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EXPLORATION OF THE LIVED EXPERIENCES OF NATIVE AMERICAN
SCIENCE TEACHERS OF THE GREAT PLAINS: A NARRATIVE INQUIRY

by

Uma Ganesan

A DISSERTATION

Presented to the Faculty of

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For the Degree of Doctor of Philosophy

Major: Educational Studies

(Teaching, Curriculum & Learning)

Under the Supervision of Professor Theresa Catalano

Lincoln, Nebraska

April, 2023

EXPLORATION OF THE LIVED EXPERIENCES OF NATIVE AMERICAN
SCIENCE TEACHERS OF THE GREAT PLAINS: A NARRATIVE INQUIRY

Uma Ganesan, Ph.D.

University of Nebraska, 2023

Advisor: Theresa Catalano

The complicated history of the education of Native American children through U.S. government-sponsored practices has led to the elimination of the Native children's sense of Indian identity, culture, and language (Noel, 2002). In addition, increased emphasis on standardization and high-stakes accountability under the No Child Left Behind Act of 2001 has resulted in less culturally responsive educational efforts and more Indigenous students left behind in school systems (Castagno & Brayboy, 2008). This has led to Indigenous students being underrepresented in science, technology, engineering, and mathematics (STEM) fields where they account for only 3% of STEM workers (Fry, Kennedy, & Funk, 2021). This dissertation study explores the racialized and gendered lived experiences of Indigenous science teachers in elementary, middle, and high school (K-12) settings in a reservation school in Nebraska. This study, grounded on critical race theory (TribalCrit), employs a qualitative methodology (i.e., narrative inquiry) that focuses on investigating the culturally and linguistically relevant pedagogical practices of the three Indigenous science teachers that could help to meet the needs of Indigenous students. Data were collected using semi-structured and in-depth interviews and classroom observations. Field notes and transcripts were compiled; and artifacts, such as lesson plans, syllabi, student worksheets, and photos were collected for

triangulating the data. Interview transcripts and field notes were coded and analyzed using Bhattacharya's (2017) thematic narrative inductive analysis and Clandinin and Connelly's (2000) three-dimensional narrative inquiry framework of temporality, sociality, and place to arrive at stories of experiences and dominant themes. Findings reveal that pedagogical practices, such as holistic learning and storytelling; nature-based outdoor science classrooms; experiential and project-based science that promotes critical consciousness and civic engagement in students; arts-based approaches; and involving Native Elders in classrooms hold promise (and serve as a model for teachers of Indigenous students in other locations/contexts) in improving Indigenous students' science learning outcomes and facilitating their upward social mobility, thereby upholding educational equity and social justice for Native American communities.

Dedication

ॐ आज्ञनेयाय विद्महे वायुपुत्राय धीमहि ।

तन्नो हनुमत् प्रचोदयात् ॥

We pray to the son of Anjana and the son of the wind God Vayu!

May Lord Hanuman lead our intellect towards intelligence and knowing!

सरस्वति नमस्तुभ्यं वरदे कामरूपिणि ।

विद्यारम्भं करिष्यामि सिद्धिर्भवतु मे सदा ॥

Salutations to Devi Saraswati, who is the giver of boons and fulfiller of wishes!

O Devi, when I begin my studies, please bestow on me the capacity of right understanding, always!

My dissertation is humbly and wholeheartedly dedicated to the Almighty Lord Hanuman, Goddess Saraswathi, my parents C.V. Balasubramanyam and B.

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மிக்க நன்றி, என் அன்பான அப்பா அம்மா!

Thank you very much, my dear father and mother!

जय हनुमान। जय माता सरस्वती ॥

Praise be to Lord Hanuman, Mother Saraswathi, and Wakoⁿda!

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CHAPTER 1

INTRODUCTION

Statement of the Problem

“Maybe it is not for you!” These are the often-repeated words that overwhelmed and doubt-ridden Native American *minoritized*¹ students hear in their K-12 science classrooms. Feelings of anxiety and perceptions of incompetence in science courses among some Indigenous² students are not surprising given that these students often have inequitable access to the kinds of science classes, teachers, resources, and opportunities necessary for academic success in science (Calabrese Barton, 2002). The complicated history of the education of Native³ American children through U.S. government-sponsored practices led to the elimination of the Native children’s sense of Indian identity, and their memory of their religion, language, and their sense of community (Noel, 2002; Torres, 2019). The confusion that has resulted for Indian students and their communities is still evidenced today. Some Native American communities, such as the Blackfeet, are helping students learn and re-learn the culture, heritage, and traditions of the Blackfeet, but a century of education based on cultural shame planted long-lasting

¹ The term “minoritized” rather than “minority” has been used in this thesis to characterize a group of people or a community marginalized in society. The term “minoritized” aligns with McCarty’s (2002) proposition that the word “minority” is stigmatizing and often numerically inaccurate. “‘Minoritized’ more accurately conveys the power relations and processes by which certain groups are socially, economically, and politically marginalized within the larger society. This term also implies human agency” (p. xv).

² The terms “Indigenous” and “Native” have been intentionally capitalized in this dissertation to note the political nature of these terms and the role of human rights where Indigenous people across the world are concerned (Castagno & Brayboy, 2008; Wachal, 2000). The capitalization of these terms also respects and reaffirms Native people’s claims of the earliest connection to land bases in the United States. Although this thesis focuses on a Native American Tribe in Nebraska, I stand in solidarity with all Indigenous people around the world.

³ Although I am fully aware of the wide range and variation among the over 500 tribal nations in the U.S., the terms “Native,” “Indigenous,” “Native American,” and “American Indian (AI),” have been used interchangeably in this thesis (Castagno & Brayboy, 2008) because my purpose is to broadly address these groups of Native people and explore their shared racialized lived experiences.

seeds of doubt, which are still being fought against within some Indian communities (Noel, 2002).

Science Education Reform in the United States

Science educators and educational institutions have long been concerned about the status of science content being taught in K-12 schools and the delivery of the content. The principal goal of science education reform is to improve student science learning outcomes by making rigorous science content accessible and holding high expectations for all students (Mensah, 2013). Educational reformers in the United States continue to strive to solve the problem of how to best teach science for optimal learning success for all students. There have been sweeping educational reforms that focus on “high academic standards and achievement for all students” (Buxton & Lee, 2014, p. 204) and an increased urgency to raise the standards of science education. According to Buxton and Lee (2014), the urgency for raising the standards for science education is due to four primary factors: (a) the growing linguistic and cultural diversity of the U.S. student population; (b) persisting gaps in standardized and high-stakes testing across the demographic subgroups that are intensified by No Child Left Behind Act (NCLB) and Race To The Top (RT³) initiatives by the government; (c) evolving social and personal motives for learning advanced science for making informed decisions and for career and college readiness; and (d) the increase in linguistic and cognitive demands which are present in Next Generation Science Standards (NGSS) and National Research Council’s (NRC) *Framework for K-12 Science Education*. The creation of NGSS and implementation of nationwide Common Core education have been in the spotlight as ways to improve K-12 education. The State of Nebraska also has adapted science

standards from NGSS called Nebraska’s College and Career Ready Standards for Science (NCCRSS) mirroring the three dimensions of NGSS of *disciplinary core ideas*, *crosscutting concepts*, and *science and engineering practices*. The purpose of NGSS and NCCRSS is to better prepare students for the workforce and college by developing critical-thinking skills and scientific literacy and building interest in science, technology, engineering, and mathematics (McWright, 2017).

Phenomenal Demographic Shift in the U. S. Population

Since historically marginalized and minoritized students in the United States belong to diverse racial, ethnic, cultural, and linguistic backgrounds, an understanding of the country’s demographic makeup is essential. Throughout history, the United States has received immigrants from around the globe, making it a truly diverse nation. The recent census report confirms that there has been a remarkable shift in the racial and ethnic composition of the United States since 2010 (U. S. Census Bureau, 2021). Even though the White⁴ population continues to be the largest race or ethnic group in the United States, their population has declined by 8.6% since 2010, and the *multiracial population*⁵ has increased by 276% (U. S. Census Bureau, 2021). Likewise, racial/ethnic distributions of students in public schools across the country have shifted too. For e.g., between fall 2009 and fall 2018, the percentage of Hispanic students in public schools increased from 22% to 27%, whereas the percentage of White students decreased from 54% to 47%, and

⁴ I have used the word “White” in the title case (first letter capitalized) in my dissertation because according to Foster (2003), “capitalizing White undermines the existing linguistic convention by disrupting the taken-for-grantedness of the norm, and ascribing or re-asserting the ethno-racial dimensions of power that are embedded in language and frame traditional discourse” (p. 1). Curry (2011) adds that “de-capitalization of the word ‘white’ next to the word ‘Black’ conveys the grammatical problematization of the relationship that exists in our linguistic structure and cultural discourse—a relationship marred by a history of racist domination” (p. 1).

⁵ Multiracial population includes Black or African American, Hispanic or Latino/a/x American, Asian American, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander populations, and two or more race populations (U. S. Census Bureau, 2021).

the percentage of students who identified as Black decreased from 17% to 15% (*Racial/Ethnic Enrollment in Public Schools, 2021*). According to the U. S. Census Bureau (2021), the American Indian and Alaska Native increased by 160% from 2010 to 2020 because an additional 5.9 million people identified as American Indian and Alaska Native, and another race group in 2020, such as White or Black or African American. Hence, together, the American Indian and Alaska Native alone or in combination population comprised 9.7 million people (2.9% of the total population) in 2020, up from 5.2 million (1.7%) in 2010. In light of this phenomenal shift in the demographics of the United States among the school-age population and to ensure a robust future with continued socioeconomic growth and innovation in the United States, it is essential to set up a knowledge base that enhances academic achievement and equity for all students, especially for the minoritized, underrepresented, culturally and linguistically diverse students (Calabrese Barton, 2002; Lee, 2003; Brown-Jeffy & Cooper, 2011).

Status of Minoritized Populations in Science in the United States

Castagno and Brayboy (2008) state that the increased emphasis on standardization and high-stakes accountability under the NCLB Act of 2001 have eventually resulted in less culturally responsive educational efforts and more Indigenous children left behind in our school systems. Since STEM courses are highly standards-driven and science teachers are made accountable for students' scores on high-stakes tests, many minoritized students are forced to quit science before they complete high school due to not receiving equitable access and opportunities to learn science. They do not have teachers of Color (TOCs) as successful role models from their own culture or language that they could look up to (Atwater & Riley, 1993; Villegas & Irvine, 2010). The so-called "achievement

gap⁶” of Black, Hispanic, Native American, and other minoritized students is widening (*The widening achievement gap in the U.S.*, 2021; *NAEP*, 2022). The Program for International Student Assessment (PISA) is a worldwide study by the Organization for Economic Cooperation and Development (OECD) in nearly 80 nations of 15-year-old students’ scholastic performance in mathematics, science, and reading. For the average scores of math, science, and reading, the United States is lowly ranked at #25, and it is ranked #18 for science in the 2018 PISA worldwide ranking (*PISA 2018 Worldwide Ranking*, 2020). Furthermore, according to the recent PISA data, there is an increase in the gap between the top and bottom 10 percent of student performance for 15-year-old U.S. students in reading and math, as compared to other countries (*The widening achievement gap in the U.S.*, 2021; *NAEP*, 2022). Minoritized populations are also very much underrepresented in the Science, Technology, Engineering, and Mathematics (STEM) fields. For example, just 8% of Hispanic people and 9% of African Americans are a part of the STEM workforce, as compared to 67% of Whites and 13% of Asians in the STEM workforce. Native American, Native Hawaiian, Pacific Islander, and people who identify with two or more racial groups account for only 3% of STEM workers. (Fry, Kennedy, & Funk, 2021). Moreover, explicit and/or implicit racialized lived experiences; and overt or covert racial, cultural, or linguistic discrimination and microaggressions in their K-12 educational experience force many minoritized students

⁶ In this study I have included references to the problematic term “achievement gap” in order to address how this issue has been presented by others. However, when referring to this issue myself I choose to discuss it in terms of “education debt” (borrowed from Ladson-Billings (2006a, 2006b), which describes the cumulative impact of fewer resources and other harm directed at students of Color, or “opportunity gap” to emphasize those arbitrary circumstances in which people are born—such as their race, ethnicity, ZIP code, and socioeconomic status—determine their opportunities in life, rather than all people having the chance to achieve the best of their potential (Mooney, 2018). “Opportunity gap” draws attention to the conditions and obstacles that young students face throughout their educational careers, therefore it accurately places responsibility on an inequitable system that is not providing the opportunities for all kids to thrive and succeed (Mooney, 2018).

to develop negative attitudes towards learning science, and these racialized lived experiences also take a toll on the professional development and retention of teachers of Color (Kohli, 2008; Kohli, 2018; Bettini et al., 2021).

Widening Representation Gap Between Students and Teachers

As opposed to increased student diversity, recent reports from the Pew Research Center and the National Center for Education Statistics (NCES) state that elementary and secondary public school teachers, and university faculty in the United States are considerably less racially and ethnically diverse as a group than their students, for example, in the 2017-18 school year, 79% of public school teachers identified themselves as non-Hispanic Whites, as compared to 7% Black, 9% Hispanic, 2% Asian American, and less than 2% American Indian, Alaska Native, or Pacific Islander teachers (Schaeffer, 2021). By comparison, 47% of all public elementary and secondary school students in the U.S. were White in 2018-19, according to the most recent data available. In that period, around a quarter of public-school students were Hispanic (27%), 15% were Black and 5% were Asian. Those shares have increased over time as newer generations of young people entered the classroom. About 1% or fewer were Pacific Islanders or identified as American Indian or Alaska Native, while 4% were of two or more races (Schaeffer, 2021). Given the above-mentioned statistics evidencing a wide diversity gap between students and teachers, it is no surprise that students of Color, Indigenous students, students from low-income families, and culturally and linguistically diverse students are underrepresented in STEM fields in college as well as in the workforce (National Academies of Sciences, Engineering, and Medicine, 2018).

Status Quo in Science Education: Eurocentricity and the Need for Paradigmatic Shift

Science disciplines that are taught in the majority of schools and universities around the world have adhered to the knowledge that is termed “Eurocentric or Western modern science,” which has traditionally been compiled by White, male, European scholars (Lee, 2003). Within formal educational settings where the epistemological origin of school knowledge and practice has heavily been steeped in a Eurocentric and patriarchal worldview, the histories, experiences, cultures, languages, and contributions of students and women of Color have been devalued, misinterpreted, or omitted (Delgado-Bernal, 2002; Howard & Rodriguez-Minkoff, 2017).

Traditionally, science teachers have wanted students to think like scientists as laid out in *Science for All Americans* (Rutherford & Alhgren, 1991) and assimilate into Western modern science. Aikenhead (2006) critiques this notion of “thinking like scientists” by claiming that the positivistic notions of scientific knowledge are combined with ontologies of realism and Cartesian duality to feed on reductionist and mechanistic practices in order to celebrate an ideology of power and dominion over nature. Aikenhead (2006) states that conventionally, school science has attempted to facilitate the enculturation and assimilation of students into a Western scientific way of knowing, replete with its canonical knowledge, techniques, and values. Aikenhead (2006) also states that in order to participate in school science, Indigenous students are often expected to set aside their Indigenous way of knowing, including the notion that knowledge is action and wisdom, a notion that combines the ontology of spirituality with holistic, relational, and empirical practices in order to celebrate an ideology of harmony with nature for the sake of survival. However, by trying to force a Eurocentric science curriculum on all minoritized students and by trying to acculturate them into Western

modern science, we continue the colonization of the past through processes of “cognitive imperialism” (Battiste, 1986, p. 23, as cited in Aikenhead, 2006) and “neo-colonialism” (Ryan, 2006, p. 79, as cited in Aikenhead, 2006). This reiterates the hegemonic White dominance that also silences and disregards the inequities suffered by minoritized students in schools, universities, and research domains.

Howard and Kern (2018) state that Eurocentric ways of knowing are pervasive in the cultures of modern science and science education, making Eurocentrism a barrier to multicultural success in science. They claim that in a time when our society is demanding increased diversity in science, privileging Eurocentric ideologies in the cultures of science and science education may serve to disenfranchise historically underrepresented minoritized students, rather than provide them with a welcoming space in science (Howard & Kern, 2018). Actions currently being taken by Indigenous people in communities throughout the world clearly demonstrate that a significant “paradigm shift” is underway in which Indigenous knowledge and ways of knowing are recognized as complex knowledge systems with adaptive integrity of their own (Barnhardt & Kawagley, 2005). The above-mentioned research findings call for a paradigmatic shift in science education and urge researchers to move towards constructivist and critical paradigms employing qualitative, decolonizing methodologies.

Science as a Subject Area Rooted in Positivism

In the *Handbook of Research on Science Education*, Parsons (2014) states that science education research has predominantly ignored the systemic constructions and conceptualizations of race and ethnicity that impact the life experiences of minoritized populations. The author points out that most scientific research in the mid-to-late 20th

century employed quantitative methodologies grounded in the positivistic/post-positivistic paradigm. It was only in the late 20th and 21st centuries that qualitative methods rooted in the constructivist paradigm began to be used. Hence, the narrow selection of methods greatly limited the potential of science education research to look into areas of diversity and equity in the field of science education and science teacher education (Parsons, 2014). Scholars have critiqued and rejected the use of the positivistic epistemological stance in science education and have encouraged employing the sociocultural lens and critical lens to explore the experiences of underrepresented populations (Aikenhead, 2001a; Aikenhead & Eillott, 2010; Eylon & Linn, 1988; Gilligan, 1982; Keller, 1985; Mensah, 2011; Ramos de Robles & Gallard Martínez, 2022). Eylon and Linn (1988) examined four research perspectives in science education and elaborated on the negative influence of teaching science in the positivistic tradition on underrepresented students, including women. Their findings suggest that the predominant positivistic perspective of science learning discourages women who hold more interactivist views of the world. Gilligan (1982) and Keller (1985) also concur that society would benefit from greater diversity in accepted philosophical perspectives, and they encourage policies that increase the participation of women in all aspects of science.

Mensah (2011) states that traditional methods of preparing science teachers in teacher education programs are not overtly culturally relevant for students of Color (Mensah, 2011). That means that traditional science learning environments, typically teacher-centered and lecture-based, and curriculum and content, generally do not encourage multiple perspectives. Both Mensah (2011) and Aikenhead (2001a) have critiqued this view of science as Eurocentric or Western modern science. Ramos de

Robles and Gallard Martínez (2022) state that in using sociocultural lenses, they differ from positivist epistemological positions. They highlight that understanding how culture unfolds in science classroom spaces acknowledges that outside agents are constantly mitigating upon them (Ramos de Robles & Gallard Martínez, 2022). Aikenhead and Elliott (2010) state that values, assumptions, and ideologies embedded in Eurocentric science content can conflict with values, assumptions, and ideologies of Indigenous ways of living in nature.

Need for Decolonizing Science Educational Research

Although my study focuses more on how science pedagogy is decolonized by the participants, it is important to have reflexivity regarding my own research as well. When examining decolonizing research on Indigenous education, it is helpful to review the work of some Canadian educational scholars who have been at the cutting edge of decolonizing Indigenous education. According to the Canadian Indigenous educational scholar Battiste (2013), “education has its roots in a patriarchal, Eurocentric society, complicit with multiple forms of oppression of women, sometimes men, children, minorities, and Indigenous peoples” (p. 159). Battiste (2013) states that schools, which are the pivotal locations of textual learning, are never neutral sites. Tuhiwai-Smith (1999), a prominent educational scholar from New Zealand, also states that educational research has never been neutral. Tuck and Yang (2012) and Patel (2016) have extensively discussed about decolonizing educational research methodologies. In science education too, we find that all the texts and textual elements are socially and culturally situated; the purpose and contents of the curricula are defined by the privileged people in power, which has never been in the best interest of the minoritized populations (Battiste, 2013).

Critical researchers have been using frameworks that center non-dominant voices in science education (Smith et al., 2022), and few scholars have contributed towards decolonization of science educational research (Howard & Kern, 2018). Aikenhead and Elliott's (2010) article describes developments in science education since 2006 related to an agenda to decolonize the science framework (in the Pan-Canadian context) by recognizing Indigenous knowledge as being foundational to understanding the physical world. They talk about achieving a decolonized science education by using Bennett's (1986) model of intercultural sensitivity, a multistage continuum from highly ethnocentric to highly ethnopluralistic. They state that ethnopluralism evolves in three stages: acceptance, adaptation, and integration. Aikenhead (2006) states that "decolonizing school science begins at the stage of 'acceptance' and succeeds at the stage of 'integration'" (p. 393). Specific challenges to achieving a decolonized curriculum included the articulation of Indigenous knowledge for school science, the allocation and production of resources to support teachers, and the development of teachers' professional capacities to teach the curriculum's Indigenous knowledge to all students. Szostkowski and Upadhyay (2019) state that education researchers interested in equity from a social justice perspective think about who benefits from extant systems of oppression. Solórzano and Yosso (2002) explain that social justice research strives to eliminate unjust systems while empowering those who have been subordinated within them. Theoretical perspectives including critical race theory in education (Ladson-Billings & Tate, 1995), feminist science studies (Calabrese Barton, 1998), decolonizing methodologies (Tuhiwai Smith, 1999; Darder, 2019), and culturally sustaining/revitalizing pedagogies (Paris, 2012; Paris & Alim, 2014; McCarty & Lee,

2014; Lee & McCarty, 2017) complement social justice goals for this reason. From a social justice and equity standpoint, it is crucial that critical raced and gendered epistemologies be accepted, respected, and affirmed by science educational researchers such as myself because, after all, all humans are categorized by biologists as just one species on Earth—the *Homo sapiens*.

