have their eyes out for a person [struggling] is really powerful."

– *Student response C*

The Cal Poly Humboldt Talking Circle respondents also identified professional development opportunities; course curriculum connections to Indigenous knowledges, Traditional Ecological Knowledge (TEK); activities and events with Indigenous communities; and Indigenized spaces on campus as important support structures.

"Some STEM faculty in particular do a good job making connections with people at ITEPP and INSRSEP and, in turn, because of those connections with our advisors, ... I think that they do a better job at creating spaces for Native students or internships and other things like that. That's one thing HSU as a whole does well is because we're so small, they have the opportunity to make those relationships." – *Student response D*

Respondents referred to specific people or instances when these campus connections were important. They also identified the importance of professional development through opportunities to attend conferences and participate in research. Course curricula or projects that linked to Indigenous knowledges, Traditional Ecological Knowledge, and Indigenous communities provided direct application of their studies. Activities and events with Indigenous communities, as well as Indigenized spaces on campus were mentioned in their role of supporting Native students in STEM. The responses by advisors identified the same key elements of support and the

proportion of responses aligned with the two stakeholder respondents.

Both student and alumni stakeholder groups identified a single motivation for pursuing studies in STEM and a continued driver for student success: to serve Native communities. No other reasons were discussed. Student respondents mentioned three specific campus divisions (Figure 2) in more than 50% of responses when discussing supportive experiences at Cal Poly Humboldt: The Indian Tribal Educational & Personnel Program; The Native American Center for Academic Excellence (ITEPP); Indian Natural Resources, Science and Engineering Program (INRSEP) + Diversity in STEM; and the Native American Studies Department (NAS). Snakenose pattern is a design utilized throughout the Northern California region. We are using it here to illustrate the three programs students mentioned in discussing support through STEM at Cal Poly Humboldt: INRSEP, ITEPP, and NAS.

"Once I actually got involved with mentors and advisors in the Native American Studies department and ITEPP and INRSEP, that's when I started seeing a lot of success, and I started becoming involved in internships and REUs and other experiences on campus and even got new jobs. I put in a lot more effort when it came to ITEPP and INRSEP but it was also because it was so hard to connect with my original advisors. I never even had classes with them or anything so that was difficult." – *Student response E*

"If I didn't have the support programs like ITEPP and INRSEP and NAS, who were constantly advocating for me as a student and other students, I don't think that I would have stayed at HSU." – *Student response F*

"Something for me that's been really beneficial is how within the Native American Studies Department, a lot of times projects and things that you do get turned into actual real-world applications. A lot of people's thesis projects are actually giving back to our community, directly or to students' communities back home or wherever they're doing their work. Having that in the

FIGURE 2. Three programs at Cal Poly Humboldt received the most mention when discussing effective supports for Indigenous STEM students.

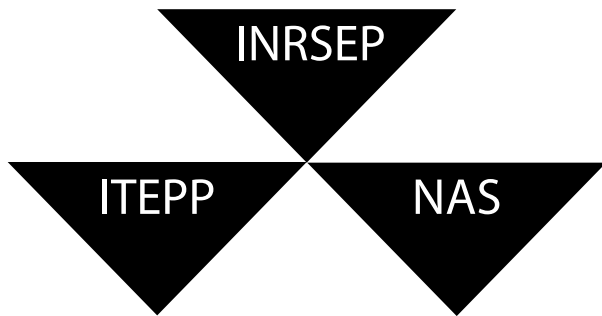


FIGURE 3. Students mentioned INRSEP in 20% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through INRSEP. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning INRSEP.

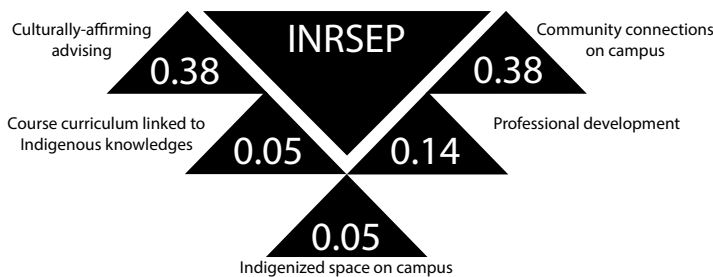


FIGURE 4. Students mentioned ITEPP in 17% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through ITEPP. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning ITEPP.

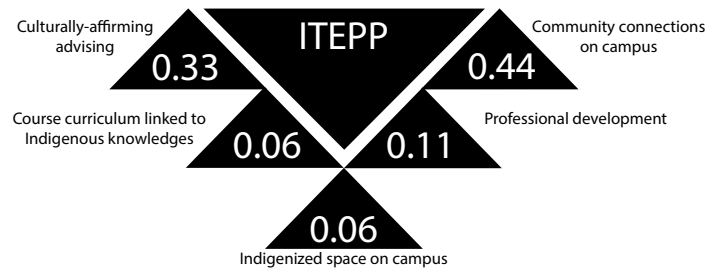
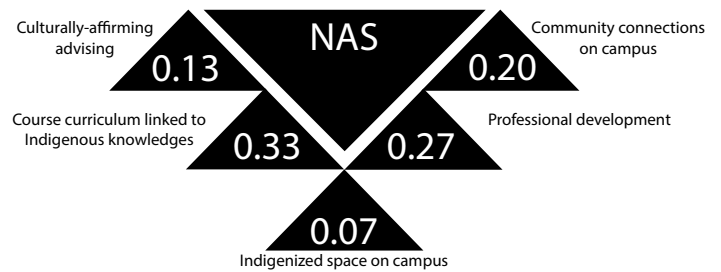


FIGURE 5. Students mentioned NAS in 14% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through NAS. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning NAS.



classroom, the direct connections that the Native American Studies Department can make to the community and local Tribes is really amazing.”
 – Student response G

“Places like ITEPP, INRSEP, and even the NAS lobby create spaces that are comfortable for Native students. I know that when I’m working a lot, having that time in between my classes to just go and sit on the couch and be with other like-minded individuals, it’s really comforting and really nice, because in some way or another, our paths cross, and it’s just nice being able to talk about different issues and see from different perspectives from people that you may have never met if you didn’t go to HSU. So ... one thing that I really appreciate is that we have those spaces to express ourselves.”
 – Student response H

Students reported receiving all of the categories of support identified through each of these organizations, however the percentage of each varied by organization as illustrated in the Big Goose design featured in Figures 2–5.

INRSEP was mentioned in 20% of the responses, ITEPP in 17%, and NAS in 14%. Within these responses, culturally affirming advising and community connections on campus were the most frequent themes associated with INRSEP (Figure 3) and ITEPP (Figure 4). NAS had the most references to course curriculum linked to Indigenous knowledges and professional development (Figure 5).

Barriers


Eight themes describing barriers to Indigenous STEM student success were identified (Table 6). Descriptions are listed in Table 7.

The proportion of responses was calculated for each stakeholder group (students and advisors) as the total number of times the theme was mentioned divided by the

number of responses. A higher proportion of responses is indicated by darker shading.

The importance of culturally affirming advising is revealed by the prominence of non-culturally responsive advising and mentoring, which is listed as one of the barriers to Native STEM student success.

TABLE 6. Themes Discussed in Talking Circles as Barriers for Indigenous Students in STEM



Barriers	Students	Advisors
Finances and time	0.30	0.22
Institutional structure and pathways	0.21	0.39
Cultural taxation	0.14	0.14
Non-culturally responsive advising (i.e., major-based advising)	0.11	0.12
Ideological discord	0.09	0.14
Experiences of racism	0.09	0.02
Low academic confidence	0.05	0.06
Disconnection or isolation from community	0.01	0.00

TABLE 7. Descriptions of Themes from the Talking Circle Transcripts of Respondents Discussing Barriers for Indigenous Student Success in STEM

Non-culturally responsive advising (i.e., major-based advising)	Respondents referred to experiences with advising that did not meet their needs or did not include their culture or community connections. Respondents discussed the format of advising meetings, faculty advisors with whom they have no classes, and a need for more holistic discussions about academic options.
Cultural taxation	Respondents referred to being tokenized in class, taking on the labor of educating professors on Indigenous cultural issues, entering spaces or conversations while feeling isolated, having their knowledge disregarded, being asked to represent all Indigenous people, and/or intervene on curriculum.
Ideological discord	Respondents referred to differences in ideologies such as between Western Science and TEK, or ideological supremacy that does not acknowledge, credit, or respect Indigenous knowledge.
Institutional structure and pathways	Respondents referred to challenges in navigating the college environment, connecting to professors or research opportunities, and the format of large class sizes in which discussion and group work is not supported.
Low academic confidence	Respondents referred to experiencing low academic confidence that impacted their ability to reach out to professors, resources, or fellow students, and included feeling unprepared for STEM courses.
Finances and time	Respondents referred to the impact of finances on their studies, including the necessity of full-time employment that reduced the amount of time available to dedicate to course work, and included the impact of long commutes to and from campus.
Experiences of racism	Respondents referred to experiencing racism.
Disconnection or isolation from community	Respondents referred to isolation from community, either by moving away from their home community, or through the loss of supportive staff.

“I had no connection to my [academic] advisors. They didn’t understand my background, they didn’t understand my culture. A lot of them don’t have a basis from taking an NAS course or history of Native peoples.... The people who helped me the most [were in] ITEPP or INRSEP.... They helped so many science students because students feel comfortable with them, they understand where we’re coming from.... [They] weren’t pushing students, they were allowing us time to heal and helping us through whatever we could and these are people that go above and beyond what their actual jobs and they do not get paid enough to do those things.” – *Student response I*

“As a Native student coming to the University, either I was completely invisible by the university or highly visible—like tokenized—in the classroom. It wasn’t until I joined INRSEP and ITEPP [that] I finally felt a more welcoming, supportive community.” – *Student response J*

Cultural taxation, ideological discord, experiences of racism, and disconnection or isolation from community were also mentioned by students.

“I was always concerned about general courses and science courses, just the clashing of Western thought with Indigenous pedagogies [and] having to choose to be the one to stand up and correct anything in class. You have to just take the burden on yourself as a student and be responsible for educating your professors on cultural competence, which can be really difficult and isolating as a student, you know. No one wants to always be that person necessarily raising their hand for that, but I think the burden is being put on students to have to educate. It should be something required of teachers or in the classroom [through] policies outlined in the class.” – *Student response L*

Advisors identified institutional structure and pathways as an important barrier to Indigenous students’ success in STEM. Advisors mentioned the role of ideological discord as a barrier the same amount as cultural taxation, suggesting an understanding of the links between the two.

Student respondents also describe trauma-inducing experiences of microaggressions, hostility, tokenism, and racism at a higher frequency (0.09) than their advisors (0.02).

“There are many great professors that I learned from who really guided my career and my journey, but I think also there were a lot of problematic macro- and microaggressions that constantly happened as a Native student in STEM and in Western science.” – *Student response N*

“With staff that were largely not folks of color there was a lot of problematic stuff that was going on, a lot of instances or experience of racism. That definitely was a lot of hardship on our part as students and a lot of folks didn’t stick around through the program because of it.” – *Student response O*

“The program that I was in had a lot of really tough times dealing with racism and numerous social justice issues.... There’s not necessarily a form you can just fill out or an easy person to go to where you know that it’s going to get dealt with. It’s really up in the air. [When] something happens to you, you might go to ITEPP and go to other places. We didn’t want to continue to have to deal with some of these issues that we were dealing with and there’s not really a way to fix it outside of just putting in a ton of unpaid labor and effort.... There’s not really a way to give feedback and there are a lot of literal barriers to even get in the room to having those conversations with folks that need to make those changes.” – *Student response P*

Additional barriers articulated by Cal Poly Humboldt Talking Circle participants are similar to those described in the literature for Native and other racially minoritized groups: finances and time, institutional structures and pathways, and low academic confidence.

“I ended up switching [out of STEM] because of the amount of rigor for school for me [while] not having any funding and not being able to get support within the field. A lot of the science courses, they would just always start with the premise

of ‘most of you won’t be here; these are weeder classes.’ [Those classes] scaring people off immediately was too much for me personally and I had to just kind of get in and get out which was really frustrating because I very much love science.”

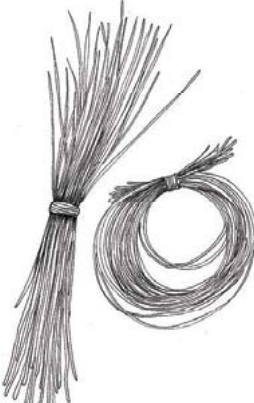
– Student response M

Ideas for Success

Seven different themes emerged to improve the Cal Poly Humboldt Indigenous STEM student experience (Table 8). The descriptions are in Table 9.

The proportion of responses was calculated for each stakeholder group (students and advisors) as the total number of times the theme was mentioned divided by the number of responses (refer to Table 6). A higher proportion of responses is indicated by darker shading.

TABLE 8. Themes Discussed in Talking Circles in Envisioning Ideas to Promote Success for Indigenous Students in STEM



Ideas	Proportion of responses	
	Students	Advisors
Indigenized curriculum adaptations	0.31	0.28
Holistic support	0.18	0.12
Funding for scholarship and programming	0.14	0.12
Tribal liaison	0.12	0.31
Diversify faculty and staff	0.11	0.05
Indigenized spaces	0.08	0.08
Culturally responsive faculty development and training	0.07	0.06

TABLE 9. Description of Themes Identified from the Talking Circle Transcripts of Respondents Envisioning Ideas to Improve Indigenous Student Success in STEM

Indigenized spaces	Respondents envisioned space for Native programs, including updates to existing buildings.
Holistic support	Respondents envisioned holistic support to address personal barriers to academic success, such as the availability of housing and transportation, offering flexible modality courses to accommodate work schedules, and improved course accessibility for Native communities through free online classes.
Culturally responsive faculty development and training	Respondents envisioned training for faculty to improve their understanding about Indigenous knowledges, cultural competency, and tools to support Native students.
Diversify faculty and staff	Respondents envisioned hiring more Native, BIPOC (Black, Indigenous, and other People of Color), and Indigenous faculty and researchers, and employing Native students as mentors.
Indigenized curriculum adaptations	Respondents envisioned curriculum adaptations that center Indigenous knowledge and improve course accessibility for Indigenous communities through free online classes. They also envisioned more options for interdisciplinary studies, to better prepare students for careers that have direct applications for Indigenous communities
Tribal liaison	Respondents envisioned a Tribal Liaison to recruit local Indigenous students and build relationships with local Tribal Nations—to ask what they need, then connect classroom projects or research to serve the community (non-extractive).
Funding for scholarship and programming	Respondents envisioned additional funding to support existing programs and expand scholarships and work-study opportunities.

Student respondents prioritized growing community partnerships, Indigenized curriculum adaptations, and the inclusion of Indigenous knowledges in curricula.

“There’s a lot of opportunity for the work that students are doing on campus to directly benefit Indigenous communities in our area. It would be cool to have folks whose job it is to make those connections. I’d love to have more classes related to [Indigenous knowledge and management]. I feel like it’s really fruitful being able to help Indigenous people outside of just my own community [by asking] our communities every year what they need and then building curriculum in classes around that—every year doing projects that center on what they need.” – *Student response Q*

“There is a history in STEM of not acknowledging Indigenous knowledges. Giving credit to Indigenous knowledge is also a way to support Indigenous students.... To acknowledge and teach, really teach, these knowledges encourages Native students to feel like ... it is respected and that’s really needed in the [STEM] curriculum.” – *Student response R*

“HSU should have a required course of TEK (like forestry TEK, fisheries TEK, or wildlife TEK), completely from a TEK viewpoint. That would go a long way to not only increase the knowledge for non-Indigenous students but also to make Indigenous students feel more connected to the program.” – *Student response S*

Providing culturally responsive training for faculty was mentioned to potentially address the barriers discussed, such as cultural taxation and experiences of racism.

“You need to equip instructors to be able to reflect what’s happening within the student body. And that might very well require some serious investment in education for them. Bringing down barriers and injustices is going to take everybody, not just students.” – *Student response T*

Student respondents expressed wanting to see diverse faculty, staff, and student mentors that included Native American and other Indigenous peoples.

