RESEARCH REPORT

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

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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 minoritized[1] 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; Kealiikanakaoleohaililani 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 area[3] 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%, 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 long-standing 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 Indigenized 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 Goudi'ni 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.

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

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

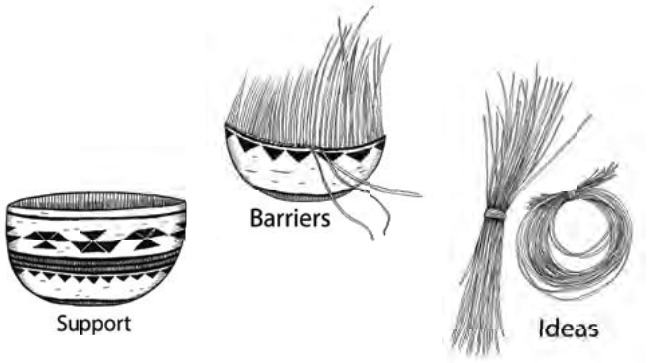
TABLE 2. Talking Circle Participant Groups, Number of People, and Questions

CAIFS (N=2)	Students (N=5)	Alumni (N=3)	Advisors (N=8)
Is there anything you'd say in response to the information you've received about the INCLUDES project? One focus of the report is what HSU is doing well to support Native students. Are there specific things to highlight? Do you see any particular areas of concern that keep tribal students from being successful in STEM at HSU? 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? Does CAIFS have any particular questions we should ask specific groups of people? What are some ways that we can best approach/interview and interact with specific stakeholder groups?	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? What does HSU do well in supporting tribal students in higher education? Are there specific resources/activites/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? 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? 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? 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. 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? What do you think would improve your experience or other student experience in the classroom or with the curriculum that you are being taught? 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? 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?	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? 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? 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? 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? 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. 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? 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? 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? 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?	What does HSU do well in supporting tribal students in higher education? Are there specific resources/activites/data that should be highlighted? Do you see any particular areas of concern that keep tribal students from being successful in STEM at HSU? 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? 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? 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? 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? 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?

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

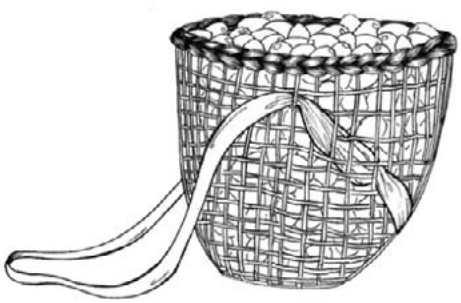
FIGURE 1. Respondents in Talking Circles discussed experiences that supported students through STEM, barriers encountered, and ideas to promote and nurture Indigenous student success in STEM.



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	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 INSREP 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.

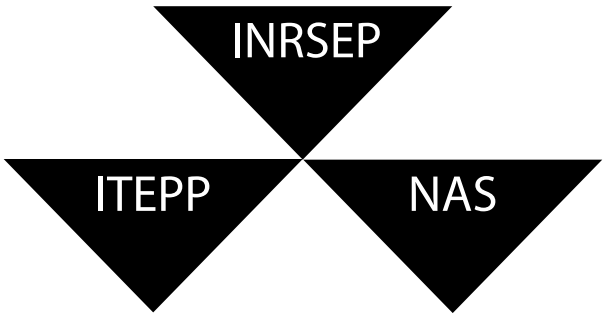


FIGURE 3. Students mentioned INRSEP in 20% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through INRSEP. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning INRSEP.

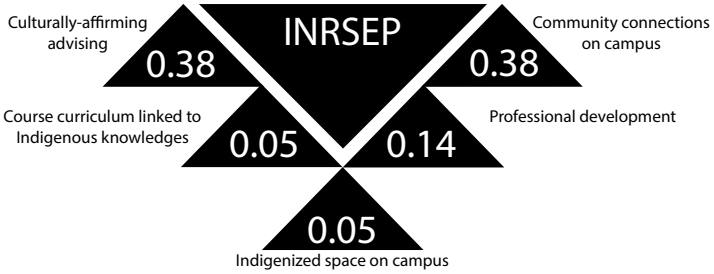


FIGURE 4. Students mentioned ITEPP in 17% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through ITEPP. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning ITEPP.

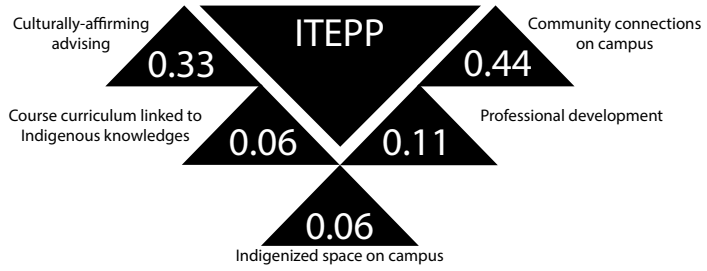
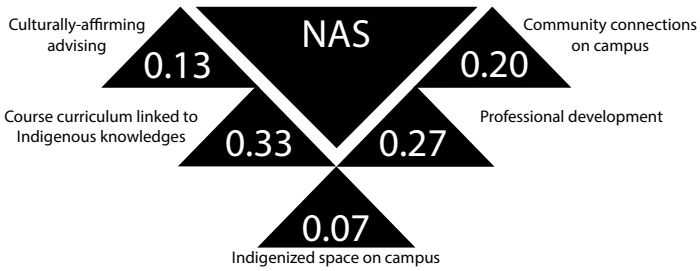


FIGURE 5. Students mentioned NAS in 14% of all responses discussing support. Students reported receiving all of the five themes of support (Table 3 and 7) through NAS. The number of mentions for each of the themes is reported as a proportion of the total responses mentioning NAS.