Context of the Study

History of Native American Education in the United States

Omi and Winant (2014) use the term “‘racial formation’ to refer to the process by which social, economic, and political forces determine the content and importance of racial categories, and by which they are in turn shaped by racial meanings” (p. 3). The history of formal U.S. education is a story where White education developed in contrast to the educational domination of the Native and Black peoples, and the relationships between White, Native, and Black education were based on terms of violent extraction and extermination (Givens & Ison, 2022). Hence, education has always been a “racial project” in the United States. (Omi & Winant, 1994, p. 56).

During the foundational century for U.S. education, systems of schooling emerged in the context of racial inequity, and racial categories were used to allocate educational resources and opportunities. Consequently, inequitable, unjust, and exploitative education was offered to Native American and Black peoples based on racist beliefs, as compared with the White peoples (Givens & Ison, 2022). Historically, the United States government sought to control Indigenous people through schools under a policy of coercive assimilation (Lomawaima, 1995).

The schooling of Native Americans started out with the U.S. government

establishing the “Civilization Fund” in 1819 where Christian missionaries within Native Indian territory were told to “Christianize” and “civilize the savages” (Spring, 2016; Noel, 2002; Lomawaima, 1999). Lomawaima (1999) examined the four tenets of colonial education: (1) that Native Americans were savages and had to be civilized; (2) that civilization required Christian conversion; (3) that civilization required subordination of Native communities, frequently achieved through resettlement efforts; and (4) that Native people had mental, moral, physical, or cultural deficiencies that made certain pedagogical methods necessary for their education. These tenets were not based on natural truths but were culturally constructed and served specific agendas of the colonizing nations (Lomawaima, 1999).

Different periods in the history of the education of the Native American children had different purposes and examples of practices (Noel, 2002). The missionary schools from 1819-1873 altered Native communities with the purpose of “Christianizing” them, whereas the off-reservation boarding schools between 1870-1901 violently removed children from their families and renamed them with a purpose of “indoctrinating” them (Noel, 2002). Givens and Ison (2022) add that formal schooling became articulated as a right of citizenship and equal opportunity for White Americans, while it was violently imposed on Native Americans, in warlike fashion, as a primary strategy for disrupting their ties to their land and shedding their tribal identity. If we consider boarding schools as metaphors of American policy towards Indigenous peoples, then Carlisle Indian Industrial School and its founder, General Richard H. Pratt, were the most iconic expressions of that metaphor in institutional form and political personality (Givens & Ison, 2022). In May 1875, Pratt “turned his prison into a school for teaching civilization

to Indians,” teaching prisoners of war from ongoing military conflict between the United States and Native nations (Adams, 1995, p. 39). The expansion of government schools, and the rise of boarding institutions like Carlisle, were part of a coordinated effort to systematize Native education (Givens & Ison, 2022).

Adams (1995) states that the act of schooling for Native American children was executed through a series of rituals and physical violence. Adams (1995), Meza (2015), and Fear-Segal (2007) list several atrocious acts of violence, corporal punishments, and sexual abuse that systematically stripped away Native children’s tribal culture. Boarding schools insisted that students drop their Indian names; forbade the speaking of Native languages; cut off their long hair; forced students to take traditional Anglo-American names; made them do military drills/militaristic techniques that meant to teach structure, which Natives were believed to lack; pray the Christian way; sing patriotic songs; and salute the American flag (Adams, 1995; Meza, 2015; Fear-Segal, 2007). Durbar-Ortiz (2014) and Lomawaima (1999) document the negative impact of boarding schools on American Indian family dynamics and traditional culture and language. Fear-Segal (2007) also argues that federal schools established to Americanize Native children did not achieve their purpose, instead they progressively racialized American Indians. Givens and Ison (2022) add that accepting U.S. expansion as justified and verbally denouncing Indigenous ways of life and dehumanizing them were central features of the sociocultural context of 19th-century Native schools established by White Americans. Adams (1995) identifies language as a critical site of racial conflict and states that Native languages were not only actively suppressed, but the students were given harsh corporal punishments to enforce language bans or to hasten students’ learning of English.

The period between 1901-1910 saw the advent of on-reservation boarding schools and day schools focusing on industrial education where the children were walled, and tough manual labor was extracted out of them with a sole purpose of “civilizing” them (Noel, 2002). Noel (2002) and Spring (2016) argue that ever since 1910, public schools in the U.S. had the purpose of “assimilating” Native American children into an “American” society. This assimilationist view of education was amplified in the “ethnocidal schooling” and “deculturalization” of Native children in both contract and boarding schools, which White people hoped would weaken Indigenous nations and facilitate land dispossession (Spring, 2016; Noel, 2002, Givens & Ison, 2022). Givens and Ison (2022) claim that the shift toward a fully systematized Native educational system as a path to citizenship reflected the dominant assimilationist ideology of federal policy, which embodied an explicit anti-tribal approach. Givens and Ison (2022) use the term “natal alienation” to explain the rupture between children and their tribal identities and family heritage (Lomawaima & Ostler, 2018, p. 79). Consequently, enduring such violence while being stripped of the languages, skills, and wisdom of their home communities, generations of Indigenous youth endured extensive trauma, creating multiple lost generations of traumatized individuals (Torres, 2019). For more than a century now, White settlers in the form of missionaries, the U.S. government and military, and educators have been responsible for grave genocides of many Native communities in North America. Hence, the physical, psychological, emotional, economic, religious, familial, political, and sexual violence and trauma suffered by the Indigenous peoples in this continent has undeniably resulted in severe language loss, cultural loss, and extreme intergenerational trauma among Native communities (Torres,

2019).

To compound matters even further, The NCLB Act of 2001 has caused all schools to adopt the same curriculum and standardized testing, which has dealt a severe blow to efforts to protect and maintain minoritized cultures and languages; hence, the uniformity of the curriculum and the standardized testing ensured that only a single culture would be represented in the classroom, while not necessarily representing the cultures of the students taught (Spring, 2016). NCLB favored a monolingual and monocultural society rather than a multilingual and pluralistic one, placing the federal government's support on the side of English acquisition, not bilingual education (Spring, 2018). Spring (2018) adds that NCLB failed to achieve its goal to close student "opportunity gaps," but it succeeded remarkably in (a) privatizing large areas of the public education landscape, (b) dismantling public schools to commodify them, and (c) prompting the creation of a formidable education industry riddled with entrepreneurs and lobbyists that have promoted neoliberalism in the education arena, all of which have resulted in more inequities and inequalities for the Indigenous populations now as compared to 60 years ago.

Despite these hardships, Native communities and tribal governments, since 1960s, have run locally controlled schools, supervised their own social programs, and sought protection in federal legislation such as the American Indian Child Welfare Act (Lomawaima, 2000). In higher education, Navajo Community College (Diné College) opened its doors in 1969, and in 1970, the National Indian Education Association (NIEA) was formed in Minneapolis, Minnesota (Lomawaima, 2000). In 1971, the Coalition of Indian-Controlled School Boards (CICSB) was established in Boulder, Colorado, and

since the 1980s, many more educational reforms facilitated Indian control of education (Lomawaima, 2000). Tippeconnic (1999) notes that tribal control and Indian control of education are being realized with the federal system, especially by those programs and schools supported by the Bureau of Indian Affairs (B.I.A.), and tribal colleges have been the most successful examples of Indian control of education. Indigenous groups lobbied the United Nations to support their right to self-determination and culturally appropriate education, and in 2007, they achieved their goal of a *Declaration on the Rights of Indigenous Peoples (Article 14)* (Reyhner et al., 2010). In their book *Honoring our heritage*, Reyhner et al. (2010) summarize Article 14 as follows:

Indigenous peoples have the right to establish and control their educational systems and institutions providing education in their own languages, in a manner appropriate to their cultural methods of teaching and learning...States shall, in conjunction with indigenous peoples, take effective measures, in order for indigenous individuals, particularly children, including those living outside their communities, to have access, when possible, to an education in their own culture and provided in their own language (p. vii-viii).

Cohen and Allen (2013) explored the impact of standardization policies of the No Child Left Behind Act (NCLB) of 2001 on the American Indian/Alaska Native (AI/AN) community and the ability of educational policy to promote sovereignty, liberty, and equity within Indigenous communities. They also explored the concept of social capital and language revitalization as recommendations to strengthen school-community relations, and they conclude that the most viable source for language revitalization rests with the community. Furthermore, research on immersion practices with Native

populations indicates both strong gains in Indigenous language competence and academic achievement measured by standardized assessments (Cohen & Allen, 2013). For example, two Navajo immersion schools located in the Navajo nation (Rock Point and Rough Rock) are exemplars of the promising practice of language revitalization (Cohen & Allen, 2013). Navajo-immersion students consistently outperform their peers in English-only classrooms on assessments of English reading, writing, and mathematics, and they also develop much stronger Navajo oral language and literacy skills (McCarty, 2008). Hermes (2005) also adds that the culture-based movement, including the language immersion programs, in Native American education is a direct response to policies of cultural genocide. The era of self-determination in Indian education (1975 to the present) has emphasized policies in support of Native cultures and languages, and many tribal schools are attempting to base schooling on local languages and cultures.

Unique Problems Faced by Native Students

Native American communities throughout the U.S. have suffered dispossession, exile, violence, discrimination, exclusion, exploitation, forcible assimilation, and family separation, and racism is a pervasive and consistent element in the schooling experiences of Indigenous youth. Students experience racism in a number of ways and from a variety of sources, including paternalism, prejudice, harmful assumptions, low expectations, stereotypes, violence, and biased curricular materials (Castagno & Brayboy, 2008). Many more researchers have argued that AI/AN students live in abject poverty on the Native American Reservations that lacks economic development, feel alienated and orphaned due to broken families and domestic violence, resort to drug or alcohol abuse, face marginalization and microaggressions by the society, and also endure demeaning societal

stereotypes about Native People (Joseph, 2018; Brown et al., 2016; Skewes & Blume, 2019; Hobot, 2017; Reinschmidt et al., 2016).

Brown et al. (2016) claim that the causes for high rates of alcohol and drug abuse among AI/AN youth are due to intergenerational stressors, cultural disconnection, stereotypes and harassment, acculturative stress, and mainstream culture clash.

Researchers also talk about pervasive influence of racism and the historical trauma resulting from colonization on American society and culture, including effects on the health and well-being of American Indian people (Skewes & Blume, 2019).

Epidemiological studies have documented greater drug and alcohol-related morbidity and mortality among AI/AN people compared to other ethnic groups, and culturally appropriate, effective interventions are sorely needed (Skewes & Blume, 2019). Hobot (2017) states that AI/ANs in urban areas experience higher rates of poverty, unemployment, low education, homelessness, and health disparities compared to the general population. Reinschmidt et al. (2016) highlighted the multifaceted personal stories of Native Elders that revealed the interconnectedness between historical trauma and resilience, and the interlinks between traditional perceptions connecting past and present, and individuals, families, and communities.

Bergstrom et al. (2003) interviewed 120 Native youth from several Indigenous tribal nations in the United States and Canada and compiled their stories in their book. This book shares what can be learned from stories of success, failure, growth, and resilience of these remarkable youth (Bergstrom et al., 2003). The authors point out that the AI/AN students encounter some unique problems in life and school, which are not experienced by any other race in the United States. In their book, Bergstrom states that

challenges await Native students daily, from facing racism and discrimination in public settings to the problems Native people sometimes bring upon themselves partly as a result of colonization, while Thomas Peacock claims that internalized oppression can make dealing with families and communities tough (Bergstrom et al., 2003). Cleary, the other author, explains why these problems make concentrating on schoolwork hard (Bergstrom et al., 2003).

Purpose of the Study

The purpose of this study is to explore the lived experiences of Indigenous science teachers in elementary, middle, and high school (K-12) settings to see how their racialized and gendered lived experiences shape their culturally and linguistically relevant pedagogical practices to meet the needs of Indigenous students. Using the methodology of narrative inquiry will allow these individual educators to share their stories and experiences and provide guidance on how to help educators meet the needs of the Native American student population. This study aims to highlight humanizing stories that might help the Indigenous teachers to heal from traumatic experiences via sharing in solidarity, highlight the voices of Indigenous science teachers, restore Indigenous knowledge in science classrooms. This study could, albeit in a small way, aid in creating equitable educational policies for Indigenous students in public schools and reclaiming social justice for the oppressed and discriminated Native American population.

Significance of the Study

Educational and Social Significance of STEM Pathways for Native Students

Science teachers play a crucial role in developing social justice-oriented, culturally responsive, scientific skillsets of students in our multilingual, multicultural, and

globalized world. Exploration of the lived experiences of Indigenous teachers could unearth many benefits. For example, empirical evidence from extant research of Villegas and Irvine (2010), Kohli (2008, 2009, 2018), Borrero et al. (2016), Bettini et al. (2021), Atwater and Riley (1993), Aikenhead (1997), Rivera Maulucci (2013), and Boutte et al. (2011) reveal important benefits that Indigenous teachers bring to K-12 schooling: (a) Indigenous teachers could serve as successful role models for all students, especially for underrepresented Native student populations; (b) since the Indigenous teachers tend to work in urban schools with high numbers of Indigenous/minoritized students, they could reduce the acute shortage of teachers; (c) many Indigenous teachers are particularly well-suited for teaching minoritized students because they bring to their work a deep understanding of the cultural, linguistic, and racialized experiences of these learners; (d) Indigenous teachers are also better positioned to understand the cultural, racial, gendered, and linguistic discrimination faced by minoritized students; (e) Indigenous teachers tend to have higher expectations of Native students and so they are more likely to use CRP strategies; (f) Indigenous teachers tend to serve as cultural brokers with the community; (g) Indigenous teachers improve students science outcomes by making science more culturally and linguistically comprehensible to students; (h) Indigenous teachers respect and affirm the culture and language of students that will improve students' self-esteem and confidence in learning science, so overall student success is enhanced, so they can take up STEM careers thereby increasing Native students socioeconomic status; (i) Indigenous teachers also could comprehend the emotions and attitudes of Native students when they learn science, as they themselves would have had similar racialized and gendered experiences when they were students in their K-12 schools; and (j) when

Indigenous teachers employ culturally and linguistically relevant strategies and multicultural science education, they will be able to provide the knowledge and opportunities required for students to become successful participants in our democratic society and uphold social justice and educational equity.

My research is significant because it is a counter-story to the persistent narrative that blames Indigenous people for educational injustices and poor performances on biased assessments. Instead, I highlight the achievements of Native American science teachers in their classrooms as told by participants using a critical, culture-based, language-based epistemological lens that is different from the deficit discourses about Indigenous students in order to explore how they deal with challenges such as impact of historical trauma and intergenerational trauma on Indigenous students' education and Western modern science pedagogical approaches that are not culturally and linguistically relevant or syntonetic with Indigenous peoples' way of living. The significance of the study also lies in the way it attempts to decolonize science education frameworks so as to decenter Eurocentric forms of knowledge construction in science education with a focus on honoring and respecting my participants' lived experiences and capturing and presenting their stories in the way they intended to present them.

Research Questions

Central Question (CQ)

In what ways can the racialized and gendered lived experiences of Indigenous science teachers in K-12 school settings shape their use of culturally and linguistically relevant pedagogical practices to meet the needs of their Indigenous students?

Sub-Questions (SQs)

- (a) How do Indigenous science teachers' lived experiences influence the types of instructional strategies they use in their classrooms?
- (b) How do Indigenous science teachers navigate their own ways of knowing and the cultural, racial, and contextualized approaches to knowledge construction within the constraints of science learning?
- (c) How do Indigenous science teachers use their own/their students' funds of knowledge to teach science to Native American students?

Definitions of the Key Terms

Indigenous and First Nations Peoples

“Indigenous,” is a legal term, encompassing the first people who existed in different regions of North America and are hence called “Native” (Kingsbury 1998; Mullen, 2019). In North America, popular racial identifiers are Indigenous and First Nations (which is frequently used in Canada) (Iseke-Barnes 2008; Munroe et al. 2013).

STEM and STEAM Education

According to Hom (2014), STEM is a curriculum based on the idea of educating students in four specific disciplines—science, technology, engineering, and mathematics—in an interdisciplinary and applied approach. The principal difference between STEM and STEAM (STEM concepts integrated with arts) is that STEM explicitly focuses on scientific concepts, whereas STEAM investigates the same concepts through collaborative, creative, inquiry and problem-based learning methods.

Emergent Multilingual Students

Emergent multilingual students are a diverse group of students representing different cultures, languages, ethnicities, and nationalities (*Our Nation's English*

Learners, n.d.). Other terms that are commonly used to refer emergent multilingual students are English language learners, language minority students, English as a Second Language (ESL) students, culturally and linguistically diverse (CLD) students, and limited English proficient (LEP) students, and students with immigrant/refugee backgrounds. Since these terms are deficit-based, do not represent learners' multilingual assets, and are not people-first language, I have used the term "emergent multilingual students." This term recognizes the increasingly multilingual biographies of many students who "come with standard and nonstandard varieties of their home languages or have studied other languages in school or fluidly move among different languages at home" (Catalano & Hamann, 2016, p. 265). Catalano, Reeves, and Wessels (2018) state that "encouraging people to say and read the entire expression "emergent multilingual students" is a more positive way of framing these students because multilingual focuses on their ability to use all their languages whereas English language learner focuses only on the language they are supposed to be learning" (p. 5).

Heritage Language Learners in the United States

Valdés (2005) states that the term *heritage language* has been used broadly to refer to non-societal and non-majority languages spoken by groups often known as linguistic minorities. Those members of linguistic minorities who are concerned about the study, maintenance, and revitalization of their minority languages have been referred to as heritage language students, e.g., Armenian language would be considered a heritage language for American students of Armenian ancestry even if such students were themselves English-speaking monolinguals (Valdés, 2005). According to Valdés (2005), "American heritage language students include children of Native American background,

foreign-born immigrants who came to the United States at a young age, the native-born children of foreign-born immigrants, and occasionally the native-born children of native-born individuals of immigrant backgrounds” (p. 413). Tran et al. (2015) also define heritage learners students who are dominant in English but whose parents or grandparents spoke the language of their ancestors.

Pedagogical Translanguaging

Cenoz and Gorter (2021) define *pedagogical translanguaging* as a theoretical and instructional approach that aims at improving language and content competences in school contexts by using resources from the learner’s whole linguistic repertoire. In essence, pedagogical translanguaging (as opposed to natural translanguaging) is the planned harnessing of the linguistic/cultural resources of students in their learning. This usually occurs because teachers include translanguaging spaces/stances as part of their regular lesson planning.

Equitable Access to Education

Equitable access to education provides access to the core elements of a quality education to the underserved, minoritized, and underrepresented student communities. The core elements include free, quality preschool; high, challenging standards, and engaging teaching and leadership in a safe, supportive, and well-resourced school; and an affordable, high-quality college degree (*Equity of Opportunity*, n.d.).

Three-Dimensional Narrative Inquiry Framework

Clandinin and Connelly’s (2000) proposed the three-dimensional narrative inquiry framework of *temporality, sociality, and place*. *Temporality* draws attention to the past, present, and future of events and people. *Sociality* draws attention to the relational aspect,

i.e., the relationship between the participants and the inquirers. *Place* draws attention to the specific, physical location where the event takes place.

Stories of Experience, Restorying, and Narrative Coherence

The researcher sees and describes stories in the everyday actions of teachers, students, and administrators, and then retells and relives those stories in a narrative inquiry. Hence, narrative inquiry is a process of collaboration involving mutual storytelling and restorying as the research proceeds (Connelly & Clandinin, 1990).

Narrative coherence is the extent to which an individual is able to construct coherent accounts of past lived experiences and memories (Vanden Poel & Hermans, 2019). To put it simply, narrative coherence is the degree to which a story makes sense.

Decolonization of Research and Thinking

Styres (2017) and Zinga and Styres (2019) clarify decolonization by first defining colonization and then explaining the purpose of decolonizing discourses in academia. According to Styres (2017), colonization is the subjugation of and control over a people, their lands, resources, and governance, thereby drawing those who are colonized into complex social, economic, and political relationships with the colonizers. Zinga and Styres (2019) explain the purpose of decolonizing discourses in research and thinking by stating that “decolonizing is the active process of decolonization and further, by their very nature, decolonizing discourses serve to erase the complex nuanced stories and lived experiences of a people by continuously centering discourses and relations of power on the colonizers” (p. 36). Tuhiwai Smith (1999) defines *decolonization* as “a process which engages with imperialism and colonialism at multiple levels. For researchers, one of those levels is concerned with having a more critical understanding of the underlying

assumptions, motivations, and values which inform research practices” (p. 20). Darder (2019) talks about a decolonizing methodology called *decolonizing interpretive approach*, the epistemological underpinnings of which point toward dismantling traditional Western philosophical assumptions and values of empiricism associated with hegemonic forms of knowledge construction.

Having a decolonizing analytical lens is very important for my study because I work with the Indigenous science teachers in Nebraska, who are grappling with hegemonic epistemological racism (following Western modern science at their schools), accountability towards students’ performance in government-mandated science standardized tests, and their own conscience of teaching their students through the culturally and linguistically responsive Indigenous way of learning science. So, using the decolonizing analytical lens could help in decolonizing science educational research and contribute towards Native language revitalization, tribal justice, sovereignty, and eventually could result in returning Native land to its rightful stewards.

After detailing the problem statement, the context, the purpose, the research questions, and the definitions of key terms in my study, I now segue into reviewing the extant literature about the research studies on programs and strategies for Indigenous students' success in STEM and the research studies on culturally and racially diverse science teachers.