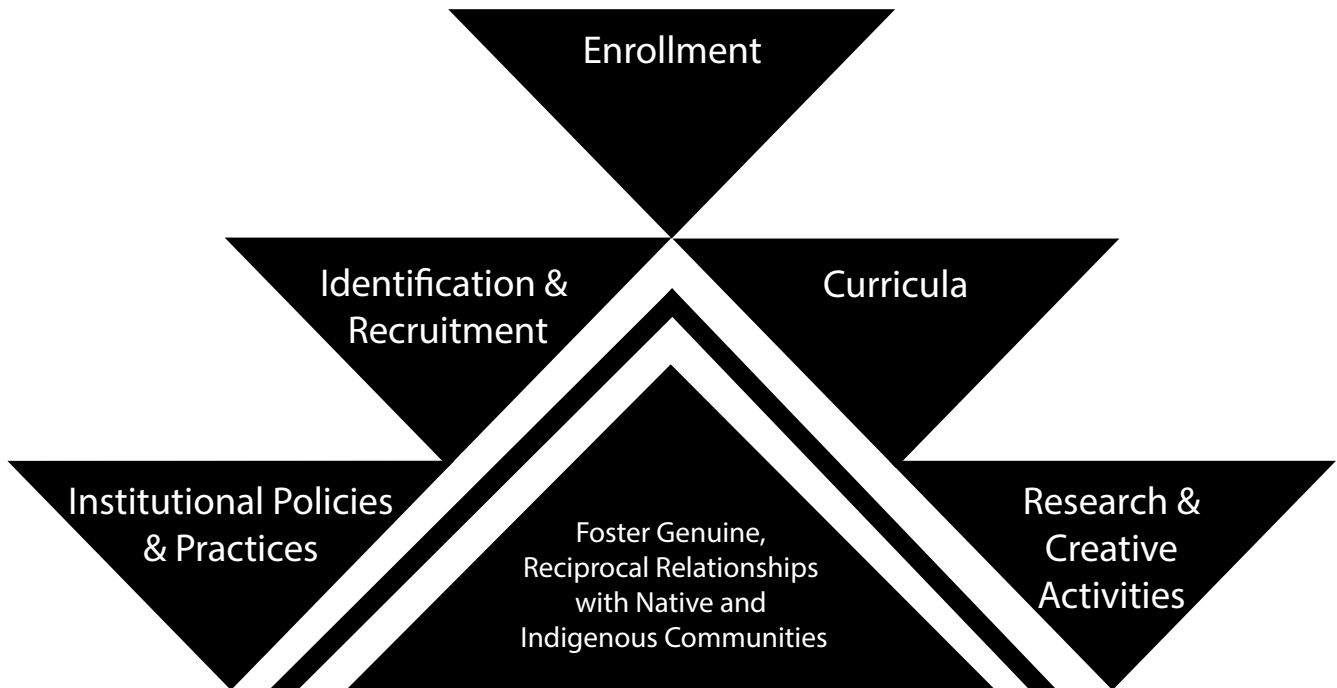
None of the respondents’ recommendations provide an avenue to address microaggressions or a way to care for those students who have experienced racial trauma.

Conclusions

By listening to Cal Poly Humboldt Indigenous STEM students and their advisors, we have learned that our Indigenous STEM students benefit when their education connects to their cultural heritage, honors their cultural wealth, and provides opportunities for them to directly assist their home communities. The student respondents in our study identified a single motivation for studying STEM—to serve Native communities. Furthermore, whether discussing supports, barriers, or ideas for improvement, student participant responses are unified in expressing the importance of engaging with Indigenous people, communities, and values in all dimensions of the educational experience. Our results support those of others who have described the importance of weaving the cultural values and heritage of Indigenous students into science education (Cajete 1999; Berkes 2000; Gavin et al. 2015; Kealiikanakaoleohaililani et al. 2018; Guenther et al. 2010; Sterling et al. 2017; and Ticktin et al. 2018).

We have also gained insights into the importance of an Indigenized campus culture. For decades, Cal Poly Humboldt’s relatively high percentage of administrators, faculty and staff who identify as Indigenous have fostered collaborations with Tribal communities individually and collectively (CAIFS). This has created opportunities for students to support Tribal initiatives for education, research, and caring for traditional lands with methods that include Traditional Knowledge. Cal Poly Humboldt students specifically highlight the importance of ITEPP, INRSEP, and the Department of Native American Studies. Their responses reveal how these three organizations synergize to provide curricular, co-curricular, and holistic support in an Indigenized framework. Though the focus of each is slightly different, all three include a high percentage of Indigenous personnel, exist in Indigenized campus spaces, and proactively reach out to Indigenous students; acknowledge their tribal affiliations and cultural

FIGURE 6. Recommendations for supporting Indigenous STEM students. These recommendations are grounded in the voices of Cal Poly Humboldt Indigenous students and their advisors. They are contextualized by the authors' expertise and insights.



University policies, programs, curricula, research and creative activities should be co-visioned in collaboration with Indigenous communities

Institutional Policies	Identification and Recruitment	Enrollment and Support	Curricula	Research and Creative Activities
<p>Enrich campus personnel with Indigenous people</p> <p>Waive tuition and fees for Indigenous students</p> <p>Commit to Indigenized campus spaces and Indigenous programs</p> <p>Create a Tribal Liaison position</p> <p>Require professional development for campus personnel that create opportunities to understand, respect, and connects with Indigenous perspectives</p> <p>Require education of all campus personnel in the ethics of incorporating Indigenous knowledge before including that content in their courses</p>	<p>Adopt ITEPP's Native student identification protocol to reveal students who identify as Native American, Alaskan Native, Native Hawaiian, and/or Pacific Islander that would not be seen using IPEDS methods</p> <p>Included non-binary/two-spirited and transgender people in enrollment data</p> <p>Work with Tribal Education Offices to proactively target Native K-12 students</p> <p>Create and incentivize transfer pathways with community colleges and tribal colleges</p>	<p>Create culturally responsive mentoring and advising for Indigenous students</p> <p>Create culturally responsive training program for campus advisors that includes trauma informed care</p> <p>Leverage student Tribal affiliation information to partner with Tribal Nations to improve support of Native students</p> <p>Ensure course assignments accommodate cultural obligations of Indigenous students</p>	<p>Collaborate with NAS Department and engage cultural practitioners and scientists to infuse STEM curriculum with TEK and Indigenous ways of knowing</p> <p>Create paid experiential learning opportunities for Native students with Tribal partners</p> <p>Establish learning outcomes for all courses that include TEK and Indigenous knowledges</p> <p>Include Native American Studies courses in STEM degree pathways</p> <p>Incorporate educational practices that are responsive to diverse learning strategies</p>	<p>Require review of all external grants that involve projects with Indigenous people by a qualified board as part of the pre-award process</p> <p>Establish protocols for research, publication, and dissemination in conjunction with each Indigenous community</p> <p>Ensure all research and creative projects that involve Native and Indigenous topics give back to those communities</p> <p>Develop an inventory of all projects that involve Native and Indigenous communities</p> <p>Involve Native and Indigenous students in research projects conducted by both Native and/or non-Native faculty that are in collaboration with Native communities</p>

backgrounds; provide holistic, culturally responsive advising; provide physical spaces to bridge culture with the campus community; intentionally connect students with self-relevant role models who weave Indigenous culture and knowledge into curricular and co-curricular experiences, and create opportunities to engage with Native communities.

The Indigenized campus experience provided by ITEPP, INRSEP, and NAS have enabled the support for Indigenous students that moves beyond acknowledgement and toward an ethical praxis of being in place. The student responses suggest this supports the development of two critical psycho-social factors essential for STEM student success: *belonging* (meaning students feel that they are legitimate members of the Academic community rather than strangers in a strange land; McClellan, 2018) and the sense of *becoming* (students have a clear vision of the path in front of them so they know where they are going and how they will get there; Habib & Ward, 2019). Achieving belonging and the self-efficacy created through becoming can be challenging for all students (Trujillo & Tanner, 2014), but it can be especially difficult for Indigenous STEM students to achieve because of the intergenerational transmittance of trauma they experience (Waretini-Karena, 2014; Linklater, 2014). Honoring and legitimizing Indiepistemological ways of knowing is a significant step in healing, as is recognition of specific cultural trauma experiences (Braveheart, 1999; Duran & Duran, 1995).

The authentic, reciprocal relationships between Indigenous campus personnel and the Tribal communities of the service area have resulted in important campus policies and practices that prime the institution towards creating a culturally responsive campus culture and promoting the reconciliation required to complete the collegiate half of the Indigenous Student Life Cycle described in this Forum's Introduction, "The Indigenous Knowledges, Encouragements, Engagements, and Experiences ('IKE) Alliance for Transforming STEM Education." In Figure 6, we propose recommendations for our campus and other campuses interested in improving support for Indigenous STEM students. We also suggest looking at organizations who have established policies, such as [Social Sciences and Humanities Research Council of Canada's Indigenous Research Statement of Principles](#) and the

[University of California's Native American Opportunity Program](#) as examples of policies that respect and enhance Indigenous people.

Acknowledgments

We thank the Cal Poly Humboldt Council of American Indian Faculty and Staff, students, alumni, advisors, the Office of Institutional Research and Analytic Reporting, Admissions, Upward Bound, EOP, and former Dean of the College of Natural Resources and Sciences and Professor of Mathematics Dale Oliver for their support and contributions to this study. We are grateful for the mentoring and guidance of our SENCER and 'IKE Alliance colleagues, with special thanks to Hokulani Aikau, Ulla Hasager, Amy Shachter; Marty Matlock, Nasrin Mirsaleh-Kohan, Summer Rae Wilkie, Tom Wood, Mike Durgalo, Eliza Reilly, and Robert Franco.

This project was supported by the National Science Foundation INCLUDES Planning Grant (# 2040991) and the Humboldt Howard Hughes Medical Institute Inclusive Excellence Award (#52008703).

References

- Alkholly, S. O., Gendron, F., McKenna, B., Dahms, T., & Ferreira, M. P. (2017). *Convergence of Indigenous science and Western science impacts student's interest in STEM and identity as a scientist*. <http://digitalcommons.wayne.edu/nfsfrp/16>
- Asai, D. J. (2020). Race matters. *Cell*, 181(4), 754-757.
- Barkaskas, P., & Gladwin, D. (2021). Pedagogical talking circles: Decolonizing education through relational Indigenous frameworks. *Journal of Teaching and Learning*, 15(1), 20–38.
- Benitez Jr, M. (2010). Resituating culture centers within a social justice framework. In L. D. Patton (Ed.), *Culture centers in higher education: Perspectives on identity, theory, and practice* (pp. 119-134). Stylus Publishing.
- Berkes, F. (2000). *Linking social and ecological systems*. Cambridge University Press.
- Bissell, T. (2004). The digital divide dilemma: Preserving Native American culture while increasing access to information technology on reservations. *Journal of Law, Technology and Policy*, 1, 129–150.
- Bohanon, J. P. (2013). *The talking circle: A perspective in culturally appropriate group work with indigenous peoples*. University of Saskatchewan I-Portal: Indigenous Studies Portal. <https://iportal.usask.ca/record/38787>

- Braveheart, M. (1999). *Oyate Ptayela: Rebuilding the Lakota Nation through addressing historical trauma among Lakota parents*. *Journal of Human Behavior in the Social Environment*, 2(1–2), 109–126.
- Brown, K. (2019). Creating culturally safe learning spaces and Indigenizing higher education. *Journal of Learning Spaces*, 8(2), 57–64.
- Brown, M. A., & Di Lallo, S. (2020). Talking circles: A culturally responsive evaluation practice. *American Journal of Evaluation*, 41(3), 367–383.
- Cajete, G. A. (1999). The Native American learner and bicultural science education. In K.G. Swisher & J.W. Tippeconnic (Eds.), *Next steps: Research and practice to advance Indian education* (pp. 135–160). ERIC Clearinghouse on Rural Education and Small Schools.
- Colegrove-Raymond, Adrienne and Franco, B. 2022. *Improving Data System for Equitable Inclusion and Success of Indigenous Students in STEM*, 'IKE Alliance Data Gathering, September 2022
- Deloria Jr, V. (1989). 1989_American Indians and Humboldt State. ScholarWorks, Cal Poly Humboldt. <https://scholarworks.calstate.edu/concern/publications/9wo325368>
- DeSousa, D. J., & Kuh, G. D. (1996). Does institutional racial composition make a difference in what Black students gain from college? *Journal of College Student Development*, 37(3), 257–267.
- Duran, E., & Duran, B. (1995). *Native American postcolonial psychology*. SUNY Press.
- Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., & Zavala, M. (2016). Improving underrepresented minority student persistence in STEM. *CBE Life Sciences Education*, 15(3). es5. <https://doi.org/10.1187/cbe.16-01-0038>
- Gavin, M. C., McCarter, J., Mead, A., Berkes, F., Stepp, J. R., Peterson, D., & Tang, R. (2015). Defining biocultural approaches to conservation. *Trends in Ecology & Evolution*, 30(3), 140–145. <https://doi.org/10.1016/j.tree.2014.12.005>
- Gilio-Whitaker, D. (2019). *As long as grass grows: The Indigenous fight for environmental justice from colonization to Standing Rock*. Beacon Press.
- Gonzalez, K. P. (2003). Campus culture and the experiences of Chicano students in a predominantly White university. *Urban Education*, 37(2), 193–218.
- Guenther, J., Castle, K., Raymond, N., & Berschl, K. (2010). Training for employment outcomes in Indigenous contexts: Straddling the space between cultures. *Vocal: The Australian Journal of Vocational Education and Training in Schools*, 8, 86–94.
- Guifrida, D. A. (2003). African American student organizations as agents of social integration. *Journal of College Student Development*, 44(3), 304–319. <https://doi.org/10.1353/csd.2003.0024>
- Guterl, F. (2014). The inclusion equation. *Scientific American*, 311(4), 38–41.
- Habib, S., & Ward, M. R. (2019). Introduction: Investigating youth and belonging. In S. Habib and M. Ward (Eds.), *Youth, place and theories of belonging* (pp. 1–11). Routledge.
- Hofstra, B., Kulkarni, V. V., Munoz-Najar Galvez, S., He, B., Jurafsky, D., & McFarland, D. A. (2020). The diversity-innovation paradox in science. *Proceedings of the National Academy of Sciences of the United States of America*, 117(17), 9284–9291. <https://doi.org/10.1073/pnas.1915378117>
- Johnson, M., Sprowles, A., Overeem, K., & Rich, A. (2013). A Place-Based Learning Community: Klamath Connection at Humboldt State University. *Learning Communities: Research & Practice*, 5(2), n2.
- Jun, A., & Tierney, W. G. (1999). At-risk students and college success: A framework for effective college preparation programs in urban environments. *Metropolitan Universities*, 9(4).
- Kealikianakaoehaililani, K., Kurashima, N., Francisco, K. S., Giardina, C. P., Louis, R. P., McMillen, H., Asing, C., Asing, K., Block, T., Browning, M., Camara, K., Camara, L., Dudley, M., Frazier, M., Gomes, N., Gordon, A., Gordon, M., Heu, L., Irvine, A.... Yogi, D. (2018). Ritual + sustainability science? A portal into the science of aloha. *Sustainability*, 10(10).
- Kuh, G. D., & Love, P. G. (2020). A cultural perspective on student departure. In J. M. Braxton (Ed.), *Reworking the student departure puzzle* (pp. 196–212). Vanderbilt University Press.
- La Valle, F. F., Camvel, D. A. K., Thomas, F. I. M., Aikau, H. K., & Lemus, J. D. (2019). Interdisciplinary research through a shared lexicon: Merging 'Ike kupuna and Western science to examine characteristics of water. *Hulili: Multidisciplinary Research on Hawaiian Well-Being*, 11(8), 167–185.
- Lee, D. N. (2014). Scientists draw on personal experience to guide their curiosity. *Scientific American*, 311(4), 47.
- Linklater, R. (2014). *Decolonizing trauma work: Indigenous stories and strategies*. Fernwood Publishing.
- Lipe, K. (2018). Toward equity and equality: Transforming universities into Indigenous places of learning. In R. S. Minthorn & H. J. Shotton (Eds.), *Reclaiming Indigenous research in higher education* (pp. 162–177). Rutgers University Press.
- Malcom, S., & Malcom-Piqueux, L. (2020). Institutional transformation: Supporting equity and excellence in STEM. *Change*, 52(2), 79–82. <https://doi.org/10.1080/00091383.2020.1732792>
- Malcom-Piqueux, L. (2020). Transformation in the US higher education system: Implications for racial equity. In *Symposium on Imagining the Future of Undergraduate STEM Education*.
- Malcom-Piqueux, L. (2022). Transformation in the U.S. higher education system: Implications for racial equity. *Imagining the Future of Undergraduate STEM Education: Proceedings of a virtual symposium* (pp. 15–16). National Academies Press.
- Mallinckrodt, B., & Sedlacek, W. E. (1987). Student retention and the use of campus facilities by race. *NASPA Journal*, 24(3), 28–32. <https://doi.org/10.1080/00220973.1987.11072005>
- McClellan, E. (2018). Communities of practice that contribute to undergraduate Identity construction: A case study. *Action, Criticism & Theory for Music Education*, 17(3).
- Meador, A. (2018). Examining recruitment and retention factors for minority STEM majors through a stereotype threat lens: Minority STEM major. *School Science and Mathematics*, 118(1–2), 61–69. <https://doi.org/10.1111/ssm.12260>