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	RRespondents 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 liasion	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.

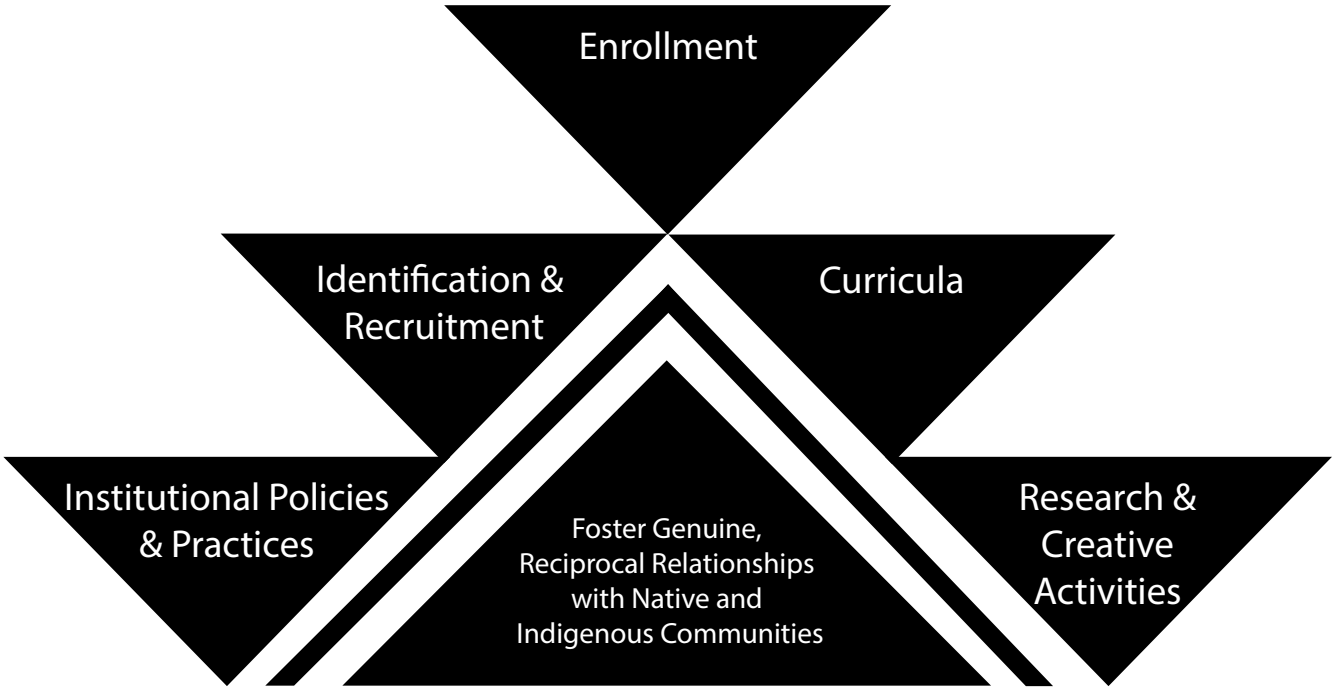
None of the respondents' recommendations provide an avenue to address microaggressions or a way to care for those students who have experienced racial trauma.

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
Enrich campus personnel with Indigenous people Waive tuition and fees for Indigneous students Commit to Indigenized campus spaces and Indigneous programs Create a Tribal Liaison position Require professional development for campus personnel that create opportunities to understand, respect, and connects with Indigenous perspectives Require education of all campus personnel in the ethics of incorporating Indigenous knowledge before including that content in their courses	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 Included non-binary/two-spirited and transgender people in enrollment data Work with Tribal Education Offices to proactively target Native K-12 students Create and incentivize transfer pathways with community colleges and tribal colleges	Create culturally responsive mentoring and advising for Indigenous students Create culturally responsive training program for campus advisors that includes trauma informed care Leverage student Tribal affiliation information to partner with Tribal Nations to improve support of Native students Ensure course assignments accommodate cultural obligations of Indigenous students	Collaborate with NAS Department and engage cultural practitioners and scientists to infuse STEM curriculum with TEK and Indigenous ways of knowing Create paid experiential learning opportunities for Native students with Tribal partners Establish learning outcomes for all courses that include TEK and Indigenous knowledges Include Native American Studies courses in STEM degree pathways Incorporate educational practices that are responsive to diverse learning strategies	Require review of all external grants that involve projects with Indigneous people by a qualified board as part of the pre-award process Establish protocols for research, publication, and dissemination in conjunction with each Indigenous community Ensure all research and creative projects that involve Native and Indigenous topics give back to those communities Develop an inventory of all projects that involve Native and Indigenous communities Involve Native and Indigenous students in research projects conducted by both Native and/or non-Native faculty that are in collaboration with Native communities

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.

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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).

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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.

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