CHAPTER 2

LITERATURE REVIEW

Research on Programs/Strategies for Indigenous Students' Success in STEM *Culturally Appropriate Approaches that Empower Indigenous Students to Learn Science*

According to Jorgensen (2020), Indigenous people have different ways of seeing, viewing, and interacting with knowledge systems. Incongruities between Western modern science and the knowledge systems of Indigenous students call for urgent measures by science teachers to employ culturally appropriate approaches and curricula, such as culturally based education (CBE), culturally responsive science curricula (CRSC), Science-Technology-Society curriculum (STS), Rekindling Traditions curriculum, and ethnoscience to meet the needs of Indigenous students in science.

Culturally responsive/appropriate education has been widely proposed as a mechanism to improve the academic achievement of Indigenous populations. Singh (2011) defines “culturally appropriate education” as the one that “melds instruction to better fit the expectations and cultural patterns of the group being served. The group’s language, culture, and its worldview are built into the routines, curriculum, and structure of the school” (p. 14). According to Kana’iaupuni (2007), there are five basic elements that comprise culture-based education: (a) Native or heritage language, (b) family and community, (c) context, (d) content, and (e) data and accountability. Two other scholars who have highlighted the importance of culture-based education are Glen Aikenhead and Gloria Ladson-Billings. To understand the science meaning-making process of Indigenous students, Aikenhead (2001a) explains that science is easily understood by

Indigenous students if there is a similarity between their own culture and experiences and the culture of modern school science (*Western modern science*) which he terms “cultural border crossings of students into school science” (p. 1). Ladson-Billings (2009) defines culturally relevant pedagogy as the pedagogy that “empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes” (p. 20).

When science educators employ culturally and linguistically relevant, culturally competent, and race- and gender-affirming science teaching, it empowers Native students to take up STEM courses and careers in the future. Hence, finding ways to incorporate (and legitimate) Indigenous knowledge systems into the mathematical or scientific school experiences is invaluable for Indigenous learners, and this creates bridges between the two worldviews, thereby validating Indigenous knowledge by offering ways of incorporating the skills and knowledge of the Indigenous people (Jorgensen, 2020). Jorgensen (2020) also urges science teachers to use their *pedagogical capital*, the unique knowledge and skill that teachers need in order to be successful in teaching STEM to Indigenous students.

Culturally Based Education. This is a widely used culturally appropriate approach, which was conceptualized by William G. Demmert, Jr. (Tlingit/Ogala Lakota), an Alaska Native, who spent his life working to improve the education of Indigenous students (Reyhner et al., 2010). Demmert (2011) emphasized that Indigenous students have trouble finding meaning in decontextualized one-size-fits-all curriculum and instruction that does not relate to their cultures, communities, and homes. According to Demmert and Towner (2003) culturally based education may be defined as approaches

that recognize and utilize Native languages as a first or second language, pedagogy that incorporates traditional cultural characteristics, and involves teaching strategies that are harmonious with the Native cultural knowledge and contemporary ways of knowing and learning. Culturally based education includes curricula based on Native culture that incorporates legends, oral histories, songs and fundamental beliefs and values of the community. It also includes parents, Elders, and community members' involvement and participation in educating Native children in the social and political mores of the community (Demmert & Towner, 2003).

Demmert brought together a consortium of like-minded teachers and schools that helped to put together a pedagogy associated with teaching, learning, and assessment called Culturally Based Education (CBE) for Native American students (American Indians, Native Alaskans, and Native Hawaiians). These programs are unique for different Indigenous student groups that the schools serve (Demmert, 2011). The consortium developed assessment tools for measuring levels of academic performance called Curriculum Based Measures (CBMs) that are used for measuring basic skills in reading, writing and mathematics. CBMs are in the language of the school (with a set in Diné, Hawaiian, Yup'ik, Ojibwe, and English) and meet national standards for validity and reliability (Demmert, 2011). Demmert (2011) adds that the consortium developed a set of CBE rubrics to help define what one might strive for in a CBE program, which are (a) *culturally based Indigenous language use*, (b) *culturally based pedagogy*, (c) *culturally based curriculum*, (d) *culturally based patterns of participation in leadership and decision making*, and (e) *culturally based methods of assessing student performance*. Demmert (2011) states that the four different levels (indicators) for each of the rubrics are

from low to high: (a) Not Present, (b) Emerging, (c) Developing, and (d) Enacting. CBE promotes a research base set of seven Center for Research on Education, Diversity, and Excellence (CREDE) principles for effective teaching that meets CBE's view of pedagogy and classroom management: (a) *teachers and students working together*; (b) *development of language and literacy across the curriculum in all content areas*; (c) *connecting lessons to students' lives*, i.e., contextualizing teaching and curriculum in students' existing experiences in home, community and school; (d) *engaging students with challenging lessons* by designing activities to advance students' understanding to more complex levels; (e) *emphasizing dialogue over lectures* through academic, goal-directed, small-group conversations; (f) *learning through observation* using models or demonstrations; and (g) *encouraging student decision making* by involving the students in choosing or designing instructional activities.

CBE can be incorporated well into science teaching and learning for Indigenous students. Gilbert (2011) provides an overview of an academically rigorous, culturally relevant and responsive curriculum and instruction model that is based on the Native Science Connections Research Project (NSCRP) and funded by the National Science Foundation (NSF). This CBE model is action and inquiry oriented as well as culturally based and integrates/connects Native students' traditional cultural knowledge with Western science for fifth-grade students in public, contract and B.I.A. schools on the Navajo, Hopi, San Carlos Apache, and Zuni reservations (Gilbert, 2011).

Gilbert (2011) explains the four phases of this culturally based education model using a sample lesson plan on "Nutrients in Native Food Plants," designed for a fifth-grade class:

1. In *Phase One: Introduction/Exploration (Inquiry and Students Perception)*, an introduction of the topic is done via dialogue in students' first language (L1) and second language (L2) discussing how the Navajo people gathered foods and use Native plants for beverages (without explaining the scientific concept in this phase). The concepts to be learned are identified as: investigating fats, sugars, and vitamin C in Native plant foods. The reasoning skills that would be developed include observing, relating, communicating, inferring, identifying, and comparing. The students learn how to collect and organize data in school, and they also take input from their family and community. Then, the whole class creates a graphic organizer with all the information collected, while the teacher acts as a facilitator. In addition to the graphic organizer, the students make Plant Boards with pictures of a food pyramid, variety of foods from magazines and recipe books, Navajo tea Plant Boards, Sumac Plant Boards (with Navajo names of the root, stem, leaves, and flowers), dried tea, and sumac berries. Students use science journals and take a pre/post quiz to assess their understanding.
2. In *Phase Two: Cultural Context (Cultural Perspective)*, the cultural context where the traditional Native cultural knowledge pertaining to the science topic, and which have been imparted in an oral tradition are taught. Five to eight Navajo words and their English translations for the lesson unit are selected to develop the vocabulary for the students. This phase includes learning about traditional Native stories and teachings as

well as traditional uses of plants by listening to community members' via guest lectures in the classroom. The students undertake field trips in the students' specific surroundings and environment where plants, landforms, and other tangible examples within the students' realm or experience can be recognized, identified, explored, explained, expanded, and amplified.

3. In *Phase Three: Classroom Science (Expansion/Scientific Explanation)*, the focus is on communicating concepts, ideas, and honing skill exercises taught in science textbooks and/or science kits. The students listen to classroom lectures, participate in hands-on inquiry-based activities, and access the textbook and electronic media to gather information. They also use measuring tools, rulers, test tubes, microscopes, telescopes, and cameras to record and monitor information, which allows students to think inductively and deductively and also hone their mathematic skills.
4. In *Phase Four: Integration of Cultural Knowledge (Connecting to Western Science/*
5. *Expanding the Idea)*, the students organize the newly learned concept with other concepts that are related to it. The students consolidate both their knowledge of the scientific vocabulary and their Native language.

Culturally Responsive Science Curriculum. This standards-based, culturally appropriate approach was conceptualized by Sidney Stephens of the Alaska Science Consortium working with the Alaska Department of Education. Stephens (2000) states that “culturally responsive science curriculum attempts to integrate Native and Western knowledge systems around science topics with goals of enhancing the cultural well-being

and the science skills and knowledge of students” (p. 7). Stephens (2000) outlines five key characteristics of CRSC: (a) it begins with topics of cultural significance and involves local experts; (b) it links science instruction to locally identified topics and to science standards; (c) it devotes substantial blocks of time and provides ample opportunity for students to develop a deeper understanding of culturally significant knowledge linked to science; (d) it incorporates teaching practices that are both compatible with the cultural context, and focus on student understanding and use of knowledge and skills; and (e) it engages in ongoing authentic assessment which subtly guides instruction and taps deeper cultural and scientific understanding, reasoning and skill development tied to science standards. CRSC is a time-consuming process that requires cultural relevance, science standards-based teaching using best practices, and ongoing and diverse ways of assessing students’ work (Stephens, 2000).

CRSC has been successful in Alaska with Yup’ik people, and not only it is culturally relevant, but it also incorporates the Alaska Science Performance Standards in teaching and assessment (Stephens, 2000). One example of a CRSC lesson is “Plants of the Tundra.” In a phase of this lesson, students do classroom observations and classification of plant samples. They undertake field trips with Elders identifying plants and discussing their significance and uses. They collect, press, and label plant samples with their Yup’ik names. They make plant booklets with pressed plant including the information collected from Elders. Then, they predict, pick, and measure the amount of berries that can be picked in a 1-meter diameter circle (Stephens, 2000).

Science-Technology-Society (STS) Curriculum. Brayboy and Castagno (2008) stated that the first science curriculum was suggested by Aikenhead and was called

Science-Technology-Society (STS). This curriculum was developed internationally over 40 years ago and emphasizes cultural border crossing between mainstream Western science and Native or Indigenous sciences (Aikenhead, 1997). In STS science education, students and teachers both become cultural border crossers with the goal of learning the culture of Western science in order to use it for practical action toward economic development, environmental responsibility, and cultural survival. Aikenhead (1997) details how the border crossings happen in a science classroom:

Border crossings within a cross-cultural STS science curriculum may be facilitated by studying the subcultures of students' everyday worlds (peers, family, tribe, nation), by contrasting those subcultures with a critical analysis of the subculture of science (its norms, values, beliefs, expectations, and conventional actions), and by consciously moving back and forth between the everyday world and the science world, switching language conventions explicitly, switching conceptualizations explicitly, switching values explicitly, switching epistemologies explicitly, but never requiring students to adopt a scientific way of knowing as their personal way (p. 232).

Rekindling Traditions Curriculum. The second science approach is also described by Aikenhead (2001b) and is called the “Rekindling Traditions: Cross-Cultural Science & Technology Units,” that illustrates cross-cultural science teaching for years 6–11, in which Western and Aboriginal sciences are integrated. Within this curricular approach, the teacher begins with an “Aboriginal framework” and then introduces Western science concepts “as useful

knowledge from another culture” (p. 343). Employing his concept of border crossing again, Aikenhead argues that the final step in this approach is the facilitation of students’ understanding of the Western science concept, thereby crossing the border from their own conceptual framework to that of Western science. Aikenhead (2001b) describes the following example of a science lesson to explain the border crossing and the interconnectedness between Aboriginal science and Western science:

For instance, in the Snowshoes and Trapping units, the technologies are originally studied from historical and cultural perspectives of the local community. Then the class takes a closer, in-depth, Western scientific look at the pressure exerted by snowshoes on snow and by traps on animals. By understanding the scientific stories about force, pressure, and energy, students learn to predict more accurately the effects of variations in the technology. While the Western science concepts do not improve students’ know-how for snowshoeing or trapping, the concepts clarify one small aspect of the overall topic. Western science does not replace Aboriginal science, it enriches a small aspect of it (p. 347).

Ethnoscience. The most-cited science and math curriculum is called ethnoscience (Brayboy & Castagno, 2008). Davison and Miller (1998) define ethnoscience as “the body of science used by the culture to make the curriculum relevant to the individual” (p. 261). Tuhiwai Smith (1999) supports the “development of ethnoscience and the application of science to matters which interest Indigenous peoples” (p.160). Snively and Corsiglia (2001) state that although we all participate in Indigenous science to a greater or lesser degree, long-resident, oral culture peoples could be thought of as specialists in local Indigenous science. Indigenous science, sometimes referred to as ethnoscience, has

been described as the study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its given universe (Hardesty, 1977; Snively & Corsiglia, 2001).

Davison and Miller (1998) explain the differences between Western science and ethnoscience using an example science lesson involving classifying Native plants. A typical Western science method would be to classify the plants by developing dichotomous keys, collecting plants, and identifying plants either by that dichotomous key or by using a book with pictures of the plants. Then, the Latin classification and naming systems are added. An ethnoscience approach to the same lesson would be quite different in content but will achieve the same objective within the classification context. For example, students on the Crow Nation Reservation in Montana may study plants Indigenous to their area. However, they could classify these plants based on their use by the Native culture using the Crow language names, religious beliefs, and the medicinal values of the plants as identifiers. This activity is culturally relevant to the Crow people, but it may not be relevant to the Indigenous people from Northern Cheyenne Reservation a few miles away from the Crow Nation Reservation. This example also reiterates the fact that generalized and uniform pedagogical curricula and practices would not work for *all* Native American populations, and reaffirms the unique and pluralistic nature of the AI/AN populations. Fasasi (2017) reported that incorporating ethnoscience perspectives into the classroom can enhance learners' knowledge and attitudes towards science.

Curricular and Pedagogical Strategies for Culturally Responsive Schooling

The widening student-teacher diversity gap makes culturally responsive schooling for Indigenous students all the more important in today's world. Two aspects of

schooling that have a significant and direct impact on students are pedagogy and curriculum (Castagno & Brayboy, 2008; Brayboy & Castagno, 2008). Culturally responsive schooling has been widely used as a promising strategy for improving the education and academic achievement of AI/AN Indigenous students in the U.S. (Castagno & Brayboy, 2008).

Creation of Curricular Cultural Standards in Indigenous Schools. The Alaska Native Knowledge Network (1998) provides an exemplary model for developing its own cultural standards for curriculum. They have adopted these curricular standards to complement the standards set forth by external governmental agencies to ensure that local cultures and languages are represented in school curricula (Castagno & Brayboy, 2008). Culturally responsive curricula connect to students' lives, represent their cultural and linguistic backgrounds, and present accurate images of both the past and present, will tap into students' curiosity and engage them in topics that are interesting to them by strengthening the quality of curricular learning materials and pedagogical strategies (Skinner, 1991; Cleary & Peacock, 1998; Agbo, 2001; Sparks, 2000).

The cultural standards for culturally responsive schools have been created by the Assembly of Alaska Native Educators to provide a way for their schools and communities to examine the extent to which they are attending to the cultural and educational well-being of their students (Alaska Native Knowledge Network, 1998). These cultural standards have been drawn up in five areas, including those for students, educators, curriculum, schools, and communities. Culturally responsive schooling assumes that a "firm grounding in the heritage language and culture Indigenous to a particular tribe is a fundamental prerequisite for the development of culturally healthy

students and communities associated with that place, and thus is an essential ingredient for identifying the appropriate qualities and practices associated with culturally responsive educators, curriculum, and schools” (Alaska Native Knowledge Network, 1998).

These kinds of educational approaches using cultural standards for Native populations require a shift in teaching methods, curricular materials, teacher dispositions, and school-community relations (Castagno & Brayboy, 2008). The other successful and most studied culturally responsive schooling efforts for Indigenous youth are Kamehameha Early Education Program (KEEP) for Native Hawaiian students, Rock Point and Rough Rock community schools on the Navajo reservations, and Tuluksak School for Yu'pik tribe in Alaska (Castagno & Brayboy, 2008; Demmert, 2001).

Although the extant literature documents several examples of CRP strategies used by teachers in different content areas for Indigenous students, this dissertation highlights only examples of strategies used by science/STEM teachers who teach Indigenous students, successfully meshing ideals of equitable, culturally relevant teaching into their science instruction showing that such science teaching is possible (Aguilera et al., 2007; Kawagley et al., 1998; Lipka, 1998; Castagno & Brayboy, 2008; Haynes-Writer & Valdez, 2021).

Valuing Indigenous Knowledge Systems as Assets of Native Students. Several educational researchers, activists, and academics from Canada (e.g., Marie Battiste, Glen Aikenhead, and Carol Mullen), New Zealand (e.g., Linda Tuhiwai Smith), Australia (e.g., Aileen Moreton-Robinson), the United States (e.g., Gregory Cajete and Tsianina Lomawaima), and scholars of the Indian origin (e.g., Kakali Bhattacharya, Bhaskar

Upadhyay, and Leigh Patel) have pioneered and contributed towards decolonizing anti-racist and justice-oriented pedagogies for Indigenous education around the world. Eisner (1985/2002) presents a chronological and historical account of education in the USA and about the trend-setting scholars' influence in U.S. education. Eisner (1985/2002) demonstrates that there has been a gradual increase in complexity in the creation of educational policy, standardization, and accountability since they were initiated, and he also gives reasons why these policies failed in our diverse, multicultural, and multilingual world. Moreover, deficit approaches to teaching and learning, firmly in place prior to and during the 1960s and 1970s, viewed the languages, literacies, and cultural ways of being of many students and communities of Color as deficiencies to be overcome in learning, and the only legitimized language, literacy, and cultural ways of schooling are that of the dominant language, as those were viewed as superior practices (Paris, 2012). Native children are continually viewed with a deficit mindset and are being subjected to "intelligence testing" (Noel, 2002).

Regmi and Fleming (2012) state that one of the arguments constantly used against Indigenous knowledge is its reliance on spiritual and cultural belief systems and that this knowledge does not pass a scientific test. This argument excludes Indigenous knowledge as a useful and meaningful way of knowing, disregarding centuries of lived experiences that were the basis of Indigenous knowledge. Lee (2005) states that Indigenous students and students from nonmainstream racial/ethnic, cultural, linguistic, and socioeconomic backgrounds come to school with already constructed knowledge, including their home language and cultural values from home and community environments. When these students are provided with equitable learning opportunities, they demonstrate academic

achievement, interest, and agency by capitalizing on their linguistic and cultural experiences as intellectual resources for new learning in their classrooms (Lee, 2005). Yet, their knowledge systems and experiences are considered discontinuous with science disciplines as traditionally defined in Western modern science (Lee, 2005). Indigenous children are being compared with middle-class White children based on their performance in standardized tests without even considering the repercussions of their violent past and their lack of “social capital” leading to the “opportunity gap” between the White and Native children (Cohen & Allen, 2013; Ladson-Billings, 2006a, 2006b). Despite the richness and depth of knowledge systems of the Indigenous and culturally and linguistically diverse people, they have been devalued for a long time. Many scholars have delineated the differences between Indigenous knowledge systems and Western modern science systems, and they have emphasized that valuing Indigenous knowledge systems as assets would prove highly beneficial for Native students.

Barnhardt and Kawagley (2005) elaborate on Indigenous knowledge systems comparing it with Western science systems. Indigenous peoples throughout the world have sustained their unique worldviews and associated knowledge systems for millennia, and they have traditionally acquired their knowledge through direct experience in the natural world (Barnhardt & Kawagley, 2005). For the Indigenous people, the particulars come to be understood in relation to the whole, and the “laws” are continually tested in the context of everyday survival, and they engage in a form of science when they are involved in the annual cycle of subsistence activities (Barnhardt & Kawagley, 2005). They have studied and know a great deal about the flora and fauna, and they have their own classification systems and versions of meteorology, physics, chemistry, earth

science, astronomy, botany, pharmacology, psychology (knowing one's inner world), and the sacred (Burgess, 1999). McKinley and Gan (2014) explained that recent knowledge in science education focuses on core epistemological debates on universalism and multiculturalism, and that more prolific research is being done in theorizing and researching practice on culturally responsive pedagogies in science education. The authors argue that knowledge of Western modern science (WMS) and traditional ecological knowledge (TEK) is necessary to understand about universalism and multiculturalism. The concepts of *cultural hybridity* and *third space* were explained using examples. Zembylas and Avraamidou (2008) stated that the notion of cultural hybridity provides science educators with a theoretical tool to unpack and understand the issues of identity (e.g., of science learners). In this work, "hybridity" is defined as the creation of transcultural forms of experiences as a result of colonization, draws attention to the nature of identity as fluid rather than "fixed," and acknowledges the contextual influence of social, historical, and political practices on identity formation (p. 981-982).

Moje et al. (2001) proposed three different but interrelated views on third space as "a bridge, a navigational space, or a space for critical understandings of the relationships between science and students' 'everyday worlds'" (p. 54). Some researchers have used third space as the space to describe how teachers, students, and others in school settings establish new forms of participation that bring together the first space of school science with the second space of the home/culture to create a third space that is inclusive of both in the form of hybrid knowledge (McKinley & Gan, 2014). This third or hybrid space draws attention to the different knowledge, discourses, and relationships that influence science learning, allowing for the collective construction of new knowledge, discourses,

and identities (Moje et al., 2004; McKinley & Gan, 2014). One example would be Glasson, Mhango, Phiri, and Lanier's (2010) in-depth interviews with Malawian farmers on their traditional agricultural practices. Glasson et al. (2010) were able to draw connections between the Indigenous way of living of these African elders and the practices relevant to the field of sustainability science to co-construct a science education curriculum. Using a third-space framework, the authors argued for creating a dialogic space that allows for bringing science educators and Malawian Elders together in order to negotiate on how best to include in the science curriculum the practical Indigenous knowledge held by the Malawian Elders as well as what sustainability science education can offer for the community, i.e., they explained about sustainable farming and the use of msangu trees, which helps in carbon sequestration (absorption of CO₂ and other greenhouse gases) and nitrogen fixation in leaves.