- Mosholder, R. S., Waite, B., Larsen, C. A., & Goslin, C. (2016). Promoting Native American college student recruitment & retention. *Higher Education. Multicultural Education*, 23, 27–36.
- Murguía, E., Padilla, R. V., & Pavel, M. (1991). Ethnicity and the concept of social integration in Tinto's model of institutional departure. *Journal of College Student Development*, 32(5) 433–439.
- Museus, S. D., & Quayle, S. J. (2009). Toward an intercultural perspective of racial and ethnic minority college student persistence. *The Review of Higher Education*, 33(1), 67–94. <https://doi.org/10.1353/rhe.0.0107>
- National Center for Science and Engineering Statistics. (2021). *Diversity and STEM: Women, minorities, and persons with disabilities*. <https://ncses.nsf.gov/wmpd>
- Okrent, A., & Burke, A. (n.d.). *The STEM labor force of today: Scientists, engineers, and skilled technical workers*. National Science Board. <https://ncses.nsf.gov/pubs/nsb20212/executive-summary>
- Osborn, D. (n.d.). *Talking Circles: Connections to Nurture Our Practice*. Talking circles overview from the First Nations Pedagogy Online Project, 1. <https://firstnationspedagogy.ca/circletalks.html>
- Phillips, K. W. (2014). How diversity works. *Scientific American*, 311(4), 42–47. <https://doi.org/10.1038/scientificamerican1014-42>
- Post-Secondary National Policy Institute. (2021, December 15). *COVID-19 & online education – PNPI Fact Sheet*. <https://pnpi.org/covid-19onlineeducation/>
- Rendón, L. I., Jalomo, R. E., Nora, A., & Braxton, J. M. (2000). Theoretical considerations in the study of minority student retention in higher education. In J. M. Braxton (Ed.), *Reworking the student departure puzzle* (pp. 127–156). Vanderbilt University Press.
- Sawyer, S. (2001). *Policies and programs of the University of New Mexico on Native American student persistence* (Publication No. 3016138) [Doctoral dissertation, University of New Mexico]. ProQuest Dissertations and Theses.
- Snyder, T. D., & Dillow, S. A. (2013). *Digest of Education Statistics 2013*. National Center for Education Statistics.
- Spowles, A., Goldenberg, K., Goley, P. D., Ladwig, S., & Shaughnessy, F. J. (2019). Place-Based Learning Communities on a Rural Campus: Turning Challenges into Assets. *Learning Communities: Research & Practice*, 7(1), 6.
- Spowles, A.E., M.D. Johnson, S. Margell, Malloy K.J., Morehead-Hillman, L., Hillman, L.C.C., Rich, A., Smith, J., Shaughnessy, F., Hurst, M.P., Mazzag, M., Oliver, D., Manor, S., Cashman, E., Siering, P., O'Dowd, A., Goley, P.D., Black, G., Goldenberg, K.R., and Johnson, M.J. 2024. "Integrating Indigenous Science, Culture, and Social Justice Concerns into first year STEM curriculum improves intellectual growth, psychosocial factors associated with retention, and academic achievement of students from racially minoritized groups historically underrepresented in STEM." *Science Education and Civic Engagement* 16(2).
- Sterling, E. J., Filardi, C., Toomey, A., Sigouin, A., Betley, E., Gazit, N., Newell, J., Albert, S., Alvira, D., Bergamini, N., Blair, M., Boseto, D., Burrows, K., Bynum, N., Caillon, S., Caselle, J. E., Claudet, J., Cullman, G., Dacks, R., and Jupiter, S. D. (2017). Biocultural approaches to well-being and sustainability indicators across scales. *Nature Ecology & Evolution*, 1(12), 1798–1806. <https://doi.org/10.1038/s41559-017-0349-6>
- Sze, J. (Ed.). (2018). *Sustainability: Approaches to environmental justice and social power*. New York University Press. <https://doi.org/10.18574/nyu/9781479894567.001.0001>
- Talking circles overview from the first nations pedagogy online project*. (2009). First Nations Pedagogy Online. <https://firstnationspedagogy.ca/circletalks.html>
- Ticktin, T., Quazi, S., Dacks, R., Tora, M., McGuigan, A., Hastings, Z., & Naikatini, A. (2018). Linkages between measures of biodiversity and community resilience in Pacific Island agroforests: Community resilience. *Conservation Biology: The Journal of the Society for Conservation Biology*, 32(5), 1085–1095. <https://doi.org/10.1111/cobi.13152>
- Tierney, W. G. (1991). Native voices in academe: Strategies for empowerment. *The Magazine of Higher Learning*, 23, 36–39.
- Tierney, W. G. (1999). Models of minority college-going and retention: Cultural integrity versus cultural suicide. *The Journal of Negro Education*, 68(1), 80–91. <https://doi.org/10.2307/2668211>
- Trujillo, G., & Tanner, K. D. (2014). Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity. *CBE—Life Sciences Education*, 13(1), 6–15.
- US Census. (2021). *Improved race and ethnicity measures reveal U.S. population is much more multiracial*. <https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html>
- Valle, L. A., Camvel, F. F., Thomas, D. A., Aikau, F. I., & Lemus, H. K. (2019). Interdisciplinary research through a shared lexicon: Merging 'Ike kupuna and Western science to examine characteristics of water. *Hāhili: Multidisciplinary Research on Hawaiian Well-Being*, 11(1), 167–181.
- Waretini-Karena, D. (2014). Transforming Māori experiences of historical intergenerational trauma [Unpublished doctoral dissertation]. Te Whare Wānanga o Awanuiārangi.
- Wilbur, J. R., Wilbur, M., Garrett, M. T., & Yuhus, M. (2001). Talking circles: Listen, or your tongue will make you deaf. *Journal for Specialists in Group Work*, 26(4), 368–384.
- Windchief, S., & Brown, B. (2017). Conceptualizing a mentoring program for American Indian/Alaska Native students in the STEM fields: A review of the literature. *Mentoring & Tutoring: Partnership in Learning*, 25(3), 329–345. <https://doi.org/10.1080/13611267.2017.1364815>

Contributions

C. R. B., H. E. R. made equal contributions to this work. C. R. B., H. E. R., A. C.-R., M. D., N. B. W., and A. E. S. conceptualized and designed the project. A. C.-R. performed the campus demographic data analysis. C. R. B., H. E. R., M. D., and A. E. S. performed the qualitative data collection. H. E. R. and M. D. transcribed the talking circle responses. H. E. R., C. R. B., and A. E. S. identified consistent themes from the responses. H. E. R.

performed the quantitative analysis of the qualitative data. All authors participated in qualitative data interpretation. H. E. R. created the data tables and figures. M. J. is the artist who created the images for the basket metaphor. A. C.-R., N. B. W., and C. R. B. contributed information on Indigenized academic and co-curricular supports. A. E. S. drafted the manuscript. All authors contributed to revising the final manuscript. A. E. S. supervised and coordinated the whole work.

This study received approval from the campus Institutional Review Board (IRB# 20-134).

About the Authors



Dr. Cutcha Risling Baldy, Associate Professor of Native American Studies at Cal Poly Humboldt, researches Indigenous feminisms, California Indians, Environmental Justice, Indigenous Natural Resource Manage-

ment, mental health and cultural interventions, and decolonization. She is the Co-Director of the NAS Food Sovereignty Lab & Traditional Ecological Knowledges Institute and Co-Principal Investigator National Science Foundation FIRE-PLAN grant in collaboration with the Karuk Tribe. She is also one of the Guiding Leaders for the State of California Native American Studies Model Curriculum project.

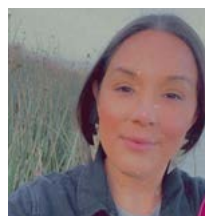


Dr. Eve Robinson is an Assistant Professor (Teaching) in Biological Sciences at the University of Calgary, Alberta, where she lives, works, and plays on Treaty 7 territory. She earned her Masters in marine science and PhD in integrative biology while becoming passionate about supporting experiential learning, adopting inclusive teaching practices, and promoting a sense of belonging for students in STEM. Previously, she led a first-year learning community at Cal Poly Humboldt for students in marine science and oceanography. NSF Transcending Barriers INCLUDES Planning Grant.



Adrienne Colegrove-Raymond serves as Cal Poly Humboldt's first Special Assistant to the President for Tribal Relations & Community Engagement. In this capacity she supports outreach to tribal nations

and help develop collaborative partnerships in the community while leading key initiatives. C A member of the Hoopa Valley Tribe, she has deep ties with local Native Tribes, Cal Poly Humboldt, and the North Coast. She is a member of the California State University Native Initiatives Executive Committee and the Humboldt County Foster Youth Education Executive Advisory Council. She has previously served as the director of Indian Tribal & Educational Personnel Program (ITEPP) and ELITE Scholars, Interim Director of the Cultural Centers for Academic Excellence, and as director of Student Academic Services Outreach Program/Talent Search/ELITE Scholars at Cal Poly Humboldt. She is an alumna of the Humboldt Journalism Department.



Marlene' Dusek comes from the Payómkawichum, Kúupangawish, and Iipai Kumeyaay people and grew up on the Rincon Reservation. She is an Indigenous queer woman, cultural practitioner, weaver, tradi-

tional foods and medicines practitioner, cultural burner, language learner, teacher, master food preserver, and community member who has always been in a relationship with the land since she was a child and stewarded in various ways using methods of Indigenous cultural management and TEK. She graduated from Cal Poly Humboldt with her Master's in Environment and Community with an emphasis in Indigenous Natural Resource Management. She also graduated from Humboldt State University with a Bachelor of Science in Environmental Management with an emphasis in Planning and Policy and a minor in Native American Studies, with a focus on Federal Indian Law. Marlene' has been a professor at Cal Poly Humboldt in the Native American Studies Department where she taught the Food Sovereignty Lab course. She also is currently the Indigenous Stewardship Coordinator for the Climate Science Alliance.



Melitta Jackson is a Yurok tribal member, Karuk and Hupa descendant. She graduated from what is now Cal Poly Humboldt in 2017 with a Bachelor's in Art Studio. Currently works for the Cal Poly Humboldt Library as the Resource Sharing and Information Specialist.



Dr. Nievita Bueno Watts is a first-generation college graduate, geoscientist and science educator whose work focuses on opening pathways and mentoring students in the sciences. Dr. Watts is currently Director of the Indian Natural Resources, Science and Engineering Program (INRSEP) + Diversity in STEM at Cal Poly Humboldt. INRSEP staff mentor science, technology, engineering and math (STEM) students through their degrees and on to graduate school or the STEM workforce.



Dr. Amy Spowles is an Associate Professor of Cellular and Developmental Biology at Cal Poly Humboldt. A fourth-generation educator, her career has focused on inclusivity in STEM education. She currently serves as the Faculty Associate Dean for Undergraduate and Graduate Programs, the Director of the Cal Poly Humboldt HHMI IE'17 Award, and the Director of the Humboldt/California Institute for Regenerative Medicine (CIRM) Bridges Training Program. Dr. Spowles was the director of the Humboldt INCLUDES Planning Grant, is an 'IKE Alliance Member, SENCER Ambassador, and is a guest editor of this special edition.

RESEARCH
REPORT

Integrating Indigenous Science, Culture, and Social Justice Concerns into First-Year STEM Curriculum: Improving Intellectual Growth, Psychosocial Factors Associated with Retention, and Academic Achievement of Students from Racially Minoritized Groups Historically Underrepresented in STEM

AMY SPROWLES
Cal Poly Humboldt

STEVEN MARGELL
Cal Poly Humboldt

KERRI J. MALLOY
San Jose State University

LISA MOREHEAD-HILLMAN
Karuk Tribe's Pikyav Field Institute

L. CHOOK CHOOK HILLMAN
Indigenous scientist, cultural practitioner, and educator

ANGELA RICH
Cal Poly Humboldt

JESSICA SMITH
RTI International

FRANK SHAUGHNESSY (deceased)
Cal Poly Humboldt

MATTHEW P. HURST
Cal Poly Humboldt

BORBOLLA MAZZAG
Cal Poly Humboldt

DALE OLIVER
Cal Poly Humboldt

SONJA MANOR
Cal Poly Humboldt

EILEEN CASHMAN
Cal Poly Humboldt

PATRICIA SIERING (deceased)
Cal Poly Humboldt

ALISON O'DOWD
Cal Poly Humboldt

P. DAWN GOLEY
Cal Poly Humboldt

GILLIAN BLACK
Cal Poly Humboldt

KATLIN R. GOLDENBERG
Cal Poly Humboldt

MATTHEW D. JOHNSON
Cal Poly Humboldt

Abstract

Deficits in college degree attainment limit important perspectives and ways of knowing that inspire creativity and innovation. Disproportional outcomes for racially minoritized groups that are historically underrepresented in science, technology, engineering, and mathematics exacerbate this problem and promote societal inequities, structural racism, professional segregation, and racial wealth gaps. Culturally responsive programming that incorporates empathy and equity for non-majority populations can empower students from diverse backgrounds to achieve their educational goals. This paper describes the outcomes of a first-year place-based learning community in which students studied the science, culture, values, and social justice concerns of the Indigenous people of the Klamath River Basin by completing a water quality experiment alongside faculty, Indigenous scientists, and cultural experts. A combination of survey data and thematic analysis was used to evaluate the impact of the program on intellectual growth, gains in psychosocial factors associated with first-year student success, and academic achievement. All student participants demonstrated intellectual growth and gains in psychosocial factors associated with STEM retention, but the effects were most pronounced for students who identified parallels between issues faced by Native American communities and their home communities. The most significant gains in STEM retention and academic achievement occurred for URG students (students from underrepresented groups) who learned about Native American culture through the water quality laboratory. The majority of students expressed the importance of understanding the cultural, environmental, and/or social justice issues of Native American people to their future careers. We believe ours is one of the first studies that specifically examines the improved outcomes for first-year URG college STEM students that can result from curriculum that highlights scientific, cultural, and social justice concerns of Indigenous communities.

Introduction

Deficits in college degree attainment limit important perspectives and ways of knowing that inspire creativity and innovation (Hong and Page, 2004; Kozlowski et al., 2022). Disproportional outcomes for racially minoritized groups that are historically underrepresented (hereafter referred to as URG) in science, technology, engineering, and mathematics (STEM) (NCSES, 2021) exacerbate this problem and promote societal inequities, structural racism, professional segregation, and racial wealth gaps (Chesky and Wolfmeyer, 2015). Student motivation to overcome barriers to persistence, retention, and graduation is increased when they see connections between their educational experience, community values, and career goals (Mishra, 2020). Linking STEM content to equity and empathy concerns is particularly impactful on URG student motivation and STEM retention, especially when students are presented with STEM career possibilities that integrate opportunities to address social and civic issues (McGee & Bentley, 2017; Gray et al., 2022). First-year STEM learning communities that include educationally purposeful activities within and outside the classroom can also create a sense of belonging, enhance student engagement, and promote personal development to result in improved graduation rates (Otto et al., 2015).

To improve STEM success at our university, we created a first-year place-based learning community called Klamath Connection (Johnson et al., 2017; Sprowles et al. 2019), which explores the science, culture, civic, and social justice issues of the Native American people of the Klamath River Basin. In August 2007, water quality scientists from the Karuk Tribe of California discovered *Microcystis aeruginosa* (*M. aeruginosa*) behind the Klamath River dams¹ (Kann & Corum, 2009). *M. aeruginosa* blooms have environmental and health consequences around the globe, resulting in increased anoxic events and the accumulation of the microcystin hepatotoxin in the water and the animals that come in contact with it. For the Indigenous people of the Klamath, the annual blooms occur during a ceremony season that requires human interaction with the river. To learn about these

¹ The discovery of *M. aeruginosa* was a significant factor in the 2023/2024 removal of the Klamath River Dams. It will be interesting to see if harmful blooms of *M. aeruginosa* are detected in fall 2024.

issues, the impacted communities, and how understanding fundamental STEM principles can help to address this problem, Klamath Connection students engaged in a water quality laboratory alongside faculty, Indigenous scientists and cultural practitioners. The activity was woven through multiple co-curricular and curricular components of the Place-Based Learning Community (PBLC).