Using Students' Funds of Knowledge. Learning about students' funds of knowledge (FOK) allow teachers to offer relevant learning experiences, achieving a fuller socio-constructivist approach to teaching and learning (González, Moll, & Amanti, 2006). Several scholars have documented the benefits of using students' FOK in science classrooms. A study by Hogg (2016) explores the relevance of the FOK concept among Māori and Pasifika students in New Zealand. This study explored the application of FOK theory with a focus on impacts for Māori and Pasifika students, as they have been found to have inequitable learning experiences. Teachers in this study developed two ways to apply students' FOK to support academic learning: drawing on and drawing out their life experiences. Improvements in learning behaviors and achievement gains were reported by students, parents, and teachers. Llopart and Esteban-Guitart (2017), two researchers

from the University of Girona in Spain, illustrated the notion of educational contextualization by examining 59 articles from the ERIC database in the areas of funds of identity and identity investment, concepts which sit within the broader framework of approaches to FOK. They focused on how students' formations of identities relate to FOK and describe strategies and resources to contextualize the curriculum based on processes of students' identity work within the FOK approach (Llopart & Esteban-Guitart, 2017). Ugandan scholars Kendrick and Kakaru (2012) describe FOK and the means of acquiring new knowledge of children living in child-headed households in Uganda's Rakai District. Using an ethnographic approach, the authors documented the experiences and activities of children in five rural home contexts, and they advance the view of children as resourceful, competent, and knowledgeable, highlighting their ability to build on, utilize, and acquire new FOK while simultaneously recognizing their conditions of extreme adversity (Kendrick & Kakaru, 2012). Another research in the Canadian context was that of Marshall and Toohey (2010) who use critical discourse analysis to examine educators' efforts to incorporate FOK from the communities and families of Punjabi Sikh students in a Canadian elementary school. In this study, students recorded their grandparents' stories of life in India on MP3 players and then translated them into picture books to serve as cultural resources in their school community. In retelling their grandparents' stories, students drew on multiple ancestral, globalized, and Western discourses in their textual and pictorial illustrations. The authors examined what happens when FOK that students bring to school contradict the normative, Western understandings of what is appropriate for children and how schools might appropriately respond to varying community perceptions of good and evil (Marshall & Toohey, 2010).

Gilbert (2011) explained that “Native American understanding of life is in reflections to cycles. The cycles of life, nature, and the elements are circles without beginning and end” (p. 48). Haynes-Writer and Valdez (2021) state that Native science is comprehensive, holistic, sacred, complete, and is a way of life, which contrasts with a linear-oriented Western modern science that is compartmentalized into various branches or specialties. Hence, science educators are obligated to understand that Native science is a way of being and that knowledge sharing is to the benefit of the students’ tribal communities. This is done by drawing from students’ FOK (Moll et al., 2009). Moll et al. (2009) defined FOK as “historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being” (p. 72). The concept of FOK is based on the recognition that an individual’s experiences within the family or community yield knowledge that is useful, powerful, and transferable (González & Moll, 2002; González, Moll, & Amanti, 2005).

An example of using the FOK of students would be Roehrig et al.’s (2011) study which focused on Ojibwe students, where a teacher created a “science exploration corner.” The Native American children visited the space daily, observed the recorded the creatures and plants that they could find. This “nature theme” weaved in the “cultural theme” for the Native students. The students and teachers then went on a “wild-ricing trip” to learn about wild rice, a sacred Ojibwe plant, rooted in the history and culture of the tribe. With the guidance of one of the Native teachers, the group used canoes and traditional equipment to rice in a small stream. Then, they observed the long process of how wild rice is processed. The teachers and students concluded that this workshop was the most beneficial workshop they had participated in. CRP practices such as the ones

mentioned above make students proud of their culture, traditions, and food habits when their FOK is valued while learning science.

Another way to incorporate students' FOK is to acknowledge students' prior knowledge and redesign science lessons. Braaten and Sheth (2016) state that "positioning students' ideas, language, and experiences is integral to teaching and learning" (p. 137). If science teachers have similar cultural, ethnic, linguistic, socioeconomic backgrounds like those of their Native students and if they redesign science lessons for their students, it will greatly encourage Native students to effectively engage with science content.

Ethnomathematics is another way in which a STEM subject has used cultural context to teach content. Ethnomathematics includes the integration of mathematical concepts and practices from the target culture to formal mathematics (Adam, Alangu, & Barton, 2003). *Math in Cultural Context* (MCC) is a long-term response to the persistent exclusion of Alaska Native language, culture, and pedagogy from the practices and norms of schooling in Alaska, and it was brought together by Alaskan Native (mostly Yup'ik) Elders, mathematicians, math educators, educational researchers, teachers, and school districts (Lipka & Andrew-Ihrke, 2009). MCC is one of the few ethnomathematics programs that has shown consistent improvements in the mathematical performance of Alaskan students (both Indigenous and other students) grounded in empirical research. A similar classroom example that Aguilera et al. (2007) talk about is the learning practices of students in a geometry class based on the development of a culturally based mathematic module called *Patterns and Parkas*. This model helped math and science teachers in an Indigenous school project which was called "University of Alaska-Fairbanks' Project for Yup'ik-based Mathematic Modules—*Math in a Cultural Context*

(MCC)” to redesign lessons that tapped into Indigenous knowledge which were relevant to Indigenous students (Aguilera et al., 2007, p. 6).

Integrating Cooperative Learning. Sparks (2000) noted that cooperative strategies tend to work very well with Native American students because these students tend to value cooperation and harmony, which maximizes a grouping methodology. Native American students are seen to do better academically in cooperative rather than competitive learning environments, which also increases student engagement (Cleary & Peacock, 1998; Gilliland, 1995; Pewewardy & Hammer, 2003; Sparks, 2000; McCarty et al., 1991). Gilliland (1995) points out that “cooperative learning is not a single method or several methods. It is an attitude toward students, a concept of learning, a whole way of life within the classroom and, hopefully, throughout the school” (p. 43). Since this strategy closely matches traditional values and behaviors within many tribal communities, cooperative learning improves student achievement and student attitudes (Castagno & Brayboy, 2008; McCarty et al., 1991). In cooperative learning strategies, teachers act as mediators of knowledge and provide assistance through the use of questions, feedback, scaffolding, and building on students’ prior knowledge of science (Pewewardy & Hammer, 2003; Brayboy & Castagno, 2008; Lipka, 1990; Kawagley et al., 1998). Sparks (2000) reiterated that students should be organized into culturally heterogeneous cooperative learning groups and given tasks requiring group cooperation and interdependence, and activities should be structured so that teams can experience success.

Integrating Visual Arts and Arts-Based Science Teaching. Arts-based practice is defined as a practice that employs a systematic use of artistic processes, and the

making of artistic expressions to illuminate, reveal, understand, and examine lived experiences (Bhukhanwala et al., 2017; Eisner, 2008). Berriz, Wager, and Poey (2018) in their book, *Art as a way of talking* state that arts inspire emergent bilinguals to use their imaginations to link their lived experiences to solving academic problems, and this broadens the possibilities for culturally and linguistically diverse students. Crawford (1995) claims that community-based, culturally responsive, and *creative* ways of knowing help Indigenous students with their formal and informal education and facilitates young students to thrive in their new linguistic environments. Community-based learning gives voice to the Native People, who have historically been subjected to decades of cruelty, deculturalization, and displacement from their homelands (Crawford, 1995). According to Babaci-Wilhite (2019), “art in an academic context or in any other area that involves group dynamics or collaborative interaction can serve as a model insight into process” (p. 11).

Science educators and scholars have come to realize that science instruction is often disconnected from the lives of all students, including Indigenous students (Buxton, 2010; Elmesky & Seiler, 2007). To address this urgent need and improve engagement levels of students, teachers and teacher-educators feel compelled to integrate STEM concepts with the arts (STEAM) across the wider curriculum. The principal difference between STEM and STEAM is that STEM explicitly focuses on scientific concepts, whereas STEAM investigates the same concepts through collaborative, creative, inquiry and problem-based learning methods. While discussing the importance of inquiry science, Krajcik and Sutherland (2010) state that various features of literacy are embedded in inquiry science: (a) linking new ideas to prior knowledge and experiences,

(b) anchoring learning in questions that are meaningful in the lives of students, (c) connecting multiple representations (e.g., art and multimodal elements), (iv) providing opportunities for students to use science ideas, and (v) supporting students' engagement with the discourses of science.

Liao (2016) gives several examples of arts-integrated STEM projects. One such example is where students were required to create an application, a physical 3-D storybook that could be used to teach a scientific concept by utilizing STEAM knowledge and skills. The students designed and engineered a 3-D display of a story by drawing on mathematical knowledge along with scientific knowledge. In this project, students learned about the scientific concepts governing electronic circuits and electricity, acquired coding skills, and gained technology skills. Liao (2016) states that future research on arts-integrated approaches to STEAM education might ensure future prosperity, offer educational opportunities, and thereby contribute to a more just and innovated scientific society. Vislavath (2019) explored the ways in which the Aboriginal communities in India utilized indigenous artistic, scientific, linguistic, and cultural resources to teach members of their own communities a scientific understanding of nature. Vislavath (2019) also looked into their usage of culturally specific short stories to impart knowledge and skills of science and technology required for application in their daily life. Bhukhanwala et al.'s (2017) research study on transformative learning methods gives examples of arts-based activities such as Play-Doh and pipe cleaner sculptures, drawings, and paintings, which were done by student teachers as artifacts to understand and interrupt the dilemmas they faced in student teaching contexts.

Many scholars suggest that teachers integrate the visual arts across the

curriculum, design learning activities that allow students to observe, and use tools such as paper, markers, videos, and chalk (Cleary & Peacock, 1998; Gilliland, 1995; Castagno & Brayboy, 2008). Reid (2015) suggested that students could research any scientific topic of their interest and present their projects in various ways through posters, art, photographs, and computer graphics.

Visual representations could also include use of the whiteboard or PowerPoint to display visual information, definitions, diagrams (e.g., graphs, tables, symbols), or to illustrate points with photographs or videos (Gillies & Rafter, 2020). The use of visual representation also validated and affirmed students' identities and knowledge. Izadi (2016) states that use of drawing in physics education motivates students to look carefully, to think deeply, and to design models; one of the teachers in the study initiated a project called "Physics in Nature." The students described a volcanic eruption and explained how it changes the ocean floor using their paintings, models, and experiments. They built a scientific apparatus for their volcano experiments; took photographs, analyzed, and interpreted the photos to arrive at results. In another experiment, they also made models of a bridge using a single sheet of paper to find the stresses, forces, maximum resistance against weight, and investigated the relevant parameters for construction of a strong bridge. This modeling activity helped students to think as designers (or) civil engineers who construct bridges in real life. Another scholar, McGinnis (2007), states that students' social worlds are multilingual and multimodal; hence, inquiry-based projects (for e.g., 5E instructional model in science instruction) are one type of pedagogical practice that can support students' literacy and language practices, create supportive classroom environments, and provide an avenue for teachers

to learn more about the social worlds of their students. Audiotaping of the science class, providing illustrated notes that represent important concepts, using a number of colorful visual aids to complement lecture material could also help Native students (Sparks, 2000). One more example would be a science teacher using multilingual and multimodal elements (e.g., gestures, drawings, and visuals) and resources to assist Native students in realizing their mistakes in the student-produced circuit symbol of a battery (Tai, 2021).

Embodied Representations in Science Teaching. Embodied representations include use of the whole body and gestures to help emphasize a point or the information being discussed. Embodied representations are demonstrated through visual, spatial, verbal and motor congruency (Gillies & Rafter, 2020). Catalano and Leonard (2016) demonstrate how space can be created in everyday curriculum for embodied experiences, reiterate the potential of dance in academic and curricular inquiry, and show connections between dance and democratic society. Khasnabis et al. (2018) state that when culturally and linguistically diverse learners create videos, poems, and hip-hop music that vividly depicts their lived experiences, the potential for contextualized and meaningful learning increases. Total Physical Response (TPR), is another method employed to teach scientific vocabulary and concepts and intercultural communicative competence by using physical movement to react to verbal input, for e.g., students act out songs, stories, skits, and even use non-verbal modes of communication, such as thumbs-up signs, handshake, and shaking of the head, etc. (Reid, 2015).

Engaging students with hands-on activities, role plays, stories, plays, skits, dance, poems, songs, movement of the body, kinesthetic manipulatives, and hip-hop will enthuse, motivate, and also help students to master concepts in content-based subjects

like science (Gillies & Rafter, 2020). Sparks (2000) also states that Native Americans tend to be highly visual learners due to their cultural upbringing. Since notetaking could be troublesome to Native American students, alternatives, such as preparing material on a word processor or presentation software can generate colorful illustrations to accompany the written word (Sparks, 2000). The history of many tribes has been passed from one generation to the next through storytelling, singing, and dancing. Hence, when oral techniques are accompanied by visual (and preferably, active) cues, it will lead to active engagement and learning for Indigenous students (Sparks, 2000). Mchombo's (2019) research on Indigenous children in Malawi employed songs and games to help children deal with issues such as manipulation of objects in space and time, adhering to exact specifications of mathematical calculations and synchronization, which is crucial to science learning. Mchombo's study revealed that songs and games assert and reaffirm the importance of Indigenous culture in the learning of mathematics and science.

Integrating Experiential Learning, Service Learning, Hands-on Learning, and Field Trips. Experiential learning is seen as an important element in CRP for promoting science teachers to experience for themselves indigenous culture, language, and cross-cultural science teaching (McKinley & Gan, 2014). Some concrete ways to employ a more holistic approach in which learning is connected to students' lives are to integrate experiential learning, service learning, hands-on learning, and field trips (Cleary & Peacock, 1998; Castagno & Brayboy, 2008; Sparks, 2000; Haynes-Writer & Valdez, 2021).

In many Native American cultures, children learn new skills by observing them and then doing them. This hands-on technique is part of their natural learning style and

should be used to the maximum extent possible (Sparks, 2000). Another research study in Nicaragua urges educators who are involved in the improvement of science instruction to explore how science education could better align with the needs and interests of specific communities, especially in areas of Central America where local knowledge has been expunged from schools (Fowler, 2020). Fowler's (2020) research draws upon Culturally Sustaining and Revitalizing Pedagogies (CSRP) to explore a single community's visions for science education and how these visions may be used as pathways for restoring relevant science education practices. In this study, many participating teachers and community members provided detailed accounts of local science knowledge or methods of teaching science that had been replaced with Westernized curriculum and pedagogies to the detriment of learning and their community. The results indicated two overarching visions that the teachers and community members had shared with the researchers: (1) a vision for reviving "Scholar Orchards" and (2) a vision for learning science with community resources. An elderly couple who participated in Fowler's (2020) study explain how Scholar Orchards, the authentic partnerships between schools and neighbors that had once existed, function. The couple stated that small plots of land were cultivated year after year by classes learning science and using the outdoor spaces as classrooms. The participating landowners frequently spent time alongside students sharing their generational expertise of how to best learn from, care for, and use the land, i.e., landowners and teachers taught about soil health, water conservation, landforms, propagation, crop rotations, fertilization, and other plant-related biological content. While the majority of the plots' yields (most commonly melons, squash, beans, and various fruit) were used in school meals or sold to purchase other education materials, a small

percentage of the harvest was returned to the partnering community member in exchange for their help (Fowler, 2020). These findings highlighted the need to partner with local teachers and community members when designing, implementing, and evaluating science education because they possess sophisticated visions for making science more relevant, sustaining, and revitalizing within their community context.

Another familiar theme to teachers is the concept of the “extended classroom” or taking instruction beyond the walls of the school (Sparks, 2000; McKinley & Gan, 2014; Hogue, 2016). This is often accomplished through field trips into the community and surrounding environment. Hogue (2016) advocated for removing the reliance on textbooks and moving to experiential project-based activities to engage students in ways that are culturally recognizable and relevant. Haynes-Writer & Valdez (2021) give two examples from Hogue’s (2016) study, which were action-oriented, experiential, hands-on STEM learning projects. One was at a Canadian Indigenous school in Kainai Nation, and the high school students completed STEM projects, and the other example was at Blackfeet Nation Reservation in Montana, where middle school students participated in an experiential 5-day science, math, and technology summer camp. Hogue (2016) stressed, “As a historically oral culture, this cultural lens includes learning through narrative, story, music, ceremony, mentorship, traditional practice, and learning from the land” (p. 168). Sparks (2000) also suggested visits to the Native-owned businesses and other local enterprises to give the cultural perspective and positive images of successful Indigenous people.

Djonko-Moore et al. (2018) examined how experiential and collaborative science education supported urban children’s science knowledge and engagement through

cultural relevance and eco-justice during a 1-week summer camp. They found that children's science content knowledge and their engagement in science lessons improved during their study. One more example is a chemistry teacher designing a 7-week experiential inquiry unit on the environmental impacts of chemicals used in industries and small businesses around the school. This project not only addressed the national science standards, but it also addressed the overall unit objective of applying relevant knowledge of chemistry to everyday situations and students' knowledge about eco-justice (Sharkey et al., 2016). Stevens et al.'s (2016) study showed that out-of-class activities (informal science education experiences) offer students the opportunity to learn in a safe environment without the fear of failure which they may experience in a traditional classroom. In this study, field trips helped students learn about solar energy, optics, flight and motion, GPS, and astronomy in five modular themes. Sparks (2000) warns that although the experiential and field trip approach work well with Native students due to its active, hands-on nature, field trips must be relevant to both the learner and the curriculum and not simply isolated experiences.

Involving Local Community and Elders. Sharkey et al. (2016) found that a professional development inquiry gave insights into how teachers develop, implement, and interpret community-based pedagogies (CBPs). This begins with recognizing and valuing the rich local knowledge which also promotes teacher autonomy and ownership to design culturally responsive science lessons. Chigeza (2011) claims that taking a resource-rich view of the Indigenous communities challenges the deficit views that blame Indigenous students and explain their perceived failure in terms of low interest in academics, poor motivation, and perceived low ability levels of Native students.

According to Chigeza (2011), cultural resources include community cultural wealth, which is an array of cultural knowledge, skills, abilities, and contacts possessed by Native student communities. Creating culturally responsive pedagogies can be achieved by helping students use their existing cultural resources in new, productive, and meaningful ways (McKinley & Gan, 2014).

Indigenous communities typically represent an outstanding example of people who live in harmony with their environment and community, and these strengths benefit their students. Using Native experts and Elders as resources, this environmental perspective can be brought to the classroom. Sparks (2000) states that including Elders as instructors in schools can prevent Native American traditions from being forgotten. Academic credentials are comparably matched by their knowledge of culture, tradition, and language. Most tribes have Elder programs, and many welcome the opportunity to talk with young people. Bringing Elders into the classroom promotes respect for their wisdom and provides positive role models for Native American students. When working with Elders, finding out what their perceived strengths are and letting them take the lead in instruction would be beneficial. They may utilize storytelling, songs, dance, music, ceremonies, or any number of vehicles to instruct students (Sparks, 2000).

As another example of community-based curriculum project for making science responsive and relevant to Native youth, Bang and Medin (2010) involved Elders and other community people in teaching along with mainstream educators in their community-based summer science programs for the urban Chicago, Illinois, Native community, and the rural Wisconsin Menominee community. The programs were designed to support students by centering on multiple ways of knowing, such as gleaning

from the natural world and learning from Elders and parents, therefore, the students themselves became generators of science knowledge and ways of knowing (Haynes-Writer & Valdez, 2021).

Language Immersion, Preservation, and Revitalization. Several studies provide evidence that Indigenous language immersion, preservation, and revitalization programs are vital to healing the negative effects of colonialism and assimilationist schooling that have disrupted many Indigenous homes and communities (Cajete, 1994; Aguilera & LeCompte, 2007; Hermes, 2007; Reyhner et al., 2010; Luning & Yamauchi, 2010; García & Wei, 2015; Coates & Leech-Ngo, 2016; Siekmann et al., 2017; McIvor & Anisman, 2018).

Cajete (1994) has asserted that access and revitalization of Indigenous bases of education must occur, “not only in the contemporary classroom, but in Indian communities as well” (p. 18). Bilingual immersion programs are an effective tool for reviving and preserving Indigenous languages (Cummins, 2009). Some of the most successful native language revitalization efforts have centered on community-based language learning in saving critically endangered languages from extinction with adults learning alongside youth (McCarty, 2008).

According to Cummins (2009), two different education programs use the term “language immersion,” namely (a) planned programs of bilingual second language instruction with a goal of being able to speak, read, and write two languages well, and (b) “submersion” education with a goal of being able to speak, read, and write only the dominant language. Submersion programs, such as the one followed in residential boarding schools for the Native peoples, displaced, subtracted the Indigenous language

from the learner's repertoire, and eventually replaced the traditional Indigenous language (Coates & Leech-Ngo, 2016).

Well-planned immersion programs, however, provide an important tool to revitalize traditional Indigenous languages (Coates & Leech-Ngo, 2016). Coates and Leech-Ngo (2016) and Cummins (2009) state that Indigenous language revitalization programs, have identified a number of "wise practices" or core features that can support the development of success of Indigenous students, such as (a) parent and community involvement; (b) making the language of the Indigenous communities as the primary language of instruction; (c) promoting bilingualism/multilingualism; (d) including Indigenous culture in the curriculum, such as Elders teaching Native crafts so that Native culture is not only a subject but the students get an embedded learning experience; (e) providing opportunities for students to use literature and resources in their Indigenous language; (f) making learners participate in language immersion camps, home-based learning and other forms of experiential learning to help support students; (g) having learners of similar abilities in the immersion language in a classroom; (h) having bilingual teachers fluent in both the Indigenous language and the other language teach students; (i) using traditional teaching methods, including Indigenous ways of knowing, learning and being, as the primary teaching method; (j) using technology when possible, as online resources can help students link to dictionaries, games, puzzles, and other innovative resources and methods of computer assisted language learning; and (k) having stable and adequate funding to support all aspects of development and implementation of the program, including resources for conducting ongoing research to help students learn traditional languages and cultures for the continued wellbeing of the community, i.e.

making the program sustainable. McIvor and Anisman (2018) add some more beneficial practices for successful immersion programs, such as teacher training and post-secondary initiatives for language retention and revitalization, policy development and political advocacy, different kinds of immersion practices/programs (e.g., cross-generational/community-based immersion, early childhood focused immersion, K-12 immersion, adult-focused immersion), and home-based learning.