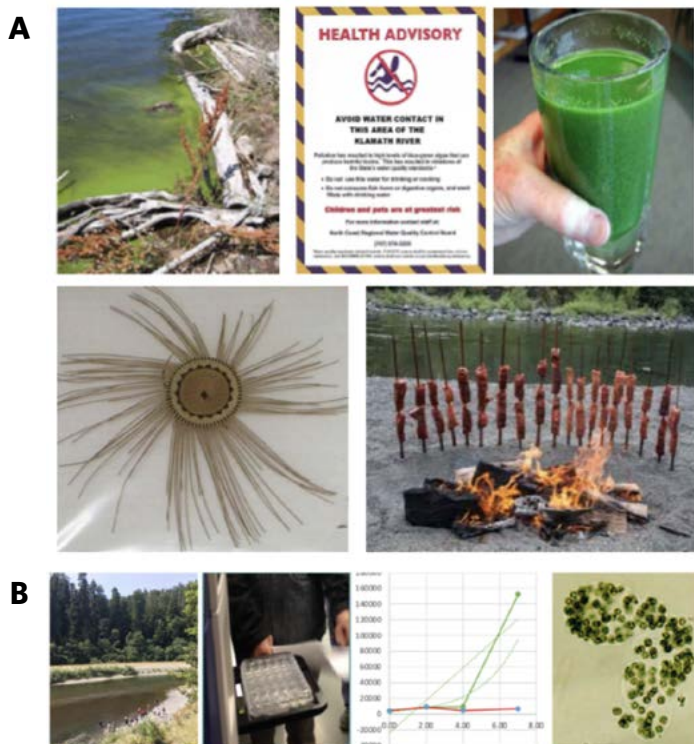
This study examines whether Klamath Connection students who learned about and/or related to the environmental, scientific, and social justice issues faced by the Native American communities of the Klamath River Basin show improvements in STEM retention and success. Our research was designed to explore three hypotheses:

1. Klamath Connection student participants who learn about Native American culture through the water quality laboratory will demonstrate intellectual growth, exhibit psychosocial factors associated with STEM retention, and show gains in academic achievement.
2. Klamath Connection student participants who see parallels between issues facing contemporary Native American communities and their home communities will demonstrate intellectual growth, exhibit psychosocial factors associated with STEM retention, and show gains in academic achievement.
3. Klamath Connection student participants who believe understanding cultural, social, and/or environmental justice issues of Native American people will help them in their future careers will demonstrate intellectual growth, exhibit psychosocial factors associated with STEM retention, and show gains in academic achievement.

Study Location

This project was performed at Cal Poly Humboldt (California State Polytechnic University, Humboldt, formally Humboldt State University), a mid-sized master's degree-granting state university located on the Pacific coast approximately 100 miles south of the Oregon border. The northernmost campus of the California State University (CSU) system, it is in a rural setting with a predominantly non-Hispanic white population (~73%, U.S. Census Bureau, 2021). The campus sits on the unceded

FIGURE 1. Klamath Connection Students Explore the Science and Culture of the Karuk and Yurok People Through a Water Quality Laboratory (WQL)



A. In 2002, water quality scientists of the Karuk Tribe discovered levels of *Microcystis aeruginosa* in the reservoirs behind the Klamath dams nearly 100 times greater than the level approved by the World Health Organization. These blooms occur during the time of year that Karuk people are in and around the river gathering food, basketry materials, and performing ceremonies.

B. Klamath Connection students conducted a basic eutrophication experiment to see if nitrogen is the factor limiting harmful algal blooms downstream of the dams. Students sampled Klamath River water and analyzed their cultures for the presence of algae, using relative fluorescence units (RFUs) of their cultures and microscopy after adding ammonium nitrate (not shown).

territory of the Wiyot people and serves a local admissions and service area with over a dozen Native American communities, including the two largest federally recognized American Indian tribes in California (the Yurok Tribe and the Karuk Tribe). Due in part to a long history of campus-community partnerships, Cal Poly Humboldt has the largest number of American Indian students of the 23 CSU campuses (CSU Student Success Dashboard). Nonetheless, the percent enrollment of American Indian students (2–3%, CSU Dashboard) is lower than the regional population (11.2%, US Census 2020).

The Curriculum

We developed curricular and co-curricular activities that weave the science, societal issues, and cultural impacts of the harmful algal blooms (HABs) of toxic *M. aeruginosa* into first-semester STEM curricula (Figure 1).² The students conducted much of the experiment as part of the pre-semester summer experience (S1). After an introductory presentation and a conversation about cultural sensitivity (S2), the students joined faculty and peer mentors on a field trip to the Klamath River to learn from Karuk and Yurok experts about the watershed and the environmental, cultural, and social justice issues created by the HABs. The students then collected Klamath River water with guidance from Karuk water quality scientists and university faculty. When the students returned to campus, they performed a eutrophication experiment to monitor their samples for the presence of *M. aeruginosa*.

In the fall semester, students identified the algal species by microscopy in their botany course (S3), collected fluorescence data from the algal photosynthetic pigments in their first-year seminar course (S1), and analyzed the relative fluorescence units (RFUs) as a proxy for cellular abundance in their math course (S4). Karuk and Yurok scientists and cultural practitioners gave lectures in the critical thinking class to discuss the cultural and environmental reasons that the Tribe monitors, manages, and advocates for the health of the river. After a culminating lecture by all first-semester faculty linking the topic to each STEM course and its associated discipline (S5), students completed a final lab report (S1) and a reflective essay in a critical thinking course (see Design and Methods below). In the second semester, students continued to explore the topic in their Native American Studies class and through a chemistry laboratory (S6).

Design and Methods

This study involves the first three cohorts of Klamath Connection students (2015, 2016, and 2017). All data collection, management, and analysis were completed under approval of the campus's Institutional Review Board (IRB 14-013) to ensure protection of the rights and welfare of

human subjects of research in accordance with the 1964 Helsinki guidelines.

Upon acceptance to the university, first-time first-year students who declared majors in biology, botany, environmental resources engineering, environmental science and management, fisheries, wildlife, or zoology received paper and electronic invitations to participate in Klamath Connection. These communications were followed by more personalized calls and emails from staff and faculty. Students who accepted the invitation began Klamath Connection pre-semester activities as soon as they arrived on campus as part of the pre-semester summer immersion experience. Once classes began, students were grouped into courses that filled their first-semester schedule: Introduction to Botany, Critical Thinking, Introduction to Math at the appropriate level, a first-year seminar, and another general education course. To facilitate block scheduling, the first cohort was comprised of students who entered the university math ready. Cohorts two and three were of all levels of math preparedness. In the second semester, all Klamath Connection students took a major-appropriate introductory chemistry course and Introduction to Native American Studies.

A survey was designed and administered to the 2016 and 2017 Klamath Connection cohorts in the third week of their spring semester Native American studies course (S7). The survey asked students 1) if the water quality laboratory and other activities were effective in increasing student's knowledge of Native American culture; 2) if the student saw parallels between issues facing contemporary Native American communities and issues in their home communities; and 3) if the student thought understanding issues faced by contemporary Native American communities would be helpful to their future career. The survey also contained a question that allowed students to self-identify their race and ethnicity by selecting all categories they identified with (American Indian, African American, Asian, Hispanic/Latino, Pacific Islander, Unknown, and/or White).³

² [Supplementary Information S1-S7](#) is available online.

³ We asked students to self-identify all categories of their race and ethnicity, because university data sorts students according to the Integrated Postsecondary Education Data System (IPEDS) protocol, which groups individuals reporting two or more ethnicities as either *Hispanic* (if one of the ethnicities is Hispanic) or *Two or More*.

To determine whether the student participants experienced intellectual growth and gains in psychosocial factors associated with first-year retention in STEM, we performed a thematic analysis of 241 reflective essays written by three cohorts of Klamath Connection students in the critical thinking course (62 in 2015; 85 in 2016; 94 in 2017). The reflective essay was written in response to this prompt given in the critical thinking course:

Now that you have completed the water quality laboratory, worked with some of its data, and examined its design from a critically thinking scientist's perspective, think about your own intellectual growth over the semester. What did you think of the process back in the pre-semester experience? Do you think about it differently now, and how?

What do you think about the role of foundational disciplines (e.g., math, botany, chemistry) in understanding complex environmental and social problems? Have those thoughts changed since you've arrived (on campus)?

The 2015 essays were analyzed by hand to identify initial codes (Sprowles). Using Atlas.ti, the codes of all 241 essays were refined and analyzed and sorted into themes (Smith). The codes and themes were reviewed and finalized by three members of our analysis team (Sprowles, Smith, and Johnson).

University-issued student identification numbers were used to identify students who completed both the essay and the survey. This allowed us to explore whether self-reported intellectual growth and gains in psychosocial behaviors associated with STEM retention coded in the essays were more common for students who reported learning about Native American culture through the water quality laboratory (WQL YES), saw parallels to their (your) home community (YOC YES) and/or believed that understanding cultural, social, and/or environmental justice issues of Native American people will help them in their future careers (HFC YES). The student respondents were subdivided based on their URG status. This resulted in four categories of respondents for each of the three hypotheses: Non-URG YES, URG YES, Non-URG NO and URG NO.

Academic achievement was assessed using retention and course success data obtained from the University's Office of Institutional Effectiveness. Retention was defined as the percentage of students returning for a second year or more in any major (= retention) or returning and still in a STEM major (= STEM retention). Student grades were used to calculate GPAs earned in STEM courses. Pass rates were calculated by categorizing A, B, C, or Credit as a "credit" and D, F, or unauthorized withdrawal as "no-credit." Students receiving an incomplete or withdrawing early were not included in these analyses.

Data analyses were conducted in R (R Core Team, 2018). The effect sizes are reported as Hedges' g (for continuous variables) or Cox's index (for binary responses) (WWC, 2017). We interpret small effects as Hedges' g and Cox's index value of 0.2–0.49, medium effects as values between 0.5 and 0.79, and large effects as values >0.8 (Cohen, 1988).

Results

A total of 97 Klamath Connection students completed both the survey and reflective essay (Table 1). Sixty-four of the 97 students (66%) self-identified as belonging exclusively to a racial or ethnic group whose representation in STEM fields is similar to that group's percentage of the U.S. population (Non-URG: White and/or Asian American) (NCSES, 2021). The remaining 33 students (34%) self-identified as belonging to at least one racially minoritized group that is historically underrepresented in STEM (URG: African American, American Indian, Hispanic/Latinx, Native Alaskan, Native Hawaiian, and/or Pacific Islander) (Table 1).

Thirty percent of Non-URG students (19 out of 64) and 39% of URG students (13 of 33) reported they had learned about the issues faced by Native Americans living along the Klamath River through the water quality laboratory curriculum (WQL YES Non-URG and WQL YES URG, respectively) (Table 2). Quotes from the essay provide important insights.

In this first quote, *Student A* describes how exploring the toxic algal blooms from different perspectives illuminated the importance of understanding the social and cultural impacts of the *Microcystis* blooms on the Indigenous communities of the Klamath Basin:

TABLE 1. Participant Demographics

The Non-URG category includes groups whose representation in STEM fields is similar to that group's percentage of the U.S. population. The URG category includes minoritized groups historically underrepresented in STEM fields.

Race/Ethnicity IPEDS	Race Ethnicity Self Identified	n
URG (n=33)		
African American		2
Hispanic/Latino	Hispanic/Latino	18
	Hispanic/Latino, African American, White	1
	Hispanic/Latino, African American, American Indian, White	1
	Hispanic/Latino, American Indian	1
	Hispanic/Latino, Pacific Islander, Asian American	1
	Hispanic/Latino, White	7
Two or More	African American, American Indian, white	1
	Pacific Islander, Asian American,	1
Non-URG (n=64)		
	White	56
	Asian American	5
Two or More	Asian American, White	3
Total		97

TABLE 2. Percentage of Students Who Report That the Water Quality Laboratory Increased Their Knowledge of Native American Culture, See Relevance to Their Own Communities, and Believe the Information Has Prepared Them for Their Future Careers. Students subdivided by Non-URG and URG

	Non-URG n=64	URG n=33
Students who learned about Native American culture through the water quality laboratory (WCL)	30% (19)	39% (13)
Students who saw parallels between issues that affect Native American communities in their own communities (YOC)	37% (24)	55% (17)
Students who think information about issues that affect Native American communities better prepared them for their future career	86% (54)	81% (27)

“As we began the experiment, the effect the algae would have on social issues had not even crossed my mind. I had viewed the damage of the increased algae as an environmental issue. ... I had viewed the data for the health damages it could cause to humans as well as their animals, but never the cultural impacts. Searching the impacts of the algal bloom on surrounding cultures in the critical thinking class just added yet another layer to the problem that I had not seen yet—how the increased amounts of toxic algae made it impossible for these tribes to perform their annual ceremonies and how that affected their social and cultural well-being.” – *Student A*

Student B describes how meaningful it was to have the opportunity to help address these issues:

“Once I heard about the fish kill, the Tribes, and how devastating it was for them, I thought that just learning about the situation was helping in some small way. I was pleased when we might actually help understand things more clearly by performing our own experiment and gathering our own data.” – *Student B*

Student C describes the importance of hearing directly from Indigenous scientists and how it broadened their perspectives:

“(Initially) I looked at the outcome of the experiment as something that only needed to be said once and then forgotten rather than diving deeper into the issues at hand. Fortunately, this ignorance did not last. ... After class discussions in the critical thinking class and a visit from two members of the Karuk Tribe Department of Natural Resources, I began to take the whole topic seriously. The guest speakers truly did spark interest for me because they applied spirituality to science in such a logical way. They did convince me that there is more to science, and you cannot completely rely on Western science or disregard the way other cultures ‘carry out’ science. Ultimately, my whole fixed perspective, which is in fact a logical fallacy, on the experiment was finally shifted.” – *Student C*

There was also a higher percentage of URG students who identified parallels between issues that affect Native American communities and their own communities, with 17 YOC YES URG students (52%) and 24 YOC YES Non-URG (37.5%) (Table 2).

Student D draws parallels between the Klamath Indigenous communities and those in a National Park close to their home:

“Both communities deal with the struggle of preserving resources and saving certain plant species as they face increasing numbers of tourists, litter, and carbon emissions within xxxx National Park, which multiple cultures have an agreement with to gain their resources.” – *Student D*

Another student compared current efforts to protect a nature preserve to another topic discussed in the critical thinking course: the fight to stop the development of a U.S. Forest Service road that would connect the towns of Gasquet and Orleans (the G-O Road). The road would pass through high country sacred to the Karuk, Yurok, and Tolowa people (Emenhiser, 2005).

“Back home, there is a conflict because the town may put a road through a nature preserve, and we are trying to get the town to take that road option off the table. Kind of similar to [the] threat to Native American lands for things like roads (G-O Road).” – *Student E*

Though the majority of free responses were related to environmental issues, some racial concerns were described:

“How people of different beliefs and cultures may be viewed as wrong/different or unjust.” – *Student F*

A strong majority of both URG and Non-URG students reported that the information they learned about issues that affect Native American communities has better prepared them for their future career (HFC URG YES 82% and HFC YES Non-URG 84%) (Table 2).

Some of these acknowledged that all lands have Indigenous history even if they are not controlled by Indigenous people:

“So I know where I am, whose home I’m on, whether it is still ‘their’ land/home.” – *Student G*

TABLE 3. Learning About Native American Culture through the Water Quality Laboratory and Seeing Parallels to Own Community Effects on Academic Behaviors and Psycho/Social Factors Associated with Student Persistence. Gains in essential learning outcomes were pronounced for URG students who also reported learning about Native American (NA) culture through the water quality laboratory (URG WQL YES). Seeing parallels (relevance) to their (your) own community (YOC YES) showed effects in all 8 categories for both URG and Non-URG students. Small Cox's index effects (0.2-0.49) are represented as *, medium (0.5-0.79) as **, and large as *** (values > 0.79) (Chen, Cohen, & Chen, 2010).