One example of a language immersion Indigenous school that has been successful is the Waadookodaading, the Ojibwe Language Immersion School at Lac Courte Oreilles, Wisconsin, United States. Hermes (2007) provided her reflections on the founding of this school in her article. In her school, all subjects, including science, were taught in the Ojibwe language. Her findings revealed that Indigenous-language immersion could be a key to producing both language fluency and academic success in culture-based schools, that a powerful culture-based curriculum could motivate and create self-esteem for Native students, and that Native culture and traditions are assets to student success. Aguilera and LeCompte (2007) examine and summarize the history and implementation of three different language immersion programs for American Indian, Alaska Native, and Native Hawaiian children in three different language communities. Evidence was found in all three cases of the tremendous adaptability in Native communities, as well as of their ability to transform their schools into academic institutions that provide opportunities for children to become well-educated bilingual and bicultural adults with intact Native cultural identities (Aguilera & LeCompte, 2007).

Hermes (2005) highlights the importance of teaching culture through an Indigenous language. Hermes (2005) states that “Ojibwe language, used as the medium

of instruction in school, provides context and gives students the opportunity to be creative participants in making meanings” (p. 50). Hermes (2005) claims that in Ojibwe, the specific word used depends on who is doing the action, to whom, and what the specific context is, and this speaks directly to interactions among people and between people and the environment. To make things clear, Hermes (2005) states that “a curriculum and school focused on relationships would emphasize making meanings (e.g., relationships) rather than the final product (e.g., test scores)” (p. 51). Reyhner et al. (2010) also reiterates the importance of culture-based education and immersion language programs. Reyhner et al. (2010) claims that language immersion programs also further efforts to decolonize Indigenous education, revitalize Native languages, and help in furthering United Nations policies supporting the rights of Indigenous peoples. Reyhner et al. (2010) describes and gives examples of the fit between place-, community-, and culture-based education and immersion language programs from Apache, Ojibwe, Diné (Navajo), Hawaiian, and Blackfeet language programs, illustrating how traditional Indigenous values are infused into language programs to help build strong positive identities in Indigenous students and their communities.

Dual language Immersion Programs (DLIP)⁷ and instruction in heritage languages has been shown to produce desirable outcomes both on linguistic and academic measures

⁷ According to Tran et al. (2015) and the *Center for Applied Linguistics* (n.d.), in dual language education, also known as Dual Language Immersion (DI, DL, DLI), students are taught literacy and academic content in English and partner language (e.g., Spanish, Mandarin, Korean). The goal is for students to develop high levels of language proficiency, literacy, academic achievement, and an understanding of diverse cultures in two languages. Tran et al. (2015) outline four main types of DLIPs: (a) two-way immersion programs involve a balanced number of native English speakers and native speakers of a partner language, (b) developmental bilingual programs enroll students who are primarily native speakers of the partner language, (c) foreign language immersion, language immersion, or one-way immersion programs enroll primarily native English speakers and (d) heritage language programs that enroll students who are dominant in English but whose parents, grandparents, or other ancestors spoke the partner language. In the context of this study, some Indigenous students are enrolled in heritage language programs (e.g., Hermes’ [2005] Ojibwe language immersion programs).

for science and STEM subjects too (Morrell et al., 2019; Tran et al., 2015). Morrell et al. (2019) focused on the challenges of a middle school science teacher and how he handled the tensions between teaching science content and addressing issues of language development in a DLIP classroom environment. Based on classroom observations, pre- and post-year interviews, and weekly teacher reflections, themes emerged that reveal the teacher's concern with teaching science in a nondominant language (Spanish), the need for support from both administration and science content and DLIP mentors, students' willingness to use their native language (Spanish), and the teacher's lack of familiarity with DLIP curriculum and pedagogy, particularly in regard to balancing the teaching of content and language. The results of another study by Tran et al. (2015) study indicate that students enrolled in DLIP outperformed their counterparts on non-DLIP in both science and mathematics. More significantly, these findings highlight the potential impact of DLIP on the teaching and learning of science and mathematics, especially for students from diverse backgrounds. Tran et al. (2015) suggest that DLIP can have a greater impact on advancing STEM education in the U.S., and they urge educators and policy makers to invest in innovative programs such as DLIP to not only improve student learning outcomes but also to prepare students to productively participate in an increasingly global society and workplace. Similarly, Mallinson and Hudley (2014) emphasized the clear need for linguists to help provide STEM educators with the training they need in language, culture, and education, so that they can apply their insights to their pedagogy. The lack of training in linguistics hinders the teachers' ability to serve culturally and linguistically diverse students, who are most likely to face the educational inequality that persists in STEM (Mallinson & Hudley, 2014). Hence, the development of intercultural

and linguistic competence in science teachers and students is very essential in the multicultural, multilingual, globalized world that we live in.

Siekmann et al. (2017) provide insights into elements of a strong immersion program. They state that for immersion educators, especially those teaching Indigenous languages, the process of materials development is essential, but creating meaningful materials is challenging, on-going, and requires sophisticated engagement with cultural and academic content. The elements that Siekmann et al. (2017) discuss are (a) highly qualified teachers who can prepare high-quality culturally congruent learning materials well supported by professional development initiatives, (b) Indigenous people in leadership positions, (c) strong institutional support, and (d) language proficiency and content area knowledge for all. Neville Edward Alexander, a proponent of a multilingual South Africa and a former revolutionary who spent 10 years in Robben Island as a fellow-prisoner with Nelson Mandela, in his article provides a strong example of the education policy adopted by the post-Apartheid South Africa, where South African teachers were not given resources or training on their own languages, thereby forcing them to resort to using English terminologies for both language and content classes, such as science and mathematics because they had never learned them in their native languages. Alexander (2004) states that every move made in the domain of language policy and planning in South Africa was determined by the single-minded pursuit of the goal of a society segregated in terms of the criterion of “race” in virtually all respects. As an example, Alexander (2004) claims that to uplift English and Afrikaans as the only languages that are socially and politically accepted, unparalleled investment of single-medium mother tongue schooling for all White children and other learners was

undertaken where material resources and human resources were provided in English and Afrikaans, much to the detriment of other South African languages development (Alexander, 2004). Hence, it could be seen from this example that strong Indigenous leadership, political and institutional support, purposeful preparation of teachers, and providing professional development opportunities to teachers could make Indigenous immersion programs in schools more successful.

The extant literature discussed above provides strong evidence that congruency between the school environment and the language and culture of the community is critical to the success of formal learning, so developing linguistic and cultural congruence is paramount to success of Indigenous students (Demmert, 2001). As language and cultural immersion programs and the student identification with the programs are associated with improved academic performance, decreased dropout rates, improved school attendance rates, and improved personal behavior, strong immersion programs are so crucial for Indigenous communities (Demmert, 2001). Pease (2004) in her research on immersion schools restated Demmert's (2001) findings in her conclusion that "immersion improves overall educational achievement, strengthens family ties, and increases retention rates, keeping Native students in school who might otherwise drop out" (p. 16).

Although many benefits are identified for language immersion programs, Siekmann et al. (2017) have also identified some challenges with regard to instruction using language immersion techniques. The authors report on a university-school collaborative project, designed to develop Yup'ik language and cultural materials for elementary-level Yup'ik immersion and Yup'ik/English Dual Language schools (K-12) in Southwest Alaska. The challenges identified by Siekmann et al. (2017) for culturally

responsive and immersion instruction are that there is lack of materials:

- (a) that reflect and accurately represent ancestral knowledge and worldview.
- (b) that are linguistically appropriate to elementary students.
- (c) that are aligned with state-mandated outcomes in the content areas, such as science and social studies.

Research evidence links student achievement with the availability of education services, especially for disadvantaged populations, including Aboriginal students (Bell & Anderson, 2004). Carr-Stewart et al. (2011) provided evidence for inequity of education financial resources in their case study that compared First Nations school funding versus provincial school funding in Saskatchewan, Canada. The researchers compared the two school systems, Yorkton Tribal Council Schools (YTC) and the Prairie Valley School Division #208 (PVSD), on their total expenses and costs for second-level services, such as administrations, professional development for teachers, and employee benefits. Carr-Stewart et al.'s (2011) findings revealed that there was a significant difference in the operating expenses of these schools and the cost per student was calculated as \$280 for YTC and \$379 for PVSD. This study emphasizes that there is also a lack of funding for professional development opportunities in which teachers of Indigenous languages receive additional language acquisition training and time to work together on establishing terms in the local language that reflect the world the students live in. Additionally, (and probably one of the biggest challenges for languages with fewer speakers) is staffing. A qualitative study conducted by Hall (2012) where perspectives of Indigenous teachers of Aboriginal students in Central Australia were collected, which provides insights into the great benefits of having Indigenous teachers at remote Indigenous community schools. In

this study, Hall (2012) states that high turnover of teachers in remote Indigenous community schools has long been considered a significant contributing factor to low academic outcomes for students in Indigenous communities. Also, since many Indigenous languages are at risk, it is difficult to find teachers that are fluent speakers of the languages. In Hall's (2012) study, all participants (Indigenous teachers) spoke their own Indigenous language (e.g., Pitjantjatjara, Luritja, and Western Arrarnta) as their primary language and their cultural and language background has oracy as the primary means of communication. Hall (2012) concluded that if improving student achievement is the goal for remote Indigenous schools, then recruitment of teachers who demonstrate quality teaching practices that can be flexibly tailored for the specific needs of remote Indigenous students and recruitment of teachers who are open to cross-cultural collaboration with Indigenous teachers and communities will need to be the top priority for Indigenous schools. Hall (2012) also states that it is very important to provide extensive and ongoing orientation, mentoring, and professional development to help support teachers to be able to work cross-culturally. Additionally, the structural and systemic inequalities that appear to exist (such as lack of departmental support and not allowing racist attitudes and behaviors to go unmanaged and unchecked) need to be dealt with by stronger practical adherence to policies already in place and an organizational culture shift (Hall, 2012).

Sheltered Instruction Observation Protocol: Integrating Native Language for Learning Scientific Vocabulary/Content. According to Lee and Fradd (1998), the "American Indian" category of students includes over 100 language backgrounds; although the majority speak English, a proportion are bilingual. The language and literacy

demands of science are acute for emergent multilingual students, as they must master rigorous standards-based content, use and understand the language of science (difficult vocabulary), and understand English (Echevarria et al., 2011). Not surprisingly, Indigenous students, who are bilingual, multilingual, or heritage learners, face difficulties while learning scientific vocabulary and trying to learn English.

Early research on teaching science to English learners was strongly influenced by English to Speakers of Other Languages (ESOL) models that included sheltered content instruction (Chamot & O'Malley, 1996). The ESOL strategies to integrate science content with second language instruction have been found to work well with Indigenous students, and one of them is Sheltered Instruction Observation Protocol (SIOP) developed by Echevarria and Short (1990) and Echevarria, Vogt, and Short (2010). *Sheltered instruction* is defined by Echevarria and Short (1990) as “an approach for teaching content to English language learners in strategic ways that make the subject matter concepts comprehensible while promoting the students’ English language development” (p. 3). Echevarria et al. (2010) state that the SIOP Model has eight components and 30 features that, taken together, have been shown to improve student achievement in science. The eight components include: *Lesson Preparation, Building Background, Comprehensible Input, Strategies, Interaction, Practice & Application, Lesson Delivery, and Review & Assessment*. Acquisition of language is also enhanced by having both content objectives (*what* the students will learn during the lesson) and language objectives (*how* the students will learn the content of the lesson) for every lesson (Echevarria, Vogt, & Short, 2010).

Many scholars have studied the benefits of using the SIOP model in teaching

science (Echevarria & Short, 2000; Echevarria et al., 2011; Lee et al., 2013; Nargund-Joshi & Bautista, 2016; Reynolds & O'Loughlin, 2019). Nargund-Joshi and Bautista (2016) compared and contrasted two approaches to support emergent multilingual students' language growth in a constructivist-oriented science classroom while teaching lessons on land pollution. They used a framework for inquiry-based science instruction called the 5E Learning Cycle (Bybee, 2006) and a framework for language instruction called SIOP developed by Echevarria, Vogt, and Short (2002). The findings revealed that with meaningful preparation, these two instructional frameworks provide a powerful combination, enhancing students' learning of science and empowering emergent multilingual students to think about important ideas even if they may not be able to fully express them in English. Echevarria et al. (2011) collaborated with science teachers to develop SIOP lesson plans for four instructional units: Cell Structure and Function, Photosynthesis and Respiration, Cell Division, and Genetics. The researchers concluded that when teacher implementation was high, students' science achievement rose dramatically. The studies mentioned in this section point that SIOP is effective, but I would like to add that it is not as effective as models in which content is delivered in the home language as well as the school language, such as in dual language programs (Thomas & Collier, 2012). Collier and Thomas's (2004) longitudinal research findings from one-way and two-way dual language enrichment models of schooling demonstrate the substantial power of this program for enhancing student outcomes and fully closing the achievement gap in the second language (L2). Dual language schooling also can transform the experience of teachers, administrators, and parents into an inclusive and supportive school community for all (Collier & Thomas, 2004).

Translanguaging Theory and Practices. English is widely used to teach academic content areas, such as science. Exclusive use of English in the classroom is also highly recommended and enforced in a large number of countries (Cenoz & Gorter, 2020). However, students coming from different language backgrounds often find English difficult to navigate, especially in content-heavy, scientific vocabulary-rich subjects like science. Castagno and Brayboy (2008) provide the evidence for this statement and state that teachers must be clear, explicit, and direct about the terminology used in subject areas such as science. They also claim that many of the terms used in math and science have different meanings than their everyday meanings, and this can be especially confusing for students whose first language is not English. Hence, a strict separation of students' native languages and English can be problematic because it prevents students from using resources they have previously acquired in their own languages (Cenoz & Gorter, 2015; Kubota, 2018). As has been already discussed that culturally responsive schooling has a firm grounding in the heritage language and culture Indigenous to a particular tribe and is a fundamental prerequisite for the development of culturally healthy students and communities associated with that place (Alaska Native Knowledge Network, 1998), it is paramount to learn more about the different models, such as natural translanguaging, and pedagogical translanguaging to understand the ways to help Indigenous students achieve improved academic outcomes and for the wellbeing of tribal communities.

In discussing about the current state of knowledge about academic literacy, pedagogies, and multiliteracies, Kafle and Canagarajah (2015) state that multiliteracies are a new area of consideration in academic literacy, and more scholars are studying their

implications for understanding and teaching academic communication. According to Kafle and Canagarajah (2015), multiliteracies constitute a mixing of languages, modalities, and cultures, including diverse varieties of English and diverse visual, oral, and multimedia resources. They distinguish the two pedagogical models that are used in classrooms: code-switching and code-meshing. Kafle and Canagarajah (2015) state that code-switching models treat the languages of the learners as discrete entities (like putting different languages in different boxes) and encourage the learners to keep the academic and vernacular discourses distinct and separate from each other. Whereas, code-meshing models, see the languages as integrated into the repertoire of the students and aim to teach the strategic use of both the standard and minoritized languages in hybrid texts. Thus, rather than seeing competence as compartmentalized, code meshing models see it as a combined ability. In the context of a multilingual and multicultural world that we live in, Indigenous education scholars emphasize the need to go beyond code-switching, code-meshing, and biliteracy to embrace other dynamic systems of linguistic development from the perspective of the pluriliteracies approach (García, 2009; García & Flores, 2013). García and Flores (2013) call the pluriliteracy approach a flexible multiple model of biliteracy as it provides a framework, which can fully account for the complex and dynamic process of meaning-making by using the students' full linguistic repertoire. Hence, a new pedagogical model called *translanguaging* was posited by García (2009). García and Wei (2015) claim that for people speaking and practicing the majority language and those practicing the minoritized languages, translanguaging space would enable them to build dynamic plurilingual practices for the twenty-first century.

According to García (2009), translanguaging is an “approach to bilingualism that

is centered not on languages as has been often the case, but on the practices of bilinguals that are readily observable” (p. 44). The fluid and flexible language practices of bilingual/multilingual homes and communities (i.e., translanguaging) can be leveraged to promote learner ability to develop the scientific language practices required in schools (García, 2009; Poza, 2018). Similarly, Oliver et al. (2021) have highlighted that translanguaging involves fluid movement between linguistic codes, so it can be used in ways that are both powerful and playful, and for purposes that allow it to support effective interaction and communication, i.e., those engaging in translanguaging mix their language repertoires, making linguistic choices to match the situation and their needs. In this way, translanguaging represents both a psycholinguistic and sociolinguistic perspective of language use (Oliver et al., 2021).

Translanguaging pedagogies have been found to have huge potential for Indigenous students and for language-minoritized students, whether they are emergent bilingual or not because they build on students’ linguistic strengths, and they also reduce the risk of alienation at school by incorporating languaging and cultural references familiar to them (García & Wei, 2015). Otheguy et al. (2018) also reiterate the significance of translanguaging in plurilingual classrooms, as they attempt to clearly distinguish between code-switching and translanguaging. Otheguy et al. (2018) state that code-switching “constitutes a theoretical endorsement of the idea that what the bilingual manipulates, however masterfully, are two separate linguistic systems,” (p. 282) whereas “translanguaging is the deployment of a speaker’s full linguistic repertoire without regard for watchful adherence to the socially and politically defined boundaries of named (and usually state and national) languages (p. 283). Otheguy et al. (2018) reiterate that

translanguaging is from the perspective of an “insider,” that is of the learners themselves whereas codeswitching comes from the perspective of an “outsider” who observes the learners’ language use and behavior. Otheguy et al. (2018) also postulated that “a named language is a social construct, not a mental or psychological one” (p. 283). Since English is taught in Indigenous classrooms because it is the socially and politically defined dominant language in the United States, translanguaging pedagogies that give equal importance to Indigenous languages could be important and hugely successful strategies for Native American student populations.

The two types of translanguaging that most scholars have categorized are *natural translanguaging* and *pedagogical translanguaging*. Williams (2012) defined *natural translanguaging* as the flexibility of bilingual learners to take control of their own learning, to self-regulate when and how to language, depending on the context in which they are performing language. Cenoz and Gorter (2021) define *pedagogical translanguaging* as a theoretical and instructional approach that aims at improving language and content competences in school contexts by using resources from the learner’s whole linguistic repertoire. They state that pedagogical translanguaging is multilingual, heteroglossic, and learner-centered, and it endorses the support and development of all the languages used by learners (Cenoz & Gorter, 2021; Kiramba, 2019). García & Wei (2015) state that teachers use pedagogical translanguaging strategically as a scaffolding approach to ensure that emergent bilinguals at the beginning points of the bilingual continuum engage with rigorous content, access difficult texts, and produce new language practices and new knowledge. Wei’s (2011) take on translanguaging, the “Moment Analysis,” is an analytical tool situated within the larger

theory of translanguaging in education; it is not only "a space for the act of translanguaging" but also "a space created through translanguaging" (Wei, 2011, pg., 1222; Vaish, 2019). España et al. (2019) claim that translanguaging theory is changing how bilingualism and multilingualism are viewed as well as how language education programs are designed for language-minoritized students. Kiramba (2019) states that language code-switching, translating, borrowing, and blending of languages are norms with a focus on the process or act of meaning-making for students.

In the extant literature related to science education, it is documented that underrepresented students become enthusiastic and engage more with science content if they are given opportunities to do science activities that promote usage of their native languages in Indigenous language immersion programs (Demmert & Towner, 2003; Stephens, 2000; Demmert, 2001; Demmert, 2011; Pease, 2004). A number of national and international studies have explored and found pedagogical translanguaging valuable in K-12 science classrooms with minoritized students. A few examples are (a) successful heteroglossic practices with multilingual science students in Kenya (Kiramba, 2019); (b) science teachers as engaged language planners with multicultural and multilingual students in Texas (Langman, 2014); (c) bridging discourses in science classrooms in South Africa (Probyn, 2015); (d) translanguaging practices in science laboratory sessions (Pun & Tai, 2021); (e) continuity of learning in a translanguaging science classroom in Sweden (Karlsson et al., 2020); and (f) developing scientific scholarship in a multilingual classroom in Zimbabwe (Charamba, 2020). A recent study by Tai (2021) explored the CRP practices of an experienced math and science teacher who teach culturally and linguistically diverse learners in Hong Kong. This teacher utilized photos (an actual

circuit and a circuit diagram), technological aid (iPad), different varieties of Chinese (i.e., translations of English scientific terms in standardized Chinese and translations of his English questions in Cantonese) and switching between spoken English and Cantonese to guide students in drawing the correct circuit symbol of a battery. Tai's (2021) findings corroborated Aikenhead's (2001) concept of border crossings, i.e., engaging in translanguaging can allow science teachers to help students to transcend from their everyday life culture into the cultures of science and mathematics. In another international study of science classrooms in Swaziland, Rollnick and Rutherford (1996) found the use of learners' main languages (for e.g., SiSwati) to be a powerful means for learners to explore their ideas. Data analysis revealed that use of SiSwati along with English served several important functions for students, including articulation and elimination of alternative conceptions, clarifying of scientific concepts, and formulating ideas during group work.