Themes		WQL			YOC		
		n	%	Cox's Index	n	%	Cox's Index
Intellectual Growth							
Critical Thinking Skills	Non-URG	8	50.0%	0.10	11	44.0%	-0.144
	URG	3	37.5%	-0.44	11	61.1%	0.43*
Gaining new knowledge/perspectives	Non-URG	14	87.5%	0.37*	21	84.0%	0.28*
	URG	7	87.5%	0.70**	15	83.3%	0.78**
Connecting social and environmental issues	Non-URG	12	75.0%	-0.14	21	84.0%	0.47*
	URG	7	87.5%	0.59**	14	77.8%	0.20*
Interdisciplinary/connectedness	Non-URG	10	62.5%	0.05	16	64.0%	0.20*
	URG	5	62.5%	0.06	12	66.7%	0.41*
Role of Foundational STEM Courses	Non-URG	12	75.0%	0.00	21	84.0%	0.63**
	URG	7	87.5%	0.81***	14	77.8%	0.57**
Psycho/Social Factors of STEM Success							
Connections with students/faculty	Non-URG	3	18.8%	-0.35	7	28.0%	-0.041
	URG	3	37.5%	0.26*	6	33.3%	0.36*
Helped with transition to university	Non-URG	2	12.5%	0.12	5	20.0%	1.3***
	URG	1	12.5%	0.03	3	16.7%	N/A
Intro to major/forming scientist identity	Non-URG	9	56.3%	0.00	17	68.0%	0.59**
	URG	5	62.5%	0.16	10	55.6%	-0.038

Others described the importance of humility, respect and relationship building:

“It helped me realize it is important to know what tribes you are working with to not only respect their culture but to create strong connections.” – Student H

“I believe it will help me understand who I’m working with and ... how to best work with different communities.” – Student I

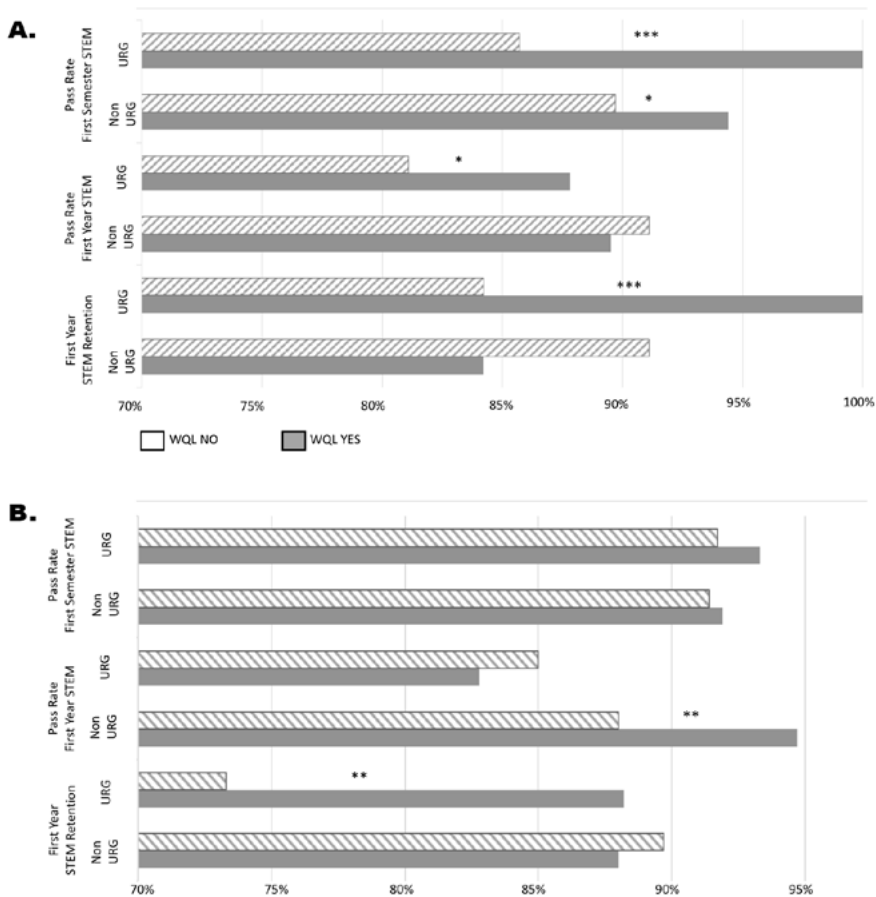
“As a doctor, I (will) have to be culturally aware of my patients to treat them.” – Student J

Though these comments were meaningful, the small proportion (<20%) of HFC NO students prohibited examining the impact of this on additional student outcomes.

The thematic analysis of the reflective essays produced eight themes (Table 3). Five were indicative of intellectual growth: *gaining new knowledge and perspectives, connecting social and environmental issues, relevance of STEM foundational courses to social and environmental issues, interdisciplinary connectedness, and critical thinking* (Association of American Colleges and Universities, 2007). Three themes were psychosocial factors associated with college success and academic achievement: *connections to staff and faculty* (Astin, 1993), *assisting with transition to university* (Hurtado and Carter, 1997), and *forming a scientist identity* (Trujillo and Tanner, 2014).

A higher percentage of students who reported learning about Native American issues in the water quality laboratory (WQL YES) reported gains in *new knowledge and perspectives* than those who did not (WQL NO). Only

FIGURE 2. Klamath Connection Students Explore the Science and Culture of the Karuk and Yurok People Through a Water Quality Laboratory (WQL)



A. Impact of Learning about Native American Culture through the Water Quality Laboratory.

B. Seeing Parallels Between Issues Facing Native American People and Their Own Community on First-Semester STEM Pass Rates, First-Year STEM Pass Rates and Retention into the Second Year

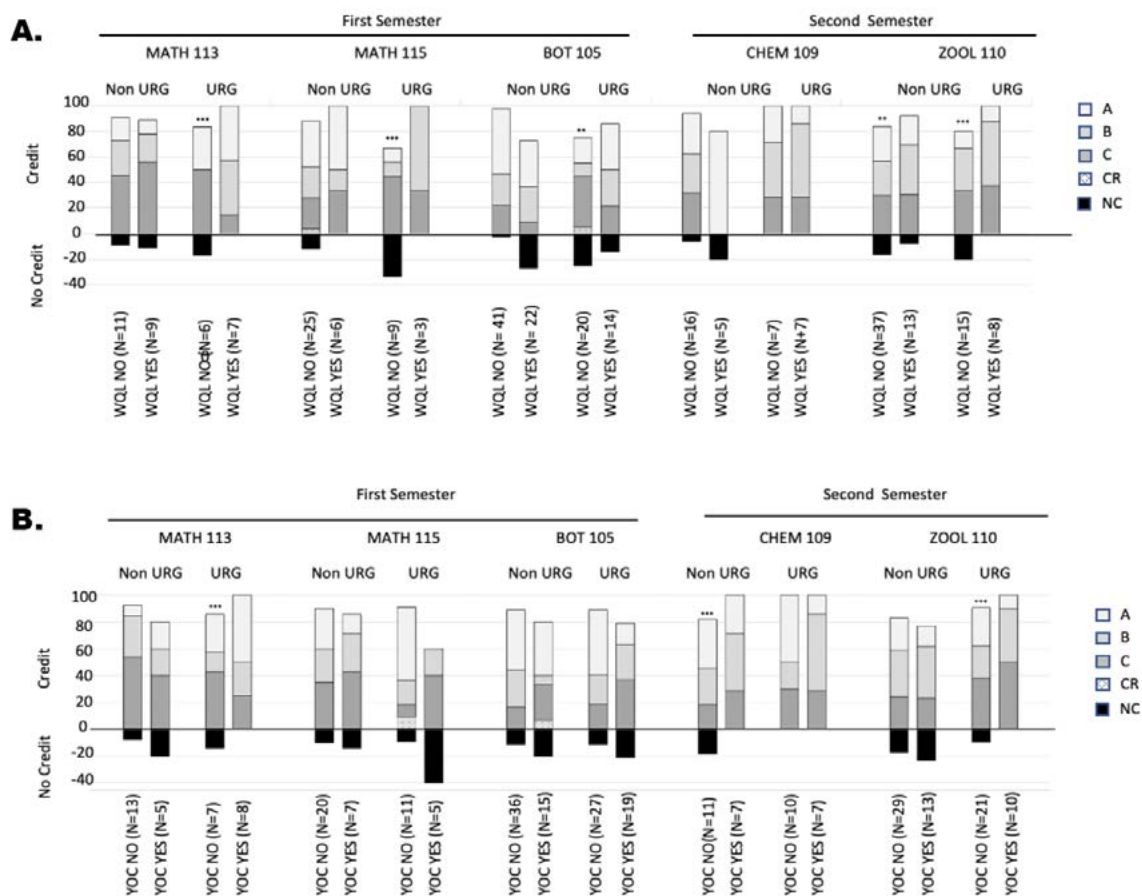
Cox's g. * = small effect, ** = medium effect, *** = large effect.

a small effect differentiated the WCL YES Non-URG students from WCL NO Non-URG, whereas the effect was medium for URG students. A higher percentage of WCL YES URG students also reported *connecting social and environmental issues* (medium effect size), seeing the role of core STEM classes in understanding these issues (*role of foundational STEM courses*, large effect size), and *making connections with students and faculty* (small effect).

Students who saw parallels between issues faced by Native American communities and their own communities (YOC YES) also had a higher percentage of comments associated with the themes than those who did not (YOC NO). Both URG and non-URG YOC YES

students reported gains in *connecting social and environmental issues* and *interdisciplinary connectedness* (small effects), and gains in *understanding the role of foundational STEM courses* (medium effect). The YOC YES URG students also reported gains in *critical thinking*, and *connections with students and faculty* (small effects) and in *new knowledge/perspectives* and *role of foundational STEM courses* (medium effects). YOC YES Non-URG had the most gains of any group, with additional gains in *new knowledge and perspectives*; in *role of foundational STEM courses*; and in *forming scientist identity*. They were the only group to show an increase in the percentage of

FIGURE 3. Pass Rates and Grade Distributions in First-Year STEM Bottleneck Courses for URG and Non-URG Students Who A) Learned about Native American Culture Through the Water Quality Lab (WQL YES) and B) Saw Parallels Between Issues Faced by Native Americans and Their Own Communities (YOC YES). Cox's g. * = small effect, ** = medium effect, *** = large effect.



students reporting a gain in *helped with transition to the university* (large effect).

To examine gains in STEM persistence and academic achievement, we began by exploring first-semester and first-year STEM pass rates and first-year STEM retention. All WCL YES students had higher semester STEM pass rates than WCL NO students, but only WCL YES URG students had increased first-year STEM pass rates and first-year STEM retention (Figure 2A).

There were two increases in persistence and achievement seen for YOC YES students. Non-URG YOC YES students had a medium increase in first-year STEM pass rates and URG YOC YES students had a medium increase in first-year STEM retention (Figure 2B).

Next, we explored the individual pass rates of first-year STEM bottleneck courses (Figure 3). WQL YES students had higher pass rates in all of their first-year

STEM bottleneck courses, with four having Cox's g effect sizes of medium to high. YOC YES URG students had gains in the first-semester pass rate of their college algebra course (MATH 113 URG). In the second semester, CHEM 109 YOC YES Non-URG students and Introductory Zoology (ZOOL 110) YOC YES URG students had improved pass rates.

Finally, we explored the impacts of our program on first- and fourth-year overall GPAs, units earned, and STEM GPAs (Table 4). There was a medium effect of learning about Native American issues through the water quality laboratory (WQL YES) for URG students in first-year overall GPA (3.23 vs. 2.86) and fourth-year overall GPA (3.19 vs. 2.97). There was a large effect of WQL YES for URG students on average first-semester STEM GPA (3.31 vs. 2.33) and small effects on average first-year STEM GPA (2.89 vs 2.58), and on first attempt

TABLE 4. Impact of Learning about Native American Culture Through the Water Quality Laboratory (WQL) and Seeing Parallels to Issues Faced by Native Americans to Own Communities (YOC) on GPAs and Retention. Hedges' g interpretation of effect is *small (0.2-0.49), **medium (0.5-0.79), and ***large (>0.79) (Chen, Cohen, and Chen 2010).

		WQL							YOC						
		Yes	mean	SE	No	mean	SE	Hedges' g	Yes	mean	SE	No	mean	SE	Hedges' g
First Year															
	GPA														
	Non-URG	n=19	2.97	0.19	n=45	3.19	0.099	-0.3	n=25	3.21	0.14	n=39	3.07	0.117	0.2*
	URG	n=13	3.23	0.14	n=19	2.86	0.186	0.51**	n=17	3.07	0.12	n=15	2.94	0.24	0.18
	Units Earned														
	Non-URG	n=19	39	3.89	n=45	44.67	2.261	-0.36	n=25	47.2	3.14	n=39	40.28	2.45	0.44*
	URG	n=13	41.08	2.53	n=19	38.74	4.035	0.15	n=17	38	2.45	n=15	41.6	4.819	-0.24
Fourth Year															
	GPA														
	Non-URG	n=19	3.23	0.15	n=45	3.28	0.075	-0.08	n=25	3.26	0.12	n=39	3.26	0.085	-0.01
	URG	n=13	3.19	0.12	n=19	2.97	0.1	0.51**	n=17	3.07	0.11	n=15	3.11	0.108	-0.09
	Units Earned														
	Non-URG	n=19	39	3.89	n=45	44.67	2.261	-0.36	n=25	47.2	3.14	n=39	40.28	2.474	0.44*
	URG	n=13	41.08	2.52	n=19	38.74	4.035	0.15	n=17	38	2.45	n=15	41.6	4.819	-0.24
STEM GPA															
	1st semester														
	Non-URG	n=18	2.72	0.27	n=39	2.58	0.18	0.12	n=22	2.76	0.26	n=35	2.53	0.18	0.2*
	URG	n=13	3.31	0.2	n=14	2.33	0.265	1.15***	n=15	2.95	0.32	n=12	2.61	0.233	0.35*
	1st year														
	Non-URG	n=19	2.69	0.26	n=45	2.83	0.136	-0.15	n=25	2.92	0.18	n=39	2.7	0.163	0.22*
	URG	n=13	2.89	0.25	n=19	2.58	0.224	0.32*	n=17	2.74	0.22	n=15	2.66	0.27	0.08
	1st attempt STEM Bottleneck														
	Non-URG	n=19	2.4	0.26	n=45	2.64	0.138	-0.23	n=25	2.63	0.21	n=39	2.53	0.155	0.09
	URG	n=13	2.54	0.26	n=19	2.25	0.239	0.29*	n=17	2.29	0.2	n=15	2.45	0.303	-0.17

bottleneck classes (2.54 vs. 2.25). There were no meaningful effects for Non-URG students on these metrics.

Fewer gains in GPA were evident for students who reported seeing parallels with their own communities (YOC YES). There was a small impact on first-semester STEM GPA for both YOC YES URG (2.95 vs 2.61) and YOC YES Non-URG (2.76 vs. 2.53) students. YOC YES Non-URG students also had small gains in first-year overall GPA (3.21 vs. 3.07), average first-year units earned (47.2 vs. 40.28), and first-year STEM GPA (2.92 vs. 2.70).

Discussion

Our study demonstrates that weaving Indigenous science, culture, and social justice concerns into first-year STEM curricula can engage and inspire students to overcome barriers to STEM retention and improve academic outcomes. Our first two hypotheses were supported, but in different ways. Students who learned about Native American culture through the water quality laboratory (WCL YES) had gains in intellectual growth, psychosocial factors associated with STEM retention, and academic achievement. The greatest impacts were seen in

STEM retention and academic achievement for WCL YES URG students, with improvements in first-year STEM pass rates, retention, and improvements in overall GPA and STEM GPAs by half a letter grade. This result supports the work of others who have demonstrated that including social context in STEM education can improve academic outcomes when students identify relationships between STEM curricula and diverse cultural perspectives (Estrada et al., 2011), altruistic goals (Lee, 2014), and/or empathy and equity matters (McGee & Bentley, 2017).

The students who saw parallels between issues faced by Native American communities and their own communities also had gains in intellectual growth and psychosocial factors, but they were predominantly observed in YOC YES Non-URG students. With the extensive literature supporting the influence of students' home communities on their collegiate success (Mishra, 2020), we anticipated a greater impact for the YOC YES URG students. It is curious that when asked to describe the similarities between issues faced by Native American communities of the Klamath Basin and their own community, only one YOC YES student highlighted family values. All the other YOC YES students highlighted parallels

in environmental and social justice concerns. It would be interesting to know how many of these students come from communities that value this educational approach. Perhaps our students would find the programming more relatable if we incorporated urban values, something that has historically been challenging for place-based programs grounded in eco-literacy and outdoor education. (Shannon & Galle, 2017).

Since more than 80% of the students in this study believed understanding Native American communities will be important to their future careers, we were not able to evaluate our third hypothesis. We do know that these same cohorts of Klamath Connection students have increased first-year retention and graduation rates when compared to non-Klamath Connection students with the same majors (Johnson et al., 2020, 2023). College student motivation is directly linked to student retention (Graham et al., 2013), which can be increased by understanding post-graduate job prospects (Reardon et al., 2015) and financial security (Próspero & Vohra-Gupta, 2007). It would be interesting to explore whether identifying broader STEM career possibilities impacts intellectual growth, retention, and/or academic achievement, using PBL participation as the variable.

We believe ours is one of the first studies to specifically examine the power of creating curriculum that highlights scientific, cultural, and social justice concerns of Indigenous communities and how a curriculum of this kind might improve outcomes for first-year URG college STEM students. Though we are encouraged by our results, we hesitate to draw expansive conclusions due to the small sample size of our study and the opt-in nature of the initial iterations of Klamath Connection. Cal Poly Humboldt is in the process of launching place-based learning communities for all first-year students. This will allow us to see if similar outcomes are observed when more students participate in activities co-created with the Indigenous communities of our area. We will also evaluate the impact of this approach on students who were not given the choice to participate in a learning community.

It is important to note that there were 52% fewer URG students than non-URG in this study. Of the URG, only three self-identified as American Indian (Table 1). If we are going to continue place-based learning communities, it is essential that they serve the people of our region.

Aikenhead (2006, pp. 107–108) stated that “culture-based clashes occur in science classrooms for students whose worldviews and cultures (including their home language) differ from those of Western science conveyed by school science.” This can be exacerbated when place-based educators promote a colonized educational environment by excluding critical interrogation and introspection about how place intersects with race, gender, and colonialism (Shannon & Galle, 2017). As we expand place-based learning communities, we will strive to create culturally responsive programming that not only incorporates the values, perspectives, and cultures of our region, but also creates an educational environment that attracts and empowers Native American students.

Acknowledgments

This work was supported by the California State University under the CSU STEM Collaboratives Grant (PI Johnson, Co-PI Sprowles); the U.S. Department of Education under the Hispanic Serving Institutions STEM Grant [P031C150193, PI Johnson, Co-PI Sprowles]; the Howard Hughes Medical Institute Inclusive Excellence Award [52008703, PI Johnson, Co-PI Sprowles], and the Transcending Barriers Grant funded by the Keck Foundation [Eliza Riley, Project Director, Stony Brook University; Humboldt PI Sprowles].

We thank Lisa Hillman for writing the cultural sensitivity document read by all the Klamath Connection participants before visiting the Klamath River (S2)

Leaders and collaborators from the Karuk, Yurok, and Hoopa Tribes helped inform, inspire, and enrich our program. We especially thank Leaf G. Hillman, Joshua Saxon, Susan Fricke, Thomas O'Rourke, James Gensaw, Frankie Myers, David Hillemeier, Rosie Claburn, Seafha Ramos, Keith Parker, Rocco Fiori, Chris West, Mark Higley, and Javier Kinney.

We thank Lisa Castellino, Michael Le, Gay Hylton, and Yao Min for their guidance in data collection and analysis. We thank Rouhollah Aghasaleh for his critical review of the manuscript.

Important guidance and insights were provided by colleagues from the SENCER Transcending Barriers to Success initiative and the HHMI Inclusive Excellence initiative. Special thanks to Eliza J. Reilly, Ulla Hasager,

Hokulani Aikau, Bob Franco, Amy Shachter, Jonathan Baker, Kahoalii Keahi-Wood, Tracy Johnson, Blake Riggs, Kia (Laura) Burrus, Mica Estrada, and John Matsui.

Staff members Jessica Matthews, Nicole Ryks, and Lauren Enriquez were vital contributors to this program.

An integrative program like this is not possible without collaborators throughout the university. We extend special thanks to Marlon Sherman, Cutcha Risling Baldy, Kaitlin Reed, Adrienne Colegrove Raymond, Pimm Allen, Daniel Saveliff, Tracy Smith, Carly Marino, Steven St. Onge, Alexander Mihai Tomescu, Kami Larripa, Susan Morrison, David Baston, Steven Smith, Rich Boone, Theodora Kalikow, Alexander Enyedi, Lisa Rossbacher, Cheryl Johnson, Rosamel Benavides-Garb, Kellie Jo Brown, and Leslie Rodelandier.

Most important, we thank all the first-year STEM students whose aspirations and promise propel our work.

References

- Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. Teachers College Press.
- Association of American Colleges and Universities. (2007). *College learning for the new global century: A report from the National Leadership Council for Liberal Education & America's Promise*. <https://nsee.memberclicks.net/assets/docs/KnowledgeCenter/IntegratingExpEduc/BooksReports/82.2.%20college%20learning%20for%20the%20new%20global%20century.pdf>
- Astin, A. (1993). *What matters in college: Four critical years revisited*. Jossey-Bass.
- Benitez, M. (2010). Racialized rhetoric, racialized bodies, racialized spaces: Politicizing how race and racism are experienced in higher education. *Iowa State Conference on Race and Ethnicity*, 11(1).
- Chesky, N. Z., & Wolfmeyer, M. R. (2015). *Philosophy of STEM education: A critical investigation*. Springer. <https://doi.org/10.1057/9781137535467>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Routledge.
- Emenhiser, J. A. (2005). The G-O Road. In B. Taylor (Ed.), *Encyclopedia of Religion and Nature* (Vol. 1). Continuum.
- Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology*, 103(1), 206–222. <https://doi.org/10.1037/a0020743>
- Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science*, 341(6153), 1455–1456. <https://doi.org/10.1126/science.1240487>
- Gray, D. L., Ali, J. N., McElveen, T. L., & Sealy, M. (2022). The cultural significance of 'we-ness': Motivationally influential practices rooted in a scholarly agenda on Black education. *Educational Psychology Review*, 34(4), 1985–2013.
- Hong, L., & Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences*, 101(46), 16385–16389. <https://doi.org/10.1073/pnas.0403723101>
- Hurtado, S., & Carter, D. F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging. *Sociology of Education*, 70(4), 324–345. <https://doi.org/10.2307/2673270>
- Johnson, M., Sprowles, A., Overeem, K., & Rich, A. (2017). A place-based learning community: Klamath Connection at Humboldt State University. *Learning Communities: Research & Practice*, 5(2), n2.
- Johnson, M. D., Sprowles, A. E., Goldenberg, K. R., Margell, S. T., & Castellino, L. (2020). Effect of a place-based learning community on belonging, persistence, and equity gaps for first-year STEM students. *Innovative Higher Education*, 45(6), 509–531. <https://doi.org/10.1007/s10755-020-09519-5>
- Johnson, M. D., Margell, S. T., Goldenberg, K., Palomera, R., & Sprowles, A. E. (2023). Impact of a first-year place-based learning community on STEM students' academic achievement in their second, third, and fourth years. *Innovative Higher Education*, 48, 169–195. <https://doi.org/10.1007/s10755-022-09616-7>
- Kann, J., & Corum, S. (2009). Toxicogenic *Microcystis aeruginosa* bloom dynamics and cell density/chlorophyll a relationships with microcystin toxin in the Klamath River, 2005–2008. *Aquatic Ecosystem Sciences LLC and Karuk Tribe Department of Natural Resources*, Orleans, CA.
- Kozlowski, D., Larivière, V., Sugimoto, C. R., & Monroe-White, T. (2022). Intersectional inequalities in science. *Proceedings of the National Academy of Sciences*, 119(2), e2113067119.
- Lee, D. N. (2014). Taking it personally. *Scientific American*, 311(4), 47. <https://doi.org/10.1038/scientificamerican1014-47>
- McGee, E., & Bentley, L. (2017). The equity ethic: Black and Latinx college students reengineering their STEM careers toward justice. *American Journal of Education*, 124(1), 1–36. <https://doi.org/10.1086/693954>
- Mishra, S. (2020). Social networks, social capital, social support and academic success in higher education: A systematic review with a special focus on 'underrepresented' students. *Educational Research Review*, 29, 100307. <https://doi.org/10.1016/j.edurev.2019.100307>
- National Center for Science and Engineering Statistics (NCSES). (2021). *Women, minorities, and persons with disabilities in science and engineering*. Directorate for Social, Behavioral and Economic Sciences, National Science Foundation. NSF 21-321. <https://ncses.nsf.gov/pubs/nsf21321>
- Otto, S., Evins, M. A., Boyer-Pennington, M., & Brinthaup, T. M. (2015). Learning communities in higher education: Best practices. *Journal of Student Success and Retention*, 2(1), 1–20.
- Próspero, M., & Vohra-Gupta, S. (2007). First generation college students: Motivation, integration, and academic achievement. *Community College Journal of Research and Practice*, 31(12), 963–975. <https://doi.org/10.1080/10668920600902051>

- R Core Team. (2018). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. <https://www.R-project.org>
- Reardon, R. C., Melvin, B., McClain, M. C., Peterson, G. W., & Bowman, W. J. (2015). The career course as a factor in college graduation. *Journal of College Student Retention: Research, Theory, & Practice*, 17, 336–350. <https://doi.org/10.1177/1521025115575913>
- Shannon, D., & Galle, J. (Eds.). (2017). *Interdisciplinary approaches to pedagogy and place-based education: From abstract to the quotidian*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-50621-0>
- Sprowles, A., Goldenberg, K., Goley, P. D., Ladwig, S., & Shaughnessy, F. J. (2019). Place-based learning communities on a rural campus: Turning challenges into assets. *Learning Communities: Research & Practice*, 7(1), 6.
- Thiry, H., Weston, T. J., Harper, R. P., Holland, D. G., Koch, A. K., & Drake, B. M. (2019). *Talking about leaving revisited: Persistence, relocation, and loss in undergraduate STEM education*. Springer Nature. <https://doi.org/10.1007/978-3-030-25304-2>
- Trujillo, G., & Tanner, K. D. (2014). Considering the role of affect in learning: Monitoring students' self-efficacy, sense of belonging, and science identity. *CBE—Life Sciences Education*, 13(1), 6–15. <https://doi.org/10.1187/cbe.13-12-0241>
- United States Census Bureau. (2021). *Improved race and ethnicity measures reveal U.S. population is much more multiracial*. <https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html>
- What Works Clearinghouse (2017). *Procedures Handbook, Version 4*. https://ies.ed.gov/ncee/wwc/Docs/referenceresources/wwc_standards_handbook_v4.pdf. Accessed July 2018.
- Windchief, S., & Brown, B. (2017). Conceptualizing a mentoring program for American Indian/Alaska Native students in the STEM fields: A review of the literature. *Mentoring & Tutoring*, 25(3), 329–345. <https://doi.org/10.1080/13611267.2017.1364815>

Data Availability Statement. The datasets generated during and/or analyzed during the current study are not publicly available, because the privacy of the individual participants could be compromised. They are available from the corresponding author on reasonable request.

About the Authors



Amy Sprowles is a fourth-generation educator. She is an associate professor of biological sciences at Cal Poly Humboldt and Director of the Humboldt CIRM Bridges Program and is Faculty Representative for two California State University initiatives in STEM education: CSUPERB and STEM NET. Dr. Sprowles is an 'IKE Alliance Founding Member, SENCER Ambassador, was the director of the Humboldt INCLUDES Planning Grant, and is a guest editor of this special edition. She has also served the University as Faculty Associate Dean of Undergraduate and Graduate Studies and Department Chair. At the time of this study, she served as Co-Principal Investigator; Co-Principal Investigator and Co-Director of the CSU STEM Collaboratives Award and the Cal Poly Humboldt DHSI STEM Grant; Director of the Cal Poly Humboldt HHMI Inclusive Excellence Award; and Principal Investigator and Director of the Humboldt Transcending Barriers to Success grant. She co-developed and co-taught the Klamath Connection critical thinking course, helped develop the survey (S7), led the design and

authorship of the water quality laboratory, and taught all components (S1), was a co-presenter of S5, led and coordinated this research project, conducted the survey and essay coding, and is the primary author of this article.



Steven Margell served as Assessment Coordinator for the Cal Poly Humboldt DHSI STEM and HHMI Inclusive Excellence grants at the time of this study. He performed the descriptive data analysis. He is currently an analyst with the Cal Poly Humboldt Office of Institutional Research and Analytic Reporting.



Kerri J. Malloy (Yurok/Karuk) is an assistant professor of Native American and Indigenous studies at San Jose State University. His research focuses on the genocide of Indigenous peoples and the ongoing healing and reconciliation in North America. He has over 15 years of experience working with federally recognized tribes and tribal

organizations. He chairs the Indigenous Caucus and serves on the Advisory Board of the International Association of Genocide Scholars. He holds a Master of Jurisprudence in Indian Law from The University of Tulsa and a doctoral degree in holocaust and genocide studies from Gratz College. He was a lecturer in Cal Poly Humboldt's Native American Studies Department at the time of this project, contributed to the summer immersion and critical thinking curriculum, taught the Klamath Connection Native American Studies course, and helped design the survey instrument (S7).



Lisa Morehead-Hillman (enrolled Karuk) is the founder of the Karuk Tribe's Pikyav Field Institute and author of multiple publications, including the cultural sensitivity document (S2) used in this study. The Klamath Connection students benefited from her guest lectures, as well as the overarching tribal guidance of the program.



L. Chook Chook Hillman is a Karuk Indian, Indigenous scientist, cultural practitioner, and educator. He taught best practices in water quality sampling to faculty and students at the Klamath River. He co-authored S1 and gave guest lectures

to Klamath Connection students.



Angela Rich is a research associate supporting the College of Natural Resources and Sciences (CNRS) at Cal Poly Humboldt by translating complex institutional data into actionable information that can be used for planning, problem solving,

and informing CNRS's educational goals. Her work also helps inform strategic planning, assessment activities, and broad questions about student success in CNRS. Angela has over 20 years of experience conducting research in higher education, social services, healthcare, and military arenas. Her skill set includes assessment, program evaluation/development, needs assessments, and research/policy work. Angela is proficient in both quantitative and

qualitative methodologies and has specialized training and experience in Community-Based Participatory Research (CBPR) and culturally competent research methods. She served as the assessment coordinator for the Humboldt State University Division for Retention and Inclusive Student Success at the time of this report. She led the design of the NAS survey instrument (S7).



Jessica Smith was a recent graduate of Cal Poly Humboldt's public sociology master's degree program at the time of this study. She performed the thematic analysis of the essays. She is a harm reduction research analyst at RTI International.



Frank Shaughnessy (*deceased*) was Emeritus Professor of Botany and Marine Biology. He was a founding member of the Klamath Connection Place-Based Learning Community (PBLC), co-author of S1, author of S3, and co-presenter of

S5. He won the Cal Poly Humboldt Outstanding Professor Award in 2021.



Matthew P. Hurst is a professor in the Chemistry Department at Cal Poly Humboldt with a PhD in marine analytical chemistry from the University of California at Santa Cruz. He teaches analytical, environmental, and general chemistry

courses, and his research focuses on water quality issues in the local coastal ocean, estuaries, and rivers. He primarily studies trace metal and nutrient cycling, with an interest in determining the toxicity and/or bioavailability of elemental species and the fate and transport of emerging pollutants. He was a Klamath Connection chemistry instructor, co-author of S1, and author of S6.



Borbolla Mazzag serves as the Associate Dean of Academic Affairs in the College of Natural Resources and Sciences at Cal Poly Humboldt. Bori received her PhD in applied

mathematics in 2002 from UC Davis; after postdoctoral positions at the College of William and Mary and the University of Utah, she joined the Cal Poly Humboldt math faculty in 2005. Bori's research interests are mathematical biology and mathematical modeling. She served as the Chair of Mathematics and Computer Science Departments from 2017 to 2021. Bori is passionate about providing broad access to STEM education and STEM careers and creating equitable and impactful experiences for all STEM students. She was one of the Klamath Connection mathematics instructors, a co-author of S4, and co-presenter of S5.



Dale Oliver is a professor of mathematics at Cal Poly Humboldt, where for more than 30 years his primary focus has been on the mathematical preparation and enhancement of K-12 teachers of mathematics. After serving as

Dean of the College of Natural Resources and Sciences, he served as an AAAS Science and Technology Policy Fellow, with an assignment at the National Science Foundation to support monitoring and evaluation of the Improving Undergraduate STEM Education Program for Hispanic-Serving Institutions. His ongoing interest is to improve STEM education at all levels, especially implementing policies and practices that support an inclusive and equitable ecosystem in undergraduate STEM education. He was one of the Klamath Connection mathematics instructors, a co-author of S4, and co-presenter of S5.



Sonja Manor is an experienced mathematics educator who currently serves as a lecturer at Cal Poly Humboldt. As Place-Based Math Coordinator at Cal Poly Humboldt, she has worked with faculty from across the University

to develop the interdisciplinary mathematics curriculum for incoming STEM students. These projects include revising the Klamath River algal growth labs, authoring a Humboldt Bay Sea Level Rise modeling activity that incorporates local geology, and creating an ocean acidification lab which uses local pH data and compares the Humboldt Bay estuarine environment to nearby open

coastal systems. These interdisciplinary units are central to the integrated place-based curriculum at Cal Poly Humboldt. Ms. Manor recently completed an ESCALA certificate in teaching and learning for Hispanic-Serving Institutions and has focused her 20-year teaching career on making mathematics meaningful and interesting with applications. She believes that students are more motivated when their courses feel relevant and connected to other disciplines. She served as one of the Klamath Connection mathematics instructors, was a co-author of S4, and a co-presenter of S5.



Eileen Cashman is the Chair of the School of Engineering at Cal Poly Humboldt and a professor in environmental resources engineering. She was involved in co-authoring the water quality activity (S1) and co-directed the PBLC

from 2016 through 2019.



Patricia Siering (*deceased*) was a professor of biological sciences. A microbial ecologist, she was a co-author of the water quality activity (S1), worked with Klamath Connection students on the associated field biology methods, assisted students

during the Klamath field trip, and helped students synthesize the linked curricula in the first-year experience course.



Alison O'Dowd earned her BS in environmental science from the University of Oregon and her PhD in aquatic ecology from UC Berkeley. She is a professor and Chair of the Department of Environmental Science and Management at Cal

Poly Humboldt and the Co-Director of Cal Poly Humboldt's River Institute. Her research interests are in the fields of aquatic ecology and ecological restoration. More recently, her research has explored the impacts of dams and dam removal on downstream ecosystems in the Klamath, Trinity, and Eel Rivers. She assisted students during the Klamath field trip, helped them collect

fluorescent data, and helped students synthesize the linked curricula in the first-year experience course.



P. Dawn Goley earned her PhD at the University of California, Santa Cruz, studying the behavioral ecology of Pacific white-sided dolphins. She began teaching and conducting marine mammal research in the Department of Biological Sciences at Cal Poly Humboldt in 1996. Undergraduate and graduate students have gained valuable research experience in her Marine Mammal Education and Research Program through long-term studies of the behavioral ecology of gray whales, Steller sea lions, harbor seals, and elephant seals, as well as by studying stranded marine mammals. Dr. Goley was a founding member of Klamath Connection, assisting students during the Klamath field trip. She helped them collect fluorescent data and helped students synthesize the linked curricula in the first-year experience course. She went on to be a leader in the design of Rising Tides and Among Giants Place-Based Learning Communities (PBLCs) in the College of Natural Resources and Sciences and helped develop the course Science 100: Becoming a STEM Scientist in the 21st Century for each of these PBLCs.