There are other studies based in the United States that address translanguaging in formal K-12 science learning environments. Espinosa (2016) and Espinosa et al. (2016) investigated translanguaging in a middle school bilingual (Spanish/English) science classroom in New York City. In Espinosa's (2016) study, the translanguaging episodes were drawn from a science unit on the three states of matter. Learners were encouraged to employ flexible language practices in classroom discussions and in their written work. The bilingual science teacher modeled the kinds of translanguaging practices learners could implement with texts and peers to access science-content knowledge, which included discussing and deepening their understanding of science vocabulary in both Spanish and English (Espinosa, 2016). Kelly (2014) argues about the importance of

discourse practices for science learning, especially specific discursive practices such as scientific argumentation, which can be made successful using translanguaging practices in science classrooms (Licona & Kelly, 2020). Licona and Kelly (2020) investigated translanguaging in an English/Spanish dual language, urban, middle school science classroom as the teacher and students employ a scientific argumentation framework to address biodiversity socio-scientific issues. Sayer (2013) investigated the use of TexMex, a local vernacular drawing on English and Spanish, in a second-grade science classroom in Texas. TexMex was used extensively by the students in both community and classroom meaning-making activities, including the formal learning of science content (Sayer, 2013; Infante & Licona, 2018). Poza (2018) studied K-5 science classrooms in San Francisco Bay Area, and the researcher's observation and data analysis reveal that students readily rely on translanguaging processes to make meaning of new scientific content and linguistic forms. Infante and Licona's (2018) study results suggested that translanguaging as pedagogy functioned as a linguistically responsive approach that gave emergent bilinguals access to the scientific practices and content of the curriculum intervention. It is noteworthy that none of these studies mentioned above explore translanguaging in science classes in Indigenous settings in the United States. This points to a gap in studies of American Indian populations and the way that translanguaging could be useful in immersion type (e.g., dual language) settings in this context.

Given the evidence from studies discussed in this section, it is clear that adopting translanguaging pedagogical practices in Indigenous school settings could be a promising practice to ensure academic success and cultural, social, emotional, psychological, and familial wellbeing for their students. However, very few studies in the extant literature

have focused on translanguaging practices for AI/AN students, so there exists a knowledge gap in this area. Hence, in the context of this study of science teachers of a particular Indigenous community, the concept of translanguaging will be explored as it relates to the lived experiences of the participants and their students in their science classrooms.

Place-, Community-, and Culture-based Education for Success with STEM learning. Culture-based schools have been an important initiative in Native American education for more than 45 years (Swisher & Tippeconnic, 1999). Howard and Kern (2018) state that having multiple worldviews (multiple ways of knowing/being/valuing) in STEM is a vital component to success, and Indigenous ways of knowing are simultaneously ancient and contemporary and inform cultural understandings of community and place. They emphasize that “without cultural knowledges, scientific knowledge is contextually vacuous...they ground the knower to the place” (Howard & Kern, 2018, p. 1139). When Howard and Kern (2018) about the typical factors that are considered for success, academic and professional achievement through grades, graduation rates, college/university education, employment, salary, and power in the society come first to mind. More importantly for the Native peoples, achievement in these arenas is important within the inequitable neoliberal context of access and participation in STEM careers, so many Native American and Indigenous communities view these achievements as tools for self-determination and capacity-building when used for the greater good of the community (Howard & Kern, 2018). Hence, educational success in STEM fields is intertwined with place-, community-, and culture-based education for Indigenous students. Bang and Medin's (2010) studied both urban and rural

Native American communities and focused on culturally based epistemological orientations and their relation to the cultural practices associated with science instruction. They summarized evidence on the efficacy of community-based science education and urged teachers and researchers to shift their orientation toward science education from having students adopt specific epistemologies to supporting students' navigation of multiple epistemologies. Tribal communities are likely to support the success of individual students because of the greater potential for impact on the community, while at the same time students aim to "give back" to their communities (Howard & Kern, 2018). Indigenous STEM scholar Gregory Cajete (2015) puts forth the notion that success is viewed in ways that extend beyond individuals to include human communities, land, ecosystems, and sovereignty.

Scholars such as Chinn (2007), Buxton (2010), and Sutherland and Swayze (2012) have studied about the importance of the role of culture, community, place, personal experience in science education for Indigenous students. These scholars use a conceptual framework of critical place-based pedagogy proposed by Gruenewald (2003) to make sense of the ecological harm that humans have caused and how to solve social problems through science projects enacting critical pedagogy of place. According to Gruenewald (2003), enacting a critical pedagogy of place is a two-step social and political process of *decolonization* and *reinhabitation*. Decolonization, a notion central to critical pedagogy, is a process of recognizing and then overturning ways of thinking that are instilled by the dominant culture that do social, political, and ecological violence (hooks, 1992). Reinhabitation, an idea from the ecological arm of place-based pedagogy, is learning to live in closer harmony with environments and ecosystems that have been

previously damaged by ecological misuse (McGinnis, 1999).

Buxton (2010) states that when teachers and students begin to critically question social and environmental imbalances in their local surroundings, the role they play in creating and maintaining those imbalances, and actions they could take to reduce those imbalances, they are engaged in the decolonization and reinhabitation central to a successful critical pedagogy of place. Buxton's (2010) study involved middle school-aged youths' participation in Social Problem Solving through Science (SPSS) project that studied local environmental challenges with implications for human health and well-being. Students considered environmental risk factors in a series of structured activities to develop background knowledge on environmental health issues. The findings of the study showed that the project enhanced students' science content knowledge while engaging them in a process of decolonization and reinhabitation of their places as members of society.

Some examples of international studies that highlight the importance of land- and water-based decolonizing pedagogies are as follows:

- (a) Mowatt et al. (2020) present reflections from an Indigenous land- and water-based institute held from 2019 to 2020 for Indigenous graduate students, coordinated by faculty in the School of Child and Youth Care at the University of Victoria (Canada) and facilitated by knowledge keepers in local W SÁNEĆ and T'Sou-ke nation territories. Their stories and analysis amplify the integration of Indigenous ways of being and learning, with a focus on local knowledges and the stories emphasized that more ethical land and community engagements are integral to Indigenous postsecondary education (Mowatt et

al., 2020).

- (b) Leon et al. (2019) examine a practice of decolonizing pedagogy used by a group of Indigenous Elders and community Knowledge Holders of Musqueam people called the Medicine Collective at the University of British Columbia in Canada. They describe the five components of a land-based decolonizing model that illustrate how Indigenous pedagogical practices can be mobilized in an urban setting, and across disciplines and communities. This framework includes five elements that are not necessarily sequential but reflect a cyclical process: (1) research into local culture; (2) preparation for land-based understanding; (3) adoption of protocol principles that emphasize orality; (4) application to community well-being; and (5) negotiation of relational ethics.
- (c) Zinga and Styres (2019) developed specific decolonizing and anti-oppressive pedagogies that are used within Canadian higher education classrooms. The authors acknowledge that an understanding of cultural positionalities and relations of place is very important while creating curricular content for teaching about Indigeneity and issues concerning power and privilege for the First Nations students. Zinga and Styres (2019) focus on how aspects of curriculum can at once minimize, trigger and/or provoke various aspects of resistances. They also consider how the positionality of the instructor and purposeful and mindful choices regarding curriculum, course content, and classroom practices assist students to reflect on their own positionality and the ways networks and relations of power and privilege are implicated in learning and teaching.

Chinn's (2007) study reports findings from a 10-day professional development institute on curricular trends where secondary science and mathematics teachers from different countries explored the roles of culture, place, and personal experience in science education through writings and group discussions. After a presentation on Indigenous Hawaiian practices related to place and sustainability, they evaluated Indigenous practices more positively and critiqued the absence of locally relevant science and Indigenous knowledge in their own national curricula. The teachers then identified local issues of traffic and air and water quality they would like their students to address and developed science lessons based on students' prior knowledge, place, and culture. The findings revealed that critical professional development employing decolonizing methodologies articulated by Indigenous researchers has the potential to raise science teachers' awareness of the connections among personal and place-based experiences, cultural practices and values, and teaching and learning (Chinn, 2007).

Sutherland and Swayze (2012) note that Indigenous science education needs to focus more on real-world issues based on students' lives and communities, providing opportunities for personally meaningful, experiential, inquiry-based, and place-based learning that is fundamental to scientific and environmental literacy. Environmental learning associated with place integrates humans and nature and develops ecosystems knowledge characteristic of sustainable cultures (Chinn, 2007). Cajete (1994) notes that traditional education for Native Americans has always been ecologically based on how tribes adapted to specific environments in unique ways. This environmental ecology can easily become a part of the everyday science curriculum in the classroom, as is highlighted by Zoicher and Hougham's (2020) study which intentionally integrates place-

based experiential education to offer a way to engage American Indian students and other culturally and linguistically diverse students in responding to the intersectionality of culture, power, and the local environment using innovative pedagogical practices. The authors critique the U.S. environmental education curriculum in that it has not entirely focused on understanding the biophysical environment of the local rural or tribal populations (such as land and water issues), and little attention has been paid to discussions about the environmental problems created by the dominant Western cultural norms, such as dumping of industrial wastes into rivers or lakes and other environmentally destructive effects of human activity (Zocher & Hougham, 2020).

Torso et al. (2021) report on the impact of a culturally relevant STEM education program and affiliated internship aimed at cultivating Coeur d'Alene Tribal youth participation in STEM and associated leadership desires. The Coeur d'Alene Basin, located in northern Idaho, contains a U.S. Environmental Protection Agency Superfund site, which has been on the National Priorities List since 1983 as a result of toxic metal contamination from historical mining practices. The Coeur d'Alene Tribe has resided in this region since time immemorial and are profoundly affected by these environmental hazards (Torso et al., 2021). Since leaders among Native American community membership in STEM can support the community's ability to mitigate these issues as a sovereign nation, culturally relevant STEM educational programming was initiated (Torso et al., 2021). The findings of this study show that the educational programming facilitated youth comprehension of STEM, participation in STEM fields, and desire to become a leader in their community (Torso et al., 2021).

Equitable Assessment Strategies in Indigenous Science Classrooms. The

National Assessment of Educational Progress (NAEP) reports the results of the National Indian Education Study (NIES), which is designed to describe the condition of education for American Indian and Alaska Native (AI/AN) students in the United States (*Student groups and trend reports - National Indian Education Study*, 2022). The study samples fourth- and eighth-grade AI/AN students in public, private, Department of Defense, and Bureau of Indian Education (B.I.E.) funded schools, and the study provides educators, policymakers, and the public with information about the academic achievement in reading and mathematics of AI/AN fourth- and eighth-grade students. Indigenous students have scored typically lower than any other racial or ethnic group (Dupuis & Abrams, 2017; NAEP, 2022). The National Center for Education Statistics publishes the *Condition of Education* reports that contain key indicators on all levels of education, labor force outcomes, and international comparisons. The National School Boards Association (NSBA)'s Senior Research Analyst, Jinghong Cai, examined educational trends for American Indian and Alaska Native students in 2020 and reported a disturbing trend that Native American students performed two to three grade levels below their white peers in reading and math. They were two times more likely to drop out of school than their white peers (Cai, 2020). The recent report also indicates that the situation for Native Americans has not improved because school dropout rates for AI/AN students were 11.5%, as compared to 4.8% for people identifying as White, and 2.4% for students identifying as Asian Americans (*The condition of education 2022 at a glance*, 2022).

Dupuis and Abrams (2017) report that even in internationally standardized assessment, such as the Programme for International Student Assessment (PISA), that was jointly developed by participating governments and administered to 15-year-olds in

schools, has provided international evidence of underachievement in science by Indigenous students compared to non-Indigenous students. Results from the PISA 2012 science portion of the test indicated that Indigenous students in the United States, Australia, and Canada have continued to exhibit poor performance compared to non-Indigenous students (Dupuis & Abrams, 2017). Indigenous scholars, Aikenhead and Michell (2011), argue that these tests are being developed using state and national science standards based on Western Modern Science (WMS) and do not include Native American knowledge (including languages). This bias disadvantages Indigenous students because assessment strategies associated with mainstream schooling are based on a worldview that does not adequately recognize or appreciate Indigenous knowledge (Barnhardt & Kawagley, 2005). Indigenous students face these unique challenges because they have been brought up to understand science and scientific reasoning in a very different way (Snively & Williams 2008).

Given the differences in worldviews between Indigenous students and their non-Indigenous peers and the perceived opportunity gap between them, innovative design and implementation of assessment modalities, variety of assessment strategies, hands-on activities, participation of local community in making of school policies, integrating culturally relevant test items in greater numbers on standardized tests, and multiple linguistically responsive forms of assessments are essential for the success of Indigenous students (LaCelle-Peterson & Rivera, 1994; Siegel et al., 2008; Grimberg & Gummer, 2012; Solano-Flores & Nelson-Barber, 2001; Demmert, 2001; Nelson-Barber & Trumbull, 2007; Castagno & Brayboy, 2008; Benson, 2012; Gilbert, 2011; Black & Atkin, 2014; Cotner & Ballen, 2017; Trumbull & Nelson-Barber, 2019).

Trumbull and Nelson-Barber (2019) emphasize the need for equitable assessment strategies for Indigenous students because assessment “has long aroused great concern because many common assessments are not only ineffective but also destructive for Indigenous students—especially when they are used to make high-stakes decisions that affect students’ life outcomes” (p. 1). Black and Atkin (2014) discuss the central role of assessment in pedagogy in all science classrooms, and they conclude that assessments that science teachers employ should nurture students’ natural curiosity, encourage students to express their scientific thinking, and create opportunities for social learning by constructive dialogue with others. However, they lament that the potential for development of teachers’ assessment skills to enrich their work has been ignored, and invalid assessment tools have been used as a means to impose on and thereby undermine professional development of teachers and impoverish education of students. In their framework for equitable assessment policies for emergent multilingual students, LaCelle-Peterson and Rivera (1994) propose four criteria for comprehensive assessment systems for emergent multilingual students. They posit that assessment systems must be comprehensive, flexible, progress-oriented, and student-sensitive (LaCelle-Peterson & Rivera, 1994). In their recent study on using mixed assessment methods, such as group participation, low-stakes quizzes, assignments, and in-class activities instead of high-stakes tests in introductory biology classes, Cotner and Ballen (2017) found that these mixed assessment strategies helped remove some of the barriers that underserved students (e.g., Indigenous students and women in STEM) face. The authors conclude that by challenging the student deficit model, science teachers can lower barriers to success for underrepresented groups in STEM. In another study with linguistically diverse middle

school life sciences course students, Siegel et al. (2008) found that a framework for equitable classroom assessments called *McCes* provided visual supports and divided questions into smaller units, sentence starters, graphic organizers, and additional prompts which significantly helped improve the English learners' performance in science classrooms.

Researchers have argued that *cultural validity* (Solano-Flores & Nelson-Barber, 2001) be recognized as a key component of assessment design and implementation.

Nelson-Barber and Trumbull (2007) explained why cultural validity is so important:

because sociocultural groups create meaning from experience in culturally determined ways, individuals have predisposed notions of how to respond to questions, solve problems, and so forth. It follows that these predispositions influence the ways in which they respond to test items (p. 134).

After NCLB, teachers who teach Indigenous students are driven by demands to attain high performance on standardized tests, so they truncate or abandon strong culture-based instruction in favor of instruction thought to prepare students to do well on the standardized tests; this is an example of how decision makers under external pressures tend to revert to “best practices” or “the One Best Way,” evoking historical movements to extinguish Indigenous languages and cultures (Trumbull & Nelson-Barber, 2019). Hence, Trumbull and Nelson-Barber (2019) have reiterated that “culturally-valid assessments” have become absolutely crucial in contemporary times to help Indigenous students succeed.

Castagno & Brayboy (2008) state that although standardized forms of assessment certainly may present difficulties for students who are not members of the dominant

culture and the way they tend to understand the questions, they also represent inappropriate and inaccurate ways of assessing knowledge in some Native language immersion and culturally focused schools for Indigenous youth.

Solano-Flores and Nelson-Barber (2001) proposed the concept of cultural validity as a form of test validity in science assessment. They state that the conceptual relevance of cultural validity is supported by evidence that culture and society shape an individual's mind and thinking. To attain cultural validity, the process of assessment development must consider how the sociocultural factors, such as values, beliefs, experiences, communication patterns, teaching and learning styles, and epistemologies inherent in the students' cultural backgrounds, as well as the socioeconomic conditions prevailing in their cultural groups, influences the ways in which they make sense of science items and the ways in which they solve them (Solano-Flores & Nelson-Barber, 2001). They suggested that attending to five areas derived from the notion of cultural validity could contribute to improving science assessment. The five areas they suggest are (a) student epistemology, (b) student language proficiency, (c) cultural worldviews, (d) cultural communication and socialization styles, and (e) student life context and values (Solano-Flores & Nelson-Barber, 2001).

Nelson-Barber and Trumbull (2007) also suggest some assessment strategies that work well for Indigenous students, such as turning to wisdom of the local culture and funds of knowledge, paying particular attention to language of testing, and using cultural experts to score and interpret student performance.

Critique of Culturally Relevant/Responsive Teaching for Native Communities

The literature review about the benefits of asset-based culturally

relevant/responsive pedagogies would not be complete if it does not include studies that critique culturally relevant pedagogies for Native communities. Although culturally responsive schooling has been around for almost 60 years and there is a plethora of literature on culturally responsive schooling, it has had little impact on what teachers do in their classrooms because it is very easily being “reduced to essentializations, meaningless generalizations, or trivial anecdotes—none of which result in systemic, institutional, or lasting changes to schools serving Indigenous youth” (Castagno & Brayboy, 2008, p. 942). Hence, a critique of culturally responsive/relevant teaching is necessary.

The general benefits of Indigenous teachers using culturally responsive pedagogies are indeed very compelling to science teachers teaching Native American students and the concepts of culturally responsive or relevant curriculum, pedagogy, and education has been advanced to provide a meaningful and effective education for students of Color (Gay, 2000). However, Battiste (2002) cautions us from tossing around or operating from the concept of “culturally responsive” or “culturally relevant” teaching and learning without getting to the deeper meaning and potential consequences for different groups of Native Peoples. Battiste (2002) states that not all Indigenous peoples ascribe to the same epistemology and reminds us of this reality:

Within any Indigenous nation or community, people vary greatly in what they know. There are not only differences between ordinary folks and experts, such as experienced knowledge keepers, healers, hunters, or ceremonialists, there are also major differences of experiences and professional opinion among the knowledge holders and workers, as we should expect of any living, dynamic knowledge

system that is continually responding to new phenomena and fresh insights (p. 12).

Castagno and Brayboy (2008) also add that we must be vigilant in our resistance to essentialize and generalize any group of people, but we must also understand that multiple epistemologies and worldviews exist and are valid and that these epistemologies are intimately connected to schooling, education, teaching, and learning. Furthermore, reclaiming Indigenous knowledges and epistemologies is an important strategy toward the actualization of sovereignty and self-determination among tribal nations (Wilson, 2004).

Paris and Alim (2014) offer three important critiques of asset-based pedagogies, e.g., culturally relevant pedagogy (Ladson-Billings, 1995), culturally responsive teaching (Gay, 2000), and sociopolitical context of multicultural education (Nieto, 1992). They problematize the asset-based pedagogies and critique them on (a) the basis of previous conceptualizations of asset pedagogies, (b) the basis that asset pedagogies foreground the heritage practices of communities of Color without considering contemporary or evolving community practices, and (c) the basis that asset pedagogies do not critically contend with problematic elements expressed in some youth cultural practices (Paris & Alim, 2014).

To flesh out the meaning of their first critique, the authors state that deficit approaches to teaching and learning have echoed across decades of education in the United States, and such approaches view the languages, literacies, and cultural ways of being of many Indigenous students and communities of Color as deficiencies to be overcome if they are to learn the dominant language, literacy, and cultural ways of being

that are demanded in schools (Paris & Alim, 2014). Schmeichel (2012) also offers the same critique that the concept of “cultural deprivation or disadvantage” was the frame used to describe children of Color within the literature in the years immediately following the *Brown v. Board of Education* decision (p. 214). Paris and Alim (2014) state that these asset-based pedagogies repositioned the linguistic, literate, and cultural practices of working-class communities of Color as resources and assets to honor, explore, and extend, but unfortunately, it has led to a “continuing cycle of inequity” (Schmeichel, 2012, p. 221). Schmeichel (2012) finds flaw in Ladson-Billings’ asset pedagogy that CRP identified the deficit approaches used by the dominant culture, located the source of the problem in the students and their families, and, in doing so, contributed to the continuing cycle of inequity. Paris and Alim (2012) claim that teaching the dominant language in the U.S. society, namely Dominant American English (DAE) language and literacy for African Americans could be done using over-simplistic pedagogical practices, e.g., engaging the students with Hip Hop language and literacy. This kind of thinking could be dangerous, as it oversimplifies CRP strategies, and it also generalizes all African Americans into just one category or stereotype. Schmeichel (2012) also gives an example of a watered-down approach to culturally relevant teaching, where a White teacher uses phrases like “act the fool” and “snap” to improve their relationship with their African American students. This again reinforces the dangers of applying thin, cultural stereotypes to a particular community of Color.

Paris and Alim’s (2014) then examine how asset pedagogies too often draw over-deterministic links between race and language, literacy, and cultural practice, such as racialized and culturally situated heritage practices of communities, e.g., Indigenous

American languages and cultural ways of knowing (Lomawaima & McCarty, 2006), African American Language and cultural ways of knowing (Lee, 1995). These pedagogies have shown that assumptions and unidirectional thought about a particular culture or linguistic groups have led to the unfortunate simplification of asset pedagogies as solely about considering the heritage or traditional practices of students of Color in teaching while ignoring the shifting and evolving practices of their communities, especially in this multilingual and multicultural world that we live in. Even the most lasting frameworks, such as the funds of knowledge (Moll & González, 1994) have been enacted by teachers in very static ways without attending to the dynamic nature of the present and future practices of youth. Schmeichel (2012) quotes Villegas (1998) by stating that culturally sensitive language strategies appear to provide a number of educational “solutions” that have profound implications for the lives of students, but “little attention was given to the social implications of those solutions” (p. 219).

Paris and Alim (2014) then focus on critical reflexivity where they turn their gaze inward, on their own communities and cultural practices as people and scholars of Color. They state that Hip Hop pedagogical studies occupy a masculinist space and often celebratory in nature; however, these studies rarely look critically at the ways in which youth might reify existing hegemonic discourses about, as examples, gender, race, sexuality, and citizenship. That means studies exclude young women, queer youth, and young men of color who do not identify as Black, or even people from other nationalities.

After offering their critiques, Paris and Alim (2014) introduce their own concept of Culturally Sustaining Pedagogy (CSP). They state that the “future of CSP must extend the previous visions of asset pedagogies by demanding explicitly pluralist outcomes that

are not centered on White, middle-class, monolingual, and monocultural norms of educational achievement” (Paris & Alim, 2014, p. 95). They also conclude that CSP must resist static, unidirectional notions of culture and race that reinforce traditional inequalities without attending to shifting and evolving ones. They also emphasize that CSP must be willing to seriously contend head-on with the problematic and progressive aspects of young people in the evolving society.

Enyedy and Mukhopadhyay (2007) unearth another critique of CRP and challenges in enacting CRP in science and math classrooms. They state that teachers need to have a great deal of content knowledge, pedagogical content knowledge, planning, continuous reflection, and a deep commitment to social justice and the education of underserved students of Color. CRP practices also demands significant investments of time, which could be difficult in a typical school day, combined with curricular and scheduling challenges and student aptitudes for learning.

Based on the above-mentioned evidence from several scholars, it is paramount that each Indigenous student is treated as an individual with intersecting identities and that teachers/researchers recognized that every Native American community is unique and different. Hence, applying widely culturally responsive curricular and pedagogical strategies could reproduce more stereotypes and could cause problems if teachers use them blindly and automatically in their classrooms based on what they have heard of one type of student/community needs (instead of looking at each student as unique individuals). It is recommended that teachers should not assume that all Native students are the same (as they shouldn't for all social/ethnic/racial groups), and CRP strategies useful for one Indigenous student community should not be imposed on another

Indigenous student/community because they belong to a different Native American tribe, and because each student's lived experiences are diverse and complex. This point is very relevant for my study because it focuses on the specific CRP strategies that are practiced by Indigenous teachers of the Earth People Public School located in the American Midwest, which may not be suitable or applicable to other Indigenous communities and their students around the world.

Research on Culturally and Racially Diverse Science Teachers

Race and Ethnicity as Powerful Forecasters of Student Success in Science

Mensah and Jackson's (2018) article on Whiteness as property in science teacher education reinforced the CRT tenets of racialized power and permanence and centrality of race in the American society. The authors state that in PK-12 school settings that were mostly White-normative; under-resourced; racially, linguistically, and ethnically diverse, the TOCs (when they were students) were alienated from learning science, did not have rich science learning experiences, and did not have teachers who prioritized science or made it interesting. Hence, when these TOCs enroll in teacher education programs and start teaching in school settings similar to their own school experiences, they are heavily influenced by their negative experiences of learning science. Even if they develop an interest to teach science in urban PK-12 settings, they understand the inequities in access to learning, mostly from personal experience, so they get discouraged to teach science. Subramaniam's (2013) study on the minoritized preservice teachers' conceptions of teaching science revealed that these teachers held a specific set of beliefs-driven instructional ideas about how science content is linked to home experiences, students' ideas, hands-on activities, and group work. Students' science outcomes do not solely rely

on textbook-based instruction, but they are dependent on TOCs' conceptions that all students can learn science and in acknowledging and respecting students' ideas about science (Subramaniam, 2013). Similarly, Bryan and Atwater (2002) conclude that science educators need to continue to identify their own beliefs and practices that undergird desirable and equitable science instruction.

Racialized Lived Experiences of Teachers of Color in Contentious Environments

The studies that I will highlight for this theme use CRT as the analytical lens for understanding the racialized lived experiences of TOCs. In their article on the state of teachers of Color, Jackson and Kohli (2016), point out that current literature focuses mostly on the recruitment problems, staffing issues, and high attrition rates, but less attention has been paid to the racialized contexts in which TOCs are prepared and teach. The authors presented eight empirical research articles that talk about the complex lived experiences of TOCs who are in the beginning of their careers. These TOCs experience intense marginalization, isolation, and are subjected to racialized and/or gendered stereotypes that limit their day-to-day professional experiences (Jackson & Kohli, 2016). Cheruvu et al. (2015) forefronts the racialized experiences of pre-service teachers of Color who must confront essentialism, ideologies of racial and linguistic inferiority and deficiency, and racial microaggressions in their preservice courses and field experiences. The author posits that due to domination of Whiteness in preservice teacher education, curricular and pedagogical practices continue to privilege the White teachers and view TOCs with a deficit mindset, thereby silencing the preservice TOCs. The author further states that since preservice TOCs' ethno-racial identities in their schooling were marginalized by dominant power structures, they may have substantially different

experiences entering teaching than White novices. Furthermore, these experiences intersect with other systems of oppression such as ableism, colonialism, heterosexism, and ageism, which was termed as *intersectionality theory* by Crenshaw (1991) and critical race theory in education (Solórzano & Yosso, 2001, 2002). Jackson and Kohli (2016) provided insights on how experiences of TOCs in their early years of teaching can provide insights into current manifestations of legacies of oppression. The authors also enlist hostile racial climate and unsupportive work environments that can constrain TOCs by silencing dialogues about issues of race in schools, limiting their access to supportive colleagues, constricting their roles and access to learning, making them adhere to restrictive curricula and pedagogical practices that are not culturally or linguistically congruent (Jackson & Kohli, 2016). All of these factors converge to inhibit the ability to enact the cultural/professional roles that may have drawn the TOCs into the teaching profession. Bettini et al.'s (2021) findings revealed that novice TOCs consistently expressed concerns about racist and microaggressive remarks that positioned them as less credible authority figures; experienced sociocultural challenges of being called “culturally suspect” that questioned the authenticity of their identities; and were othered, silenced, and marginalized by their colleagues, administrators, school district leaders, and policymakers.

Barriers That Maintain a White Teaching Force

Teachers of Color face barriers that exclude them from the teaching force, which maintain a White-teacher-normative American society. Students of Color who aspire to become teachers face socioeconomic obstacles (for e.g., low pay, negative image, poor school conditions), fail to graduate from high schools, take standardized tests that are not

culturally and linguistically relevant to them, receive no academic encouragement and support in college, struggle with internalized racism, and endure racially biased societal notions of teacher quality; all of these factors continue the exclusion of teachers of Color (e.g., African Americans males, Latinos) from the urban teaching force (Rogers-Ard et al., 2012; Gordon, 1994; Kohli, 2014). Mensah and Jackson (2018) claim that preservice TOCs can break the perpetual cycle of alienation, exclusion, and inequity in science when they are given opportunities to engage in science as learners and teachers.

Recruitment and Retainment Issues: Teacher Shortage

Villegas and Clewell (1998) lament the racial/ethnic imbalance between the teaching force and student population, chronic shortage of certified teachers, dearth of teachers qualified to teach specialized subjects like science, and high teacher attrition (especially in urban and rural schools). There also exists chronic shortage of science teachers teaching diverse learners. Comprehensive, peer-reviewed literature reviews revealed that that high attrition and low retention are serious problems that limit the number of teachers, especially in subject areas of shortage such as science, mathematics, and special education (Zeichner & Schulte, 2001; Suell & Piotrowski, 2007). Kohli (2018) also states that Color blindness and racial microaggressions manifest as macro and micro forms of racism and take a toll on the professional growth and retention of TOCs. Plachowski's (2019) findings confirm that resolving the teacher diversity gap is more than a simple recruitment problem, and the author recommends that practitioners, scholars, and policy makers must attend to the climate and culture of schools, in particular the racialized experiences of students of Color to be able to address the complexity of this issue.

Challenges Faced by Science Teachers in Using CRP Strategies

A common limitation to culturally responsive science instruction is the cognitive load—the increased burden or effort needed for knowledge transfer to occur—teachers face when preparing to enact culturally responsive curricula (Belgarde et al., 2002), particularly when trainings or supports are not available or accessible. Furthermore, structures for such preparation in formal teacher preparation settings are sparse (Mensah, 2011). For example, teachers described uncertainty in exploring and drawing upon their students' funds of knowledge—the household and community-based skills and tools accumulated over time (Rodriguez, 2013)—and often cite feeling an overwhelming responsibility to tend to every student's FOK or backgrounds. Scholars have applied the metaphor of “double bind” to explain the tensions and systemic enforcement mechanisms that TOCs experience, and this presents as a constant challenge to the TOCs (Achinstein & Ogawa, 2011; Gist, 2017; Bettini et al., 2021). Achinstein and Ogawa (2011) define double bind as “tensions between personal ties...and systemic ties” (p. 931). Some scholars have studied the perceptions, reflections, and challenges TOCs face in the current educational milieu. Science educators of Color face a persistent challenge to teach the culturally and linguistically diverse students because of the following reasons: (a) high dropout rates, (b) substandard performance in standardized science achievement examinations, (c) low university enrollments, and (d) low postsecondary enrollment in science-related fields. Hence, the educational needs of the students of Color must be addressed using novel pedagogical interventions (Suriel, 2014). Likewise, McKinley and Gan (2014) discuss the problems of lack of participation and science achievement of Indigenous and ethnically diverse students in two strands: “equity and excellence

approach” and “student success approach” (p. 284). The student success approach encompasses the complex interaction of family, social, cultural, educational, economic, and political contexts (McKinley & Gan, 2014). Teacher educators too often hear science teachers from diverse backgrounds express concerns about lack of time to teach using inquiry-based instruction, to create a scientific classroom discourse community to encourage interdisciplinary learning, and to be able to meet the Next Generation Science Standards (NGSS) (Lewis et al., 2014). Many scholars state that a persistent problem in teacher education coursework and professional development is in creating “silos” that hold multicultural education and equity-oriented work separate from other coursework in teaching methods (Braaten & Sheth, 2016; Ladson-Billings, 2014; Banks, 1993; Villegas & Lucas, 2002). Hence, science TOCs facing the above-mentioned challenges must receive professional development and support in order to effectively address their problems.

Challenges Faced by Science Teachers While Employing Equitable, Justice-Oriented Teaching

Parsons (2014) notes that the societal pressures have led to schools adopting Color blindness and postracialism. These ideologies are very demeaning to TOCs, and they do not recognize the history and culture of the people involved and denies respect to those people. While critiquing the literature, Parsons (2014) states that equity and equality were the reasons for investigating race and ethnicity in science education, and she identifies four points of critique, namely presentism, lack of conceptual clarity, individualism, and methodological myopia. Similarly, Atwater et al. (2013) in their case study on 20 Black science teacher educators who included equality, equity, and

multicultural education in their teaching, only very few were successful in their mission, and many struggled or stopped incorporating multicultural education and equity in their teaching due to student evaluations, need to gain promotion and tenure, and lack of support from their colleagues. The authors concluded that if teacher educators are going to prepare science teachers for the 21st century, then teacher candidates must be challenged to grapple with racial, ethnic, cultural, instructional, and curricular issues in order to teach justice-oriented science to US students in rural, urban, and suburban school contexts, and they must be encouraged to incorporate culturally and linguistically relevant pedagogy in their praxis.

Constant Dilemma Over Cultural/Linguistic Relevance Versus Standardization in Science

Science holds a uniquely powerful place in our global society. Science provides a knowledge base for more informed conversations with healthcare workers, educators, and business and community leaders; it demystifies key urban environmental issues like air and water quality standards, toxic dump and building regulations, and population density; and it opens doors to high-paying professions (Calabrese Barton, 2002). A group of prominent international science educators issued the following collective statement of concerns about science education for students around the world (Linder et al., 2011):

Citizens' lives are increasingly influenced by science and technology at both the personal and societal levels. Yet the manner and nature of these influences are still largely unaddressed in school science. Few students complete a schooling in science that has addressed the many ways their lives are now influenced by science and technology. Such influences are deeply human in nature and include

the production of the food we eat, its distribution, and its nutritional quality, our uses of transportation, how we communicate, the conditions and tools of our work environments, our health and how illness is treated, and the quality of our air and water. Science education is not contributing as it could to understanding and addressing such global issues as feeding the world's population, ensuring adequate supplies of water, climate change, and eradication of disease in which we all have a responsibility to play a role. Students are not made aware of how the solution of any of these will require applications of science and technology, along with appropriate and committed social, economic, and political action. As long as their school science is not equipping them to be scientifically literate citizens about these issues and the role that science and technology must play, there is little hope that these great issues will be given the political priority and the public support or rejection that they may need (pp. 2–3).

McKinley and Gan (2014) state that “the underrepresentation of Indigenous and some ethnic minority students in secondary science education is a major social and economic disadvantage for these communities and a major challenge for science educators in industrial countries” (p. 284). Hence, it is absolutely crucial for all science educators to develop scientific competence for all learners. The culturally responsive pedagogies were designed to aid the culturally and linguistically diverse student populations to fully participate in scientific society. Being scientifically literate could also help Indigenous students choose rewarding careers in science. Teachers of Color, having been minoritized students themselves, are aware of the benefits of using CRP strategies to teach science in their culturally diverse classrooms. However, TOCs are under constant

pressure because (a) systemic ties in schools devalue the critical pedagogical and culturally responsive instructional approaches that attract teachers of Color to the profession in the first place; (b) they have to comply with strict accountability policies which means that they are forced to resort to transmission-oriented instruction because their success, tenure, and promotion are largely measured by their students' performance in standardized, high-stakes testing (Bettini et al., 2021; Quita, 2003; Achinstein & Ogawa, 2012). In addition to having limited understandings of culturally responsive pedagogy, preservice teachers of Color are discouraged from using culturally relevant pedagogy or multicultural education strategies by a lack of commitment from their programs and program faculty (Jackson, 2015). Moreover, extant literature on preservice TOCs lacked information on how to systematically incorporate multicultural education in teacher preparation program designs (Jackson, 2015; Sleeter, 2001; Sheets, 2001). Laplante (1997) urges elementary science teachers to move away from the prevalent Eurocentric/androcentric perspective of teaching and move toward a culturally affirming perspective. The author argues that it is also essential that throughout this process, teachers must be encouraged and supported by colleagues, the school administration, parents, and the larger community (Laplante, 1997).

Need for Focused, Indigenous Teacher Education Programs

Ahmed and Boser (2014) emphasize the barriers that exist for students and teachers of Color and the great need of having a diverse teaching force to aid underrepresented students. The authors claim that targeted outreach to high-performing students of Color with an interest in teaching, aggressive and targeted recruitment efforts, and sustained support to TOCs and schools would help build diversity in the teaching

workforce. They also outline several recommendations for local communities, teacher education institutions, state and federal governments, policy makers, and critical stakeholders to develop an agenda to increase the racial and ethnic diversity of teachers in public schools. Darling-Hammond (2006) outlines three critical components that create stronger and more effective TEPs, which can aid teachers working with underrepresented students. These components are (a) tight coherence and integration among courses and between preservice teachers' coursework and their work in their practicum classrooms; (b) extensively supervised clinical work that links pedagogical theory and practice; and more importantly (c) having closer, proactive, effective relationships with schools that serve diverse learners and develop and model good teaching (Darling-Hammond, 2006). Darling-Hammond (2006) warns TEPs to resist watering down preparation which will ultimately underprepare teachers, undermine the reputation of schools, and devalue the overall teaching profession. In the following sections, I have categorized several ways in which TEPs can help teachers working with underrepresented students in different subject areas, including science.

The Council for the Accreditation of Educator Preparation (CAEP) is a professional accreditor that reviews departments, schools, and colleges which prepare teachers and other educators seeking teaching certifications, licensures, and endorsements in the United States or internationally (*What Is Accreditation*, 2020). The colleges and universities that apply for their CAEP accreditation have systems in place to evaluate their elementary science and secondary science education programs (in STEM). According to Darling-Hammond (2010), many schools of education undertook successful transformations in many ways: (a) by using the standards to redesign their programs; (b)

by creating stronger clinical practice; (c) by strengthening coursework around critical areas like student learning and development, assessment, subject matter pedagogy, and teaching of emergent multilingual students and special needs students; and (d) by connecting this coursework directly to practice in much more extensive practicum settings. Chin's (2004) study involved an extensive science museum experience as an alternative to traditional classroom instruction for the preservice secondary science teachers to enhance their learning to teach science. The preservice teachers visited and discussed with museum educators and developed lesson plans on teaching in the science museum.

To frame the importance of Indigenous teacher education programs, Battiste (2018) writes on the foreword of the book *Promising Practices in Indigenous Teacher Education* that

in compliance with teaching and learning involving Indigenous populations...rights-based frameworks of reconciliation demand a new understanding of the history of colonialism, new approaches to reverse the negative impacts of cognitive imperialism through a reliance on Indigenous language awareness and revitalization, Indigenous knowledges, community partnerships on the land, unpacking and restoring of the significant lifelong work and nourishing the learning spirit of teachers and students. *Promising Practices*...offers hope, inspiration and visions of educators and activists aspiring to maintain and revitalize Indigenous knowledges, languages, identities, while it builds on relevant and promising practices to reconstitute inclusive holistic cognitive justice (p. viii).

Due to the unique and diverse challenges and barriers that teacher-educators face while teaching pre-service teachers aspiring to teach Indigenous students, dedicated Indigenous teacher education programs are most crucial for the success of educators and pre-service teachers. The most widely studied Indigenous Teacher Preparation Programs (ITPs), otherwise called Indigenous Teacher Education Programs (ITEPs) are situated in countries, such as Canada (First Nations, Inuit, and Métis are Indigenous peoples most widely studied ITEPs in the extant literature), United States of America (e.g., ITEPs for the Indigenous peoples in the states of Hawaii, Alaska, Montana, and Arizona), New Zealand (e.g., ITPs for Māori peoples), and Australia (e.g., ITPs for Aboriginal peoples such as Ngunnawal, Anangu, and Koori peoples).

Madden (2015) reviewed 23 studies that represent international perspectives on ITEPs focusing on underlying theoretical assumptions, purpose, and goals of teacher educators' approaches, as well as the central themes and pedagogical methods that are featured in those studies. Four pedagogical pathways that wind, meet, and diverge were organized and examined by Madden (2015), and they are (a) learning from Indigenous traditional models of teaching, (b) pedagogy for decolonizing, (c) Indigenous and anti-racist education, (d) and Indigenous and place-based education. Madden (2015) stated that "teacher educators are involved in the doubled task of modeling what it might mean to engage Indigenous education, while preparing teachers to carry on similar work differently in schools" (p. 13). The study concluded that tracing of pedagogical pathways may support examination of the movement, and sedimentation, of knowledge practice associated with Indigenous education within and between Faculties of Education, schools, and transitional spaces, which will help in bridging knowledge and innovative

pedagogical methods that are practiced in these pathways (Madden, 2015).

Castagno (2012) has analyzed an Indigenous TEP from a tribal critical race theory perspective to highlight the great urgency of adequate, culturally responsive teacher preparation needed by pre-service teachers. Castagno (2012) collected data from 13 pre-service teachers enrolled in the TEP of a large Southwestern university, which had a goal of recruiting and graduating students from the Navajo Nation. Castagno (2012) states that federally funded Indigenous teacher preparation programs housed at mainstream, predominantly White universities can be colonial, and the work of teacher-educators is difficult given the context of imperialism, White supremacy, and assimilation that still structures educational institutions. The author concludes that by centering the Navajo Nation's ideas about what Diné education ought to look like, ITPs may come closer to fulfilling the goals of culturally responsive schooling and help in facilitating tribal nations' goals of self-determination through self-education.

Anthony-Stevens et al. (2020), in their multi-year ethnographic documentation project, discuss the efforts of another TEP, the Indigenous Knowledge for Effective Education Program (IKEEP), at the University of Idaho. Being a predominately White institution (PWI) of higher education, University of Idaho has struggled to create space in higher education for intentional support of Indigenous self-determination, sovereignty, and Tribal nation building through their ITP (Anthony-Stevens et al., 2020). The authors examine the contentious and local work of reimagining education, from the bottom up and top down, to develop leaders to serve the needs of Indigenous youth and communities through the vehicle of mainstream institutions, by analyzing the experiences of IKEEP program administration, teacher mentors, and students through the conceptual

lens of Tribal nation building in higher education. Their findings underscore how TEPs at PWIs need to engage in a radical shift toward seeing Indigenous teachers as nation builders and prioritize the infrastructure and programmatic collaboration to support them and their communities (Anthony-Stevens et al., 2020).

An important challenge in Indigenous education is the recruitment and retention of Indigenous teachers. A recent research study was conducted, that gathered and analyzed recruitment and retention strategies employed by 50 teacher education programs (TEPs) in Canada, the United States, New Zealand, and Australia to increase the number of Indigenous teachers (Landertinger et al., 2021). The study discusses several recruitment and retention strategies that were found to be successful in this regard. The specific recruitment strategies that Landertinger et al. (2021) talk about are bringing education to the students, removing financial barriers, and providing alternative pathways to admission and certification. The retention strategies discussed were (a) creating Indigenous cohorts, (b) providing specialized support services, (c) providing Indigenous-centric curriculum and program design, (d) drawing from Indigenous pedagogies, and (e) hiring Indigenous faculty and educators.