Gillian Black is a lecturer and academic advisor at Cal Poly Humboldt for first- and second-year STEM students (particularly PBLC/Klamath Connection students). She assisted students during the Klamath field trip, helped them collect fluorescent data, and helped students synthesize the linked curricula in the first-year experience course.



Katlin R. Goldenberg is the Director of Place-Based Learning Communities (PBLCs) at Cal Poly Humboldt. She has spent the past nine years expanding and institutionalizing a unique and integrated approach to learning communities, enabled by her ability to build initiatives that support

broad-scale guided enrollment across campus and create a collaborative and integrated welcome experience. Because of these efforts, and the efforts of exceptional working groups of dedicated faculty and staff, there are now 15 total PBLCs with capacity to support all first-time first-year students on campus. She coordinated the implementation of the water quality laboratory and created the block scheduling.



Matthew D. Johnson is a professor of wildlife habitat ecology at Cal Poly Humboldt, where he has taught since 1999. He earned a BS in wildlife at UC Davis and a PhD in ecology at Tulane University. His interests are in wildlife habitat ecology, with a particular focus on wildlife in agricultural areas and other working landscapes. His goal as an educator is to provide opportunities for a diversity of students to learn the skills that will empower them to contribute to a just and sustainable society, while also fostering an appreciation for how good land management practices can benefit both people and nature. As a researcher, his goal is to answer ecological questions that offer practical information for farmers to simultaneously advance their own goals and also help wildlife. Matt served as the Principal Investigator and Director of the CSU STEM Collaboratives Grant and the Cal Poly Humboldt DHSI STEM Grant [#P031C150193] and the Principal Investigator and Co-Director of the Cal Poly Humboldt HHMI Inclusive Excellence Award [52008703]. As the Klamath Connection Faculty Coordinator, he participated in all aspects of the curricular and co-curricular development, the experimental design, and qualitative and descriptive data analysis, and performed critical input on each draft of the manuscript. He was also a co-instructor of the Klamath Connection critical thinking course.

Centering Indigenous Knowledge in Undergraduate Student Research: Strengthening Cultural Resilience in Resilience Hub Planning on O‘ahu

KAUA KALAIWA‘A

University of Hawai‘i at West O‘ahu

LOMANI H. ROVA

Kapi‘olani Community College

HONU‘ĀINA NICHOLS

Mālama Loko Ea Fishpond

MIKU M. LENENTINE

Kapi‘olani Community College

Cultural resilience in disaster management is crucial for Indigenous communities. Despite its importance, discussions considering Indigenous Knowledge and culture are often limited. The Action 15 Resilience Hub Network Project on the Hawaiian Island of O‘ahu addresses resilience planning gaps through community-based research led by undergraduate students at Kapi‘olani Community College. Though the project initially utilized a Western urban resilience planning framework, it evolved to integrate Indigenous methodologies based on feedback from students and community members. This adaptive pedagogical strategy was essential for effectively engaging

Native Hawaiian and Pacific Islander students, as well as other students from underrepresented groups, by recognizing and valuing their cultural backgrounds and knowledge systems. It not only enriched student learning experiences but also highlighted the importance of culturally responsive research and teaching practices in academic institutions. Lessons learned, future suggestions, and reflections from students and community members are reported.

The Action 15 Resilience Hub Project was launched in 2022 to establish a network of resilience hubs across O‘ahu aiming to form partnerships, identify suitable

locations, and collaborate with community members on programs and services (City and County of Honolulu Office of Climate Change, Sustainability and Resilience, 2023).

Key stakeholders for the project included the City and County of Honolulu, the Department of Urban and Regional Planning at the University of Hawai'i at Mānoa, and the Center for Resilient Neighborhoods (CERENE) at Kapi'olani Community College. This collaboration successfully engaged over 3,000 residents through an island-wide survey and 110 outreach events, including 17 workshops. The project emphasized community-based participatory approaches and equity-centered design (City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, n.d.) and sought to engage vulnerable community groups including Native Hawaiian and Pacific Islander communities. The initial CERENE research team included several research staff along with 15 student leaders, called Resilience Corps Leaders, from Kapi'olani Community College.

Though the original emphasis of the project was focused on Western urban planning and hazard mitigation approaches, student and community member feedback prompted a shift toward Indigenous methodologies. This shift not only contributed to increasing social justice and equity outcomes for the project but also greatly enhanced student engagement and learning.

Background

The inhabitants of Hawai'i, one of the most geographically isolated human populations on Earth, face significant climate change impacts, including sea level rise, increased flood events, drought, extreme heat, wildfires, and more dangerous storms. The increasing risks from extreme weather and climate change threaten Hawai'i's socio-economic and biocultural resilience (Fletcher et al. 2024). To address these challenges, resilience planning in Hawai'i has come to the forefront. Following the devastating fires that destroyed the entire Lahaina town on the island of Maui in 2023, new socio-cultural-political "experiments" in resilience planning have emerged, with an emphasis on developing community resilience hubs (Fletcher et al., 2023). These initiatives involve local communities, government, non-profits, private businesses, and in

some cases institutions of higher education. Hubs serve communities year round, supporting local resilience and providing a coordinated response during emergencies (Urban Sustainability Directors Network, 2019). A unique feature of resilience hub planning, distinct from previous disaster planning efforts (Hawai'i Emergency Management Agency, n.d.), is the focus on place and physical buildings. This new emphasis has the potential to lift up Indigenous communities and practices and support greater cultural resilience.

Cultural resilience can be defined as the ability of a culture to withstand adversity, adapt and continue to grow (Holtorf, 2018). Cultural resilience allows Indigenous communities to uphold their identity and heritage despite external pressures, adapt to environmental changes, strengthen social cohesion, advocate for their rights, and support mental and emotional well-being (Holtorf, 2018; Kirmayer et al., 2011; Smith, 2021). Both cultural resilience and disaster management have been viewed most frequently through the lens of disaster risk reduction, identifying vulnerabilities to heritage sites and exploring social resilience in disaster scenarios (Fabbri-catti et al., 2020; ICORP-ICOMOS International Scientific Committee on Risk Preparedness, 2013). Despite this, though efforts were made during the COVID pandemic in Hawai'i to assess community resilience through a cultural resilience lens (Kamehameha Schools' Strategy & Transformation Group, 2021), discussions of the role of cultural resilience and 'āina-spaces ('āina-spaces is a term used by the authors for traditional fishponds, lo'i [taro pondfields], heritage sites, etc.) and their connection to disaster management have been quite limited.

'Āina-spaces may yet hold the key to modeling the psycho-spiritual resilience needed to weather the storms to come while also modeling the practical skills (such as identifying famine foods, medicinal plants, fresh water sources) for self-sufficiency that will be greatly needed for all. Thus, the role of Indigenous Knowledge systems in shaping resilience planning initiatives is crucial. However, there is no one-size-fits-all approach, and best practices are needed to guide this integration.

Initially, our project was designed using Western methodologies focused on urban planning and hazard mitigation as part of the City's Resilience Strategy (City and County of Honolulu Office of Climate Change,

Sustainability and Resiliency, 2019). However, through the research process, student and community member feedback highlighted the need for a more inclusive approach, leading us to incorporate Indigenous research frameworks inspired by *Papakū Makawalu* and “Weaving Indigenous and Western Knowledge Systems” (Wilkie et al., 2022). This shift, driven by deep partnership-building with community leaders in *‘āina*-spaces, is a direct outcome of our iterative and adaptive community-based resilience planning framework.

Though we did not plan on it initially, our inclusion of Indigenous Knowledge in this way is an example of a best practice in the decolonizing disaster risk reduction literature—the integration of Indigenous Knowledge in higher education (Ali et al., 2021). We argue that this adaptive pedagogical strategy is essential for effectively engaging Native Hawaiian and Pacific Islander (NHPI) students as well as other students from underrepresented groups, as it recognizes and values their cultural backgrounds and knowledge systems. This approach not only enriched the learning experience for the students but also demonstrated the importance of culturally responsive research and teaching practices in higher education. By integrating Indigenous Knowledge, we fostered greater student engagement and contributed to equity and inclusion within academic research. This model exemplifies how leveraging existing community strengths can enhance resilience and self-sufficiency, providing a pathway for best practices in both educational settings and broader urban resilience planning initiatives.

FIGURE 1. Community engagement workshop at Loko Ea Fishpond. Photo: Phillip Lampron.



Project Approach

The Action 15 Resilience Hub Network Project addresses resilience planning gaps on O‘ahu through community-based research conducted in part by a team of undergraduate students based in a two-year college. The project approach was informed by asset-based community development and participatory action research models (Kretzmann & McKnight, 1996; Fals Borda, 2006). The final iteration of the methodology actively sought to decolonize the research and reporting process (Smith, 2021), lift up Indigenous worldviews and values, and amplify feminist approaches to research and community development/risk management (Kovach, 2017; Wilson, 2020).

The project team employed qualitative research techniques such as comprehensive interviews, participatory mapping, focus groups, community workshops, and casual “talkstory” discussions with research subjects. The project operated at a neighborhood scale, grounding the work in a sense of identity and ownership for participants. There were both outcome-oriented and process-oriented goals. Outcome-oriented goals included identifying appropriate locations for resilience hubs. Process-oriented goals included striving for an equitable, community-led, and inclusive approach, bolstering community resilience and preparedness for disasters, and providing education and support for resilience hub planning. The approach was community led as much as possible and student centered, with the additional goals of fostering student empowerment and leadership development in STEM/Social Science, enhancing social capital and a sense of belonging, promoting intergenerational co-learning and interaction, and establishing enduring partnerships. In the initial launch of the project with the City between 2022 and 2023, approximately 3,260 participants were engaged by the student team-led outreach efforts. Outreach included participation and presentations at neighborhood board meetings, engaging key community stakeholders and neighborhood leaders, and facilitating workshops, focus groups, and follow-up discussions with regional partners. The student research team also joined community gatherings, festivals and fairs, and conducted six public Zoom webinars.

FIGURE 2. Community engagement workshop at the Japanese Cultural Center of Hawai'i. Photo: Phillip Lampron.



Another important aspect of community engagement involved reciprocity through participation in workday events and supporting the local community. Students volunteered for service Saturdays; assisted at community gardens and food distribution events; helped community partners with restoration projects such as biocultural forest restoration and making “Genki Balls” to clean the polluted Ala Wai Canal in Honolulu; and volunteered at loko i‘a (fishponds) and at other cultural resilience-focused activities such as the Hau‘ula Harvest Craft Fair and the Micronesian Youth Summit.

The research team worked closely with regional and local partners to determine the participant invitation list for each workshop (though the workshops were freely open to all members of the public), as well to enhance overall engagement and inclusion. The research team also worked with community partners to design the workshops and develop research questions.

Facilitation of the workshops consisted primarily of “tabletop” exercises conducted either at physical tables with four to ten participants or virtually in breakout rooms. The tabletop activities were led by CERENE Resilience Corps Leaders, community leaders, or volunteers interested in supporting this work. Students underwent three rounds of training to prepare them for facilitation, which included a peer mentoring component where more

FIGURE 3. Community engagement workshop at Waikiki Community Center. Photo: Authors' Collection.



experienced leaders had newly trained facilitators play an assisting role before taking on the role of lead facilitator. The workshops and tabletop discussions aimed to create a supportive, engaging, and collaborative environment for participants to share ideas, brainstorm, and learn from one another. Icebreakers and discussion prompts were used to foster familiarity among participants and facilitate intergenerational exchanges of knowledge. Resilience Corp Leaders led participants through various activities such as identifying hub locations on the maps (using stickers), ranking hub locations, evaluating building functionality, and discussing future directions and priorities. Each activity was explained in detail and every table was facilitated by two student leaders. We discovered that it was important to allow tables to progress at their own pace, and that it was crucial to have trained facilitators at every table to allow participants to explore topics in depth and adapt the research protocol to their specific needs.

The main emphasis for the project design was this community-based and -directed approach, valuing data sovereignty and honoring diverse perspectives and approaches to discussing subject matter. Establishing enduring partnerships with community leaders was a key aspect of our approach and resulted in important feedback and learnings for our research team. Co-learning was a consistent theme, allowing for an iterative feedback process, refining workshop formats and reports to incorporate community input, and enabling the community to lead as much as possible.

Students and community partners received training in qualitative interviewing, data analysis, and research

ethics through weekly and monthly Zoom calls. Leadership training and mentorship were also provided. This enabled the students to support community partners during follow-up interviews where we clarified and built on previous workshop findings, identified how to best manage and share community-held data, determined primary contacts for data inquiries, and supported follow-up collaboration and communication.

Data analysis and training with community partners and students was conducted in three phases. In the first phase, notes were transcribed, digitized and organized into themes to support thematic analysis and summary of the discussions suitable for inclusion in the Action 15 Report produced for the City. In the second phase the research team (including community partners) was invited to learn grounded theory and thematic analysis using computer-assisted techniques, for a deeper understanding of the data (Charmaz et al., 2006). In the last phase, we applied “Weaving Indigenous and Western Knowledge Systems” and “Two-Eyed Seeing” frameworks—which we later expanded to *Papakū Makawalu* (see below)—to the report writing (Bartlett et al., 2012; Wilkie et al., 2022). This served to deepen our relationship within our writing team and helped us to explore concepts more deeply, while engaging in a reflective auto-ethnographic/participant observation.

Student Learning Outcomes

Student leaders were at the heart of our research team in this community-based research process. Our students themselves come from very diverse backgrounds including Native Hawaiian, Filipino, Fijian, Persian, Chinese, Japanese, Korean, Kosraean, Jamaican, and other ethnicities. As such they were able to draw from wisdom, reflections, and traditions from their own heritage as they engaged with others in this work. Many students had the opportunity to attend a workshop for their area and also to attend their very own neighborhood board meetings as part of this work. As a result, they were extremely well received by community members and met with positive enthusiasm. This was also seen in cross-cultural contexts, where youth were met with curiosity and overall encouragement. The students at the heart and helm of this work

not only experienced deep learning for themselves but also enriched the process tremendously.

Student learning was evaluated throughout the process through regular surveys as part of the CERENE Resilience Corps Leaders program. A subset of the students was also evaluated as part of their coursework for those enrolled in a sustainability certificate program. The surveys we administered included Likert scale questions with a scale of 1 to 5 with 5 being the highest score, as well as open-ended questions to prompt deeper reflection. One hundred percent of students sampled reported agreement on the level of 4 or 5 that the experience was positive, valuable, met their expectations for the program, and increased their confidence as a leader (individual questions). Near the end of the Action 15 Project we began to work more actively in *‘āina*-spaces and to include more Indigenous research methodology into their mentoring and training. We found in our most recent sample that over 90% of students reported high levels of learning regarding “community-based research” and “Indigenous methodology,” and 90% reported medium to high levels of learning regarding “*‘āina*-spaces and resilience hubs.” Students reported gaining a comprehensive understanding of several key concepts including reciprocity, resilience, cultural resilience, resilience hubs, community resilience, and leadership. A significant part of the learning journey involved personal growth through direct community engagement and leadership roles. As one student notably expressed:

This training has really centered my thinking into what, where, and how to prepare for a disaster before and after it happens. From talking with community members through this course I ... realized how many people are unaware of resiliency hubs and how crucial they are [for] our resilience as a community. Through blue skies and gray skies, CERENE has given me more skills and knowledge than I could've imagined.

Overall, the students' reflections express the depth of their learning and the personal transformation experienced through the program. One student leader shared a deep appreciation for the community and cultural insights gained, stating:

Learning from the communities we have worked in has been a privilege To sit down and participate in

intentional conversations about our relationship with and responsibility to ‘āina [land, environment] has been the highlight of this semester for me.

Our integrative approach to education not only equipped the student participants with practical research skills but also fostered a profound connection to their community and cultural heritage, shaping their professional and personal lives.

Reflections and Learnings from the Research Team

To build relationships with our readers and honor our commitment to decolonizing the report-writing process, we are sharing direct reflections from our research team. These voices exemplify the “Weaving Indigenous and Western Knowledge Systems” approach (Wilkie et al., 2022), allowing us to elevate the experiences and perspectives of those directly involved in the project and report. Below are reflections from two student leaders and one community partner—all three of them co-authors of this report—highlighting the impact and significance of their contributions to our collective work.

Being a part of this work has enriched me with a stronger sense of responsibility to my community and culture. I have had the opportunity to be directly involved with each step of the research process, from community conversations to data analysis. As someone who is just beginning to test the waters of academia, this chance to directly participate has been very welcome. Through collaboration and accountability to the land and people, I’ve felt a strong sense of reciprocity and belonging in Hawai‘i. I see myself as a lifelong learner, one who has much to learn not only from external knowledge systems, but our own Indigenous systems as well. – Lomani H. Rova (Student Leader and Author)

I have learned about resilience, cultural communication, and collaboration. Analyzing data through AI thematic analysis was tricky at first, but then it got easier. Listening to workshop audio recordings and analyzing data was a long process, but it was meaningful. I have also improved my academic writing skills and learned to manage

overwhelming tasks by pausing to take a breath and to stay focused. Just being able to be present, whether it’s with government officials from a tiny island [or with] my fellow colleagues and learning from each other—it is all incredibly enriching and meaningful. – Kaua Kalaiwa‘a (Student Leader and Author)

As a community member and cultural advisor, this partnership has excelled in addressing resilience in Hawai‘i, centering ‘āina spaces and the ahupua‘a [land division] system. The Loko Ea x CERENE workday facilitated open dialogue about climate change and culturally informed resilience hubs. Parents and partners from various community-based organizations joined the conversation, emphasizing the responsibility I feel deeply as kanaka a ‘ōiwi: to restore and protect the sacred spaces we have left in Hawai‘i. The work is only beginning and I am excited to continue developing solutions to make ‘āina momona [fertile] once again. – Honu‘āina Nichols (Community Leader and Author)

Lessons Learned and Suggestions for the Future

Importance of ‘Āina-Based Resilience, Values, and Practices

‘Āina-based resilience practices are critically important to this work, because they help lift us up and build stronger *pilina* (relationships/connections) to the *kaona* (hidden meanings) of *‘ike kupuna* (ancestral knowledge) and deepen teachings of *aloha ‘āina* (love of the land) that are necessary for long term sustainability planning on our planet. For example, such practices create space for grief, healing, and connection with nature and the sacred, and they provide opportunities to honor and care for each other and ourselves. The approach creates spaces that are the antidote to the illness of being out of balance, the *piko* (center) of our strength. Community members, regardless of their heritage and cultural background, can experience profound centeredness and connection through these practices, experiencing a grounded sense of belonging and harmony with nature. As one of our traditional teachers shared, “This is the medicine the world needs”

(Susana Xochitlquetzalli, personal communication, 2024). It is not enough to teach about how to prepare an emergency “go kit” or how to store solar batteries, and it is not enough to develop a neighborhood evacuation plan, because such measures will only help us weather the storms better. They will not help us move into a space of living in harmony with our surroundings so that we might begin to reduce those storms (both metaphorical and physical). We all need this spiritual centeredness and places to teach us the wisdom that we have lost.

True Pilina and Relationship Building

Our preliminary findings highlight the need for continued relationship building and going as slowly as is necessary to build these relationships. This means decolonizing our sense of time (moving away from linear time), addressing the much larger challenge of denationalization (the loss of national identity), and healing intergenerational trauma for many Hawaiian families.

Because of Hawai‘i’s history of colonization and military imperialism, working in the disaster management and emergency preparedness space, which is heavily modeled after the military culture and complex, creates tremendous challenges that call for transformational healing, for instance through *ho‘oponopono* (restoration of balance) (Paglinawan et al., 2020; Le et al., 2023).

We need true relationship building and healing to decolonize the limiting structures of higher education and their greater contexts. The existing academic systems need to be re-thought and re-envisioned together with our community partners to create the kind of world that can be resilient to the incredible challenges we face. Like the grass growing, and the process of clearing it from fishponds featured in the Figure 4, we need to stand shoulder

FIGURE 4. Students working at Loko Ea fishpond.
Photo: Authors' Collection.



to shoulder in this work—mindful of systematic equity issues and what it means to stand in the pond together.

We also need to honor multiple ways of knowing while being sensitive; and balancing the goal of being place-based, Indigenizing, and amplifying feminist perspectives while also being supportive and inclusive of all our community and family. In practice, this means deep reflection and engaging in decolonizing and racial equity work at all levels with the help of Indigenous elders and skilled facilitators. Though this may seem like an impossible task, incredible work is already being done by local elders and *ho‘oponopono* practitioners our students are working with. A good example can be seen in the restoration of the Hawaiian fishponds in collaboration with military leaders at the Pearl Harbor Naval Base (Soileau, 2024). This research and examples like the Hawaiian fishpond restoration exemplify the approach we need to take in order to achieve this. We have discovered, however, that our own team still has much to learn about how to best implement these practices. *Papakū Makawalu*, which is understood as a foundation of constant growth, is a methodology and pedagogy for understanding and systematically organizing Hawaiian knowledge. We invite *Papakū Makawalu* into the space of resilience planning for our team and for Hawai‘i, and we invite others to share teachings from their place and lands that call forth this style of multifaceted, place-based reflection and exploration.

Students as Bridgers and Weavers

Students are in the best position to bridge worldviews and weave Indigenous and Western knowledge systems, develop innovative new uses for technology, and bridge the gap between modern and traditional practices. Students can leverage their digital literacy to introduce tools like Geographic Information Systems (GIS), interpret hazard maps, and analyze digital datasets, complementing Traditional Knowledge in a synergistic manner. When learning frameworks such as those we introduce here include intergenerational learning, they provide multiple benefits. Not only do our young people learn about traditional ways of practicing resilience and self-sufficiency, but they also create opportunities for *kūpuna* (elders) and older generations to be valued and seen. This intergenerational approach ensures that elders have meaningful roles and avenues to contribute, fostering a sense of purpose and

connection. At the same time, students enhance their contributions by drawing from their familiarity with advanced technology and digital tools, creating a positive synergy when used in tandem with Traditional Knowledge, effectively weaving together generational wisdom and youthful innovation.

Students and the younger generation have a special role in this work. In addition to their ability to weave Indigenous and Western Knowledge systems, they also help to provide a sense of hope and optimism for the future that may serve as an antidote to burnout in the community. They possess a unique ability to deliver urgent and impactful messages in a way that resonates deeply with others, exemplified by Kathy Jetñil-Kijiner's powerful address at the United Nations Climate Summit (Robinson, 2020). The next generation has the unique ability to share powerful perspectives and mobilize communities around climate action and social justice in a way only youth can. We saw this in our work on O'ahu at the neighborhood board meetings. Often, meetings are contentious, but when our students presented, the atmosphere visibly shifted; people began smiling, and expressions softened. Our students were very well received and often created a moment of levity in otherwise tense meeting spaces.

Conclusion

This research framework presented here employs a student-centered approach to elevate and incorporate Indigenous Knowledge, serving as a model for fostering resilience and sustainability. It empowers students to integrate principles of resilience and sustainability into their future careers and communities. Teaching students the fundamentals of community-based research in the context of experiential learning within their own neighborhoods supports best practices in decolonizing research and higher education. This methodology contributes to the redesign of undergraduate research curricula and promotes the alignment between academic exploration and community needs. The approach is particularly impactful because it embeds research at the neighborhood level, working closely with community partners who are also neighbors of the students and research team. This practical integration of Indigenous Knowledge makes the work personal and meaningful for many students, as their

efforts may directly impact the well-being and support of their families and local community.

In addition to the personal and practical nature of this work, training students in community-based research methodologies, asset-based frameworks, and flipping the narrative of the top-down expert is critically important. This training enhances equity and ethics in research, creating space for solutions to emerge by honoring diverse ways of thinking and understanding the world.

While this project focused on student leaders in the CERENE Resilience Corps Leadership Award Program, future work should expand engagement to include a broader range of students, youth leaders, citizen scientists, community members, and especially *kūpuna* and older adults. Engaging *kūpuna* and older adults will bring invaluable wisdom and experience, fostering intergenerational learning and enriching the research process. From a practical standpoint, this work takes many hands, and we need all hands on deck. Island-wide planning at the neighborhood level is impossible without a committed team of student leaders and community members working together.

Further research is needed to understand and implement cultural resilience strategies in disaster management and urban planning, especially in *'āina*-spaces and sacred spaces, to lift up Indigenous Knowledge and worldviews. Such research can only be conducted in deep partnership with the land and people, beginning at the neighborhood level.

Ultimately, this collaborative, inclusive, and locally embedded approach not only strengthens community ties but also ensures the development of sustainable and resilient communities for future generations. By centering Indigenous Knowledge systems and fostering intergenerational collaboration, this model holds the promise of creating a more equitable and resilient Hawai'i. We can protect, promote and learn from Indigenous communities, to not only honor their heritages but also strengthen collective resilience regardless of the future challenges we face.

Acknowledgments

We express our gratitude to our teachers, ancestors, and the *Kānaka 'Ōiwi* (native people), acknowledging the

traditional lands from which we work. We honor our ‘āina, heritages, communities, and all beings who have supported us. *Mahalo* (thank you) to our community partners for their invaluable contributions and collaboration. Their dedication and insights have enriched our students’ learning experiences and deepened our relationships with the land. *Mahalo* to the Action 15 Research Team including the Department of Urban Planning and Regional Planning at the University of Hawai‘i at Mānoa and the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency. Special thanks to Dr. Robert Franco, Denise Pierson, the Resilience Corps Leaders and especially Christopher Kamalu Fujimoto, Christopher Pascua, and Brianna Donnelly. We also thank Sarah Harris for believing in this work and Parker Kushima with the HSEO Wayfinders. This project would not have been possible without the generosity, wisdom, and commitment to honoring our ‘āina of all involved. We look forward to continuing this journey together embracing future endeavors with open hearts and minds.

We gratefully acknowledge the financial support provided by various organizations and institutions that made this project possible. This work was funded by the Federal Emergency Management Agency, Hawaiian Electric, and State Farm.

The study was conducted in accordance with the guidelines of the University of Hawai‘i Institutional Review Board (IRB Protocol No.2022-00652).

References

- Ali, I., Khan, A. & Khan, H. (2021). Integration of Indigenous knowledge in higher education: A critical analysis. *International Journal of Educational Research*, 105(2), 101–12.
- Bartlett, C., Marshall, M., & Marshall, A. (2012). Two-eyed seeing and other lessons learned within a co-learning journey of bringing together indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences*, 2(4), 331–340.
- Charmaz, K., Thornberg, R., & Keane, E. (2006). Grounded theory and theoretical coding. In A. Bryant and K. Charmaz (Eds.), *The SAGE Handbook of Grounded Theory* (pp. 153–177). SAGE Publications Ltd.
- City and County of Honolulu Office of Climate Change, Sustainability and Resilience. (2019). *Ola Resilience Strategy*. <https://www.resilienthonolulu.org>
- City and County of Honolulu Office of Climate Change, Sustainability and Resilience. (2023). *Action 15 Resilience Hub Project*. <https://www.honolulu.gov/ccsr>
- City and County of Honolulu Office of Climate Change, Sustainability and Resiliency. (n.d.). *Equity. Resilient O‘ahu*. <https://www.resilientoahu.org/equity>
- Fabbricatti, K., Cursi, S., & De Rosa, S. (2020). Cultural resilience and social-ecological systems: From theory to practice. *Sustainability*, 12(8), 1–18.
- Fals Borda, O. (2006). Participatory (action) research in social theory: Origins and challenges. In P. Reason and H. Bradbury (Eds.), *Handbook of Action Research* (pp. 27–37). SAGE Publications Ltd.
- Fletcher, C. H., Benjamin, S., & Mikulina, R. (2023). *Climate change impacts in Hawai‘i: The context for resilience hubs*. University of Hawai‘i at Mānoa.
- Fletcher, C., Ripple, W. J., Newsome, T., Barnard, P., Beamer, K., Behl, A., Bowen, J., Cooney, M., Crist, E., Field, C., Hiser, K., Karl, D. M., King, D. A., Mann, M. E., McGregor, D. P., Mora, C., Oreskes, N. ... Wilson, M. (2024). Earth at risk: An urgent call to end the age of destruction and forge a just and sustainable future. *PNAS nexus*, 3(4), 106.
- Hawai‘i Emergency Management Agency. (n.d.). *Disaster planning guidelines*. <https://dod.hawaii.gov/hiema/>
- Holtorf, C. (2018). Cultural resilience: Sustainable development and cultural heritage. *World Heritage and Sustainable Development: New Directions in World Heritage Management*, 4(2): 114–124.
- ICORP-ICOMOS International Scientific Committee on Risk Preparedness. (2013). *Guidelines on Cultural Heritage and Risk Management*.
- Kamehameha Schools’ Strategy & Transformation Group. (2021). *Assessing Community Resilience from a Cultural Resilience Lens*. <https://www.ksbe.edu/>
- Kirmayer, L. J., Dandeneau, S., Marshall, E., Phillips, M. K., & Williamson, K. J. (2011). Rethinking resilience from Indigenous perspectives. *Canadian Journal of Psychiatry*, 56(2): 84–91.
- Kovach, M. (2017). *Indigenous methodologies: Characteristics, conversations, and contexts*. University of Toronto Press.
- Kretzmann, J. P., & McKnight, J. L. (1996). *Asset-based community development*. ACTA Publications.
- Le, Q. T., Le, H. T., & Nguyen, H. T. (2023). Ho‘oponopono: Restoring Balance in Hawaiian Families. *Journal of Family Therapy*, 45(1), 45–61.
- Paglinawan, L. S., Olivera, R., & Paglinawan, R. (2020). *Ho‘oponopono: The Hawaiian way to put things back into balance*. University of Hawaii Press.
- Robinson, A. L. (2020). Of monsters and mothers. *The Contemporary Pacific*, 32(2), 311–339. <https://www.jstor.org/stable/10.2307/27126689>
- Smith, L. T. (2021). *Decolonizing methodologies: Research and Indigenous peoples* (3rd ed.). Zed Books.
- Soileau, K. M. (2024, March 1). Navy to work with the community to restore Loko Iā Pā‘aiāu. *Ka Wai Ola*. <https://kawaiola.news/aina/navy-to-work-with-the-community-to-restore-loko-ia-paiaiu/>
- Urban Sustainability Directors Network (USDN). (2019). *Resilience hubs: Shifting power to communities and increasing community capacity*. <https://www.usdn.org/public/>

Wilkie, S. R., Lenentine, M. M., & Hiser, K. (2022). *Final report: Weaving Indigenous and Western knowledge systems*. NSF EPSCoR Grant #2104126. <https://cerenehawaii.org/weaving-indigenous-and-western-knowledge-systems/>

Wilson, S. (2020). *Research is ceremony: Indigenous research methods*. Fernwood Publishing.

About the Authors



Kaula Kauaka'apuni Kalaiwa'a was born in Waimānalo, Hawai'i. She is a Native Hawaiian researcher interested in learning respectful and creative ways to support non-profit organizations with graphic design and technology. She currently lives in Waimānalo and is a Resilience Corps Leader with CERENE, graphic design and research assistant for the Transcending Barriers to Success in Economics Bridge Program, and a full-time Creative Media/Pacific Hawaiian Studies major at the University of Hawai'i at West O'ahu.

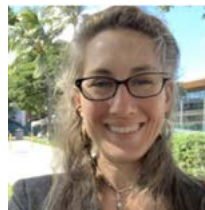


Honu'aina Nichols was born on Turtle Island, specifically on unceded Ohlone Lands, also known as San Jose, California. They were fortunate to grow up in their motherland and graduate from Kamehameha Schools Kapālama. Their genealogy traces back to the Wailupe/Kaimukī area along Keahupua o Maunalua, what used to be the largest *loko i'a* across the *pae 'āina* (the Hawaiian archipelago). Honu currently resides in Hālawa and has strong *pilina* (relational ties) to the *moku o Waialua*, specifically the *ahupua'a* of Kāwailoa. Honu works as the Climate Change Education Coordinator at Mālama Loko Ea Fishpond, a 500-year-old traditional Hawaiian fishpond for the *ali'i* (traditional nobility of the Hawaiian Islands).



Lomani Helen Rova was born in Fiji to a German mother and iTaukei (Indigenous Fijian) father. Her family hails from the island of Taveuni, in the province of Cakaudrove. Her worldviews have been largely influenced by her upbringing in the multicultural melting pot of Viti Levu, Fiji's biggest island. She draws from her family's traditional role as

gonedau or fisherpeople and custodians of the ocean, hoping to pursue a career as a marine biologist with a focus on weaving together Indigenous and external sciences. She currently lives in O'ahu, Hawai'i, attending Kapi'olani Community College and assisting with research at both the Hawai'i Institute for Marine Biology and the Center for Resilient Neighborhoods.



Miku Maria Lenentine was born in Seattle, the traditional territory of the Co-Salish people, and was raised in Alaska, Dena'ina Ełnena, the traditional homelands of the Dena'ina Athabaaan people. The bones of her ancestors on her mother's side are buried with the First People of Sinaloa, Mexico, though her family does not have any formal tribal affiliation today. Her mother's people are also from northern and southern Italy. Her father's people are from Devils' Bit Canyon, in Tipperary, Ireland, and are buried with the Gaelic peoples of primarily Irish and Scottish ancestry. Miku is the coordinator for CERENE, the Center for Resilient Neighborhoods, housed at Kapi'olani Kula Nui Kaiāulu, Kapi'olani Community College, at the University of Hawai'i.