The other important issue concerning ITEP is the role that language and identity plays in Indigenous teacher education programs. Moore's (2019) three-year on-going narrative study talks about the experiences of pre-service teachers in the Inuit Bachelor of Education (IBED) initiative and the associated Inuktitut language training program. This initiative was developed in collaboration with the Nunatsiavut Government in Canada to explore the relationships between cultural identity and learning an Indigenous heritage language as a second language. Moore (2019) used narrative methods to give voice to the

pre-service teachers' experiences through their personal stories of learning Inuktitut. The narratives reflected how language learning may contribute to an increased awareness of one's Indigenous group and make connections with it. Moore's (2019) findings revealed that strengthening of cultural identity can enhance well-being, which has implications for the learning of these pre-service teachers and the impact on their future students. Another recent narrative study by Oloo and Kiramba (2022) explored the experiences of two Indigenous teachers during and after teacher education in an Indigenous teacher education program in Canada. This study attempted to reframe teacher education to enhance the meaningful engagement of pre-service Indigenous teachers, by conducting open-ended, unstructured interviews as conversations with the study participants (Oloo & Kiramba, 2022). Four major common themes that emerged from the participants' stories are (a) factors that influenced the teacher's decision to attend ITEP, (b) Indigenous identity, (c) positive learning environments, and (d) the importance of having Indigenous teachers in Indigenous schools.

Alternative Teaching Certification Programs

Suell and Piotrowski (2007) found that high attrition and low retention are serious problems that limit the number of teachers, especially in specialized subject areas such as science. The authors found that the highest rates of attrition are in the fields of special education, mathematics, and science, each of which lose 20% each year (Suell & Piotrowski, 2007). Alternative teaching certification programs accelerate the route to teaching for people lacking an education degree or specific education classes in two- or four-year colleges of education. The National Center for Education Information (NCEI) states that alternative routes to certification have had a major impact on the teaching

profession, and as per NCEI's claims, more men, more non-Whites, more mature, life-experienced, educated professionals have become K-12 teachers as a result of alternative programs designed to certify nontraditional students (*Alternative Teaching Certification*, 2022). In the context of science education, alternative TEPs have focused on the preparation of teachers of Color in varying contexts, including preparation of teachers in subject areas of tremendous shortage, such as science, math, special education, and bilingual education (Zeichner & Schulte, 2001; Suell & Piotrowski, 2007). Exploring alternative teacher education programs is relevant for my study since my participants are Indigenous science teachers, who historically have not had access to education in highly specialized fields like science and mathematics because of being subjugated and dehumanized socially, politically, physically, psychologically, linguistically, culturally, and epistemologically by the dominant, hegemonic White American society in the U.S. and Canada. Hence, having access to alternative teacher education programs for Indigenous communities could be beneficial for them, but the underlying caveat is that the alternative TEPs might not be providing with place-based and culturally and linguistically responsive, rigorous, equitable, and research-based teacher training that truly caters to the needs of the Indigenous students.

Need for Professional Development Programs

Lisle-Johnson and Kohli (2020) underline the importance of school leaders and policymakers developing inclusive teams to select curricula that center the experiences, histories, and values of communities of Color and providing professional development (PD) programs to support teachers' efforts to learn how to provide culturally sustaining instruction in the context of accountability policy. Mensah (2011) states that teacher

educators serve as supporters and advocates for preservice teachers' ongoing professional developments. Drawing from her rich experience of teaching science methods courses for many years, Mensah (2013) states that preservice and in-service teachers must draw upon various theories and principles of equitable teaching, in science and other subject areas, to understand their students' cultural and linguistic funds of knowledge to enhance student success. Mensah (2011) adds that preparing teachers to teach diverse students must include efforts to transform and challenge the preservice science teachers' thinking about how to teach underserved and underrepresented students more effectively.

The need for Indigenous science education programs, professional development programs for teachers, and the importance of incorporating culturally responsive science curriculum proposed by the Alaska Native Knowledge Network for the Yu'pik communities (Stephens, 2000) and culture-based education on the Navajo, Hopi, San Carlos Apache, and Zuni reservations (Gilbert, 2011) have already been discussed earlier in this dissertation. This section will highlight another important educational reform in Montana with several Native American communities. Carjuzaa (2009) reviews the unique educational context of Montana, the evolution of Indian Education for All (IEFA) mandate, characterize a typical educational journey teacher candidates take, highlight the role teacher educators are expected to play in preparing teacher candidates to integrate IEFA, and reviewed the professional development opportunities provided in Indigenous teacher education programs. Carjuzaa (2009) states that Assiniboine, Blackfeet, Chippewa, Cree, Crow, Gros Ventre, Kootenai, Little Shell, Northern Cheyenne, Pend d'Oreille, Salish, and Sioux are the Native American tribes that call Montana home, and Carjuzaa and Ruff (2016) state that in Montana, 80% of emergent multilingual students

are American Indians who do not necessarily speak their heritage languages; yet, their academic English skills are inadequate to support content mastery. Carjuzaa (2009) states that Montana has taken a leadership role in Indian education issues with its unprecedented reform effort known as Indian Education for All, the landmark legislation which requires all classroom teachers to integrate curricula focusing on the histories, cultures and contemporary issues facing Montana's 12 tribes. The author further adds that integrating Indigenous knowledge across the curriculum at all grade levels is a multi-pronged, comprehensive endeavor. Carjuzaa's (2009) study on professional development for teachers to integrate IEFA in K-12 curriculum wants them to acquire background knowledge on Montana's tribes, build confidence, make connections with tribal members, review and incorporate Indian content, and learn instructional strategies that complement the implementation of culturally relevant pedagogy in order to prepare the future K-12 teachers to teach their pupils about IEFA. Carjuzaa et al. (2010) commend Montana's IEFA reforms as a transformative educational policy that exemplifies the practical application of multicultural education.

Need for Providing Holistic Opportunities for Student-Teachers of Color

According to Kohli and Pizarro (2016), TOCs are often not able to engage holistically, to grow in ways that accomplish their goals, or to advocate for their communities. Darling-Hammond (2006) offered some solutions how to holistically involve the TOCs. She stated that in schools that are working explicitly on an equity agenda and high-quality curriculum for diverse learners, student teachers or interns are "encouraged to participate in all aspects of school functioning, ranging from special education and support services for students to parent meetings, home visits, and

community outreach to faculty discussions and projects aimed at ongoing improvement” (p. 309). This kind of participation helps prospective teachers understand the broader institutional context for teaching and learning and begin to develop the skills needed for effective participation in collegial work on school improvement throughout their careers (Darling-Hammond, 2006).

Insights from International Studies on Science Teacher Education

According to Bruce, Podemski, and Anderson (1991), a professional global perspective is needed to widen the study of education and the search for educational problems. International science teacher education programs, although practiced in diverse geographical contexts, could offer some solutions to problems in science teacher education in the United States. One example of an international science education development project is Lewthwaite et al.’s (2010) study, which reported on the several phases of a five-year science education development project in Nunavut, Canada. Lewthwaite et al. (2010) focused on the cases of three Inuit school communities for identifying and achieving their aspirations for science education and fostering culture-based education programs, especially Nunavut’s cultural inclusion policies, curriculum agenda, and teacher education protocols that positively support and influence the school’s response to science as a curriculum area. The authors conclude that visions of long-term science development projects depend on policy and leadership conditions that are manifested at the school-community and divisional and territorial levels (Lewthwaite et al., 2010).

Other findings of studies on science teacher education from Australia, African countries, India, Malaysia, and South Korea converge on common global science

education issues related to (a) development of science teacher education curriculum (Mahmud et al., 2018; Im et al., 2016; Treagust et al., 2015); (b) the vital role that science plays in improving socioeconomic conditions of people (Mahmud et al., 2018; Ogunniyi & Rollnick, 2015); (c) over-commercialization of the education sector (Goel & Goel, 2012); (d) stricter entry requirements to teacher education programs (Treagust et al., 2015); (e) effective alternative pathways to teaching (Treagust et al., 2015); (f) educational policies and political laws that influence STEM learning (Im et al., 2016; Mahmud et al., 2018; Goel & Goel, 2012); (g) shortage of qualified science teachers that creates demand and supply imbalance (Ogunniyi & Rollnick, 2015; Mahmud et al., 2018; Treagust et al., 2015; Im et al., 2016; Goel & Goel, 2012); (h) importance of incorporating dual language programs and culturally and linguistically responsive science instruction (Ogunniyi & Rollnick, 2015; Mahmud et al., 2018); (i) equitable assessment methods in science classrooms (Ogunniyi & Rollnick, 2015; Mahmud et al., 2018); (j) recruitment and retention issues (Ogunniyi & Rollnick, 2015; Im et al., 2016); (k) alienated and incompatible modes of teacher education (Goel & Goel, 2012); and (l) chronic teacher quality crisis (Goel & Goel, 2012; Ogunniyi & Rollnick, 2015). All of the above-mentioned issues identified by the international researchers could be applicable in the American context too, so TEPs in the United States would benefit if they gleaned from international studies on science teacher education.

Characteristics of Culturally Responsive Educators of Indigenous Students

As discussed in another section of this dissertation, The Alaska Native Knowledge Network has developed “cultural standards” that are essential ingredients for identifying the appropriate qualities and practices associated with culturally responsive

educators, curriculum, and schools. According to the *Alaska standards for culturally responsive schools* (n.d.), the characteristics of culturally responsive educators are that they:

- (a) *incorporate local ways of knowing and teaching in their work* by recognizing the validity and integrity of the traditional knowledge systems, utilizing Elders' expertise in multiple ways in their teaching, and providing opportunities and time for students to learn in settings where local cultural knowledge and skills are naturally relevant.
- (b) *use the local environment and community resources on a regular basis to link what they are teaching to the everyday lives of the students* by regularly engaging students in appropriate projects and experiential learning activities in the surrounding environment, utilizing traditional settings such as camps as learning environments for transmitting both cultural and academic knowledge and skills, and providing integrated learning activities organized around themes of local significance and across subject areas.
- (c) *participate in community events and activities in an appropriate and supportive way* by becoming active members of the community in which they teach, making positive and culturally appropriate contributions to the well-being of that community, and exercising professional responsibilities in the context of local cultural traditions and expectations.
- (d) *work closely with parents to achieve a high level of complementary educational expectations between home and school* by promoting extensive community and parental interaction and involvement in their children's education, involving

Elders, parents and local leaders in all aspects of instructional planning and implementation, seeking to continually learn about and build upon the cultural knowledge that students bring with them from their homes and community, and seeking to learn the local heritage language and promote its use in their teaching.

(e) *recognize the full educational potential of each student and provide the challenges necessary for them to achieve that potential* by recognizing cultural differences as positive attributes around which to build appropriate educational experiences, providing learning opportunities that help students recognize the integrity of the knowledge they bring with them and use that knowledge as a springboard to new understandings, reinforcing the students' sense of cultural identity and place in the world, acquainting students with the world beyond their home community in ways that expand their horizons while strengthening their own identities, and recognizing the need for all people to understand the importance of learning about other cultures and appreciating what each has to offer.

Having reviewed the extant literature on different programs and strategies for Indigenous students' success in STEM and studies on culturally and racially diverse science teachers, it becomes all the more important to address the philosophical assumptions and theoretical framework that guide my study, which is detailed in the next chapter.

CHAPTER 3

THEORETICAL FRAMEWORK

Philosophical Foundations

All research that is conducted by researchers is guided by a set of philosophical underpinnings. According to Guba (1990), paradigms are a “basic set of beliefs that guides action” (p. 17). Held (2019) states that paradigms are human constructions. All researchers have their own unique way to read their worlds, so there are multiple paradigms, and Denzin and Lincoln (2018) term these beliefs as paradigms or interpretive frameworks. Hence, based on their own subjective worldview and assumptions (paradigm or paradigmatic orientation), educational researchers seek to understand what the nature of reality is (ontology); what constitutes as knowledge (epistemology); what values, principles, and ethics guide research (axiology); what purposes and considerations guide research designs (methodology); what theories lie behind research methodologies (theoretical framework); and what specific approaches, actions, and behaviors are employed in research (methods) (Held, 2019; Crotty, 1998). Considering the philosophical and epistemological perspectives and paradigms is critical both for evaluating others’ research as well as the ability to conceptualize and operationalize one’s own research designs (Babchuk & Badiee, 2011).

Phillips and Burbules (2000) state that educational researchers usually align themselves to three major paradigms. These paradigms are (a) positivism/post-positivism (guided by realist ontologies of logical realism, naïve realism, and empiricism and objective epistemology); (b) interpretivism/constructivism (guided by relativist ontology and subjective epistemology); and (c) critical paradigm (guided by ontology of historical

realism that is constructed by historical and sociopolitical structures and power relations within the society and modified subjective epistemology) (Phillips & Burbules, 2000). Mertens (2015) also states that most social science and qualitative researchers conduct their research under the umbrella of post-positivist, constructivist or interpretivist, transformative, and pragmatic paradigms. Philosophical assumptions in qualitative research direct the researchers to their research goals and outcomes, decide the scope of training and research experiences, and form the basis of evaluative criteria for research-related decisions (Creswell & Poth, 2018). Kim (2016) encourages qualitative narrative inquirers to be well versed with macro-level theories (interpretive paradigm), meso-level theories (methodological paradigm), and micro-level theories (disciplinary [individual topic area] paradigm) to be able to justify their worldview, choices of their methodology, and research topics. Due to the scope and goal of this dissertation are not to necessarily analyze the diverse philosophical assumptions discovered until date, an attempt has been made to outline the ones that have influenced and informed my study.

Western Eurocentric Paradigms and Epistemologies

Traditionally, the Western Eurocentric paradigms and epistemologies have had the “power” and have imposed a vice-like grip on academia and research for a long time. The Westerners did not only take their bodies to the colonized world, but they also influenced (or) imposed their thinking on to colonized people, which might be called as ontological oppression. McClish-Boyd and Bhattacharya (2021) state that “the field of qualitative research remains largely White” (p. 534), and the viewpoints of the traditional (Eurocentric, White, male) canon have directly influenced the way researchers think until today.

Critical Research Paradigms, Epistemologies, and Diverse Knowledge Systems

In the late 20th century, Indigenous scholars across the globe started to critically examine Eurocentric dominance in academia and research and resisted it by articulating and reclaiming Native Peoples' research methodologies and paradigms (Held, 2019). A number of education scholars have talked about critical raced and raced-gendered epistemologies that emerge from a social, cultural, and political history different from the dominant race (e.g., Delgado-Bernal, 1998; Ladson-Billings, 1995a, 2000; Scheurich & Young, 1997). According to Scheurich and Young (1997), "epistemologies, along with their related ontologies and epistemologies, arise out the social history of a particular social group...epistemological racism...has *negative results for people of Color in general and scholars of Color in particular*" (*emphasis added*, p. 8). Scheurich and Young (1997) emphasize that there is a lack of understanding among researchers as to how race is a critically significant epistemological problem in educational research. Scotland (2012) states that the ontological position of the critical paradigm is historical realism, where reality is shaped by social, ethnic, political, economic, cultural, gender values, and power relations within the society. Similar to Indigenous scholars who resisted Western epistemologies, Scotland (2012) reiterated that the scientific and academic communities, which legitimize and validate knowledge claims, unconsciously contribute to systems of oppression. To connect these studies with my own, researchers such as myself who are not Native American need to be conscious of what damage has already been done to these communities when researchers worked with them in the past. So, I will proceed with utmost caution focusing on the pedagogy used by my participants. It is important for me to center the voices of my participants in order to decolonize my

own research practice.

Western Modern Science and Deweyan Educational Philosophy

Science disciplines that are taught in majority of schools and universities around the world have adhered to the knowledge that is termed as “Western modern science,” (Lee, 2003, p. 4) which has been traditionally compiled by male, White, European scholars. John Dewey is one of the traditional Eurocentric, White, male educational theorists. John Dewey began his career as a science teacher and the early influence of science on Dewey’s scholarly work explains the obvious connection between Dewey’s conception of thinking and scientific inquiry (Bybee et al., 2006). In *How We Think* (Dewey, 1910/1933), Dewey outlines his views on the complete act of thought and describes some indispensable traits of reflective thinking. These traits include (1) defining the problem, (2) noting conditions associated with the problem, (3) formulating a hypothesis for solving the problem, (4) elaborating the value of various solutions, and (5) testing the ideas to see which provide the best solution for the problem. Dewey’s traits conform to the traditional positivistic notions of Western modern science.

Dewey’s philosophy took on a social constructivist/progressivist stance in his book *Experience and Education*. Dewey (1938) believed that individuality, progress, and change are fundamental to one’s education. Believing that people learn best from what they consider most relevant to their lives, progressivists center their curricula on the needs, interests, experiences, and abilities of students. Being a progressivist, Dewey (1938) outlines a new philosophy based on individuals’ social experience of education where every individual is able to contribute towards a growing notion of “ideal utopian society” with each individual contributing to their full potential. In a progressivist school,

students learn actively. The students interact with one another and develop social qualities such as cooperation and tolerance to understand different points of view. In addition, students solve problems in the classroom similar to the problems they might face in their everyday lives. Progressivists, such as Dewey, believed that education should be a process of ongoing growth, not just a preparation for becoming an adult. Dewey (1938) states that “there is one permanent frame of reference...the organic connection between education and personal experience” (Dewey, 1938, p. 25).

Critical Educational Praxis and Freirean Critical Pedagogy

Upadhyay et al. (2021) referred to the Global South as the countries that are considered economically disadvantaged, mostly nation-states in Africa, Asia, Oceania, and South and Latin America; these countries used to be known as the Third World until around 1990. Global South is conceptualized as nations whose people have been subjugated by multinational capitalism and, in many cases, previously colonized nations (Upadhyay et al., 2021). One of the great educational theorists from the Global South is Paulo Freire, who wrote the book *Pedagogy of the Oppressed* (Freire, 2005). Kim (2016) states that Freire’s work is strongly influenced by critical theory and became the foundation of critical pedagogy. Kim (2016) states that Freire worked to raise consciousness and eradicate oppression and the culture of domination through praxis in which critical pedagogy is enacted. As a teacher and teacher-educator of Color, I relate very much to the quote from Freire’s book: “knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other” (Freire, 2005, p. 72). Freire (2005) states that critical praxis is the union of action and reflection and of theory

and practice. Paulo Freire has referred to praxis as the reassertion of human action for a more human world on two levels, the individual and social, where the simultaneous changing of circumstances and self-change occur, whereas critical praxis is threefold and includes self-reflection, reflective action, and collective reflective action. Critical educational praxis occurs in two contexts, namely the authentic dialogue between learners and the social reality in which people exist. Freire's philosophies and epistemologies align well with the critical and transformative paradigm.

Theoretical Orientations: Pedagogies for Decolonizing Education

This dissertation is grounded on the theories of antiracist and critical pedagogies in science teaching for Indigenous students and pedagogies for decolonizing education. Antiracist and critical pedagogies in science teaching and decolonizing pedagogies draw heavily from several theories, such as culturally relevant pedagogies, multicultural education, and equity pedagogy (Ladson-Billings, 1994a, 1994b, 1995b, 2000, 2001, 2006a, 2006b, 2009, 2014; Nieto, 1999; Gay, 2002, 2010; Nieto & Bode, 2018; Banks, 1995; Banks et al., 2001; Banks, 2004, 2015); critical race theory (CRT) in education (Ladson-Billings & Tate, 1995; Ladson-Billings, 1994a, 1998; Solórzano, Ceja, & Yosso, 2000; Delgado & Stefancic, 2001); critical pedagogy and anti-racist pedagogy (Giroux, 1981; hooks, 1984; Freire, 1998; Ladson-Billings, 1998; Sleeter & Bernal, 2004); social justice pedagogy and antiracist pedagogy in science teaching (Calabrese Barton & Upadhyay, 2010; Morales-Doyle, 2017; Upadhyay et al., 2020; Upadhyay et al., 2021); culturally sustaining/revitalizing pedagogy (Paris, 2012; Paris & Alim, 2014; McCarty & Lee, 2014; Lee & McCarty, 2017); and tribal critical theory (Brayboy, 2005; Castagno, 2012; Mullen, 2021; Joseph, 2018). All these theories are relevant and significant for my

study because they not only provide the analytical lens to analyze my participants' (Indigenous teachers) stories, but each theory also adds unique and distinct dimension, meaning, and depth to their narratives.

Culturally Relevant Pedagogies, Multicultural Education, and Equity Pedagogy

Gloria Ladson-Billings (1994a, 1994b) first described about culturally relevant teaching and the significance of multicultural education research based on her extensive research on successful teachers of African American children. She claims that culturally relevant pedagogy “empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes” (Ladson-Billings, 1994a, p. 18). Ladson-Billings (1995a) states that all learning is influenced by cultures and the context in which it takes place. Culturally relevant teaching involves three dimensions: (a) development of critical sociopolitical consciousness, (b) maintenance of cultural competence, and (c) academic success (Ladson-Billings, 1995b).

The first tenet of CRP of sociopolitical consciousness is the ability to “critique the cultural norms, values, mores, and institutions that produce and maintain social inequities” (Ladson-Billings, 1995b, p. 162). So, CRP necessitates the development of sociopolitical consciousness in both teachers and students. The science teachers must engage critically with their students, school, community, and the issues of the larger society. Teachers should bring in multiple historical and contemporary perspectives into the classroom and should be fearless to identify political underpinnings of certain societal issues and stimulate students to contribute towards social action projects. The second tenet of cultural competence includes affirming students' cultural identities, facilitating the process of students forming a positive cultural identity and maintaining cultural

integrity, and using students' cultural knowledge in the classroom (Ladson-Billings, 1995b, 2009). The third tenet of academic success is achieved by teachers using CRP to support students' development of academic skills, hold high expectations for all students, and attend to students' learning needs by inspiring students to empower themselves for excellence. Ladson-Billings (1995a) also states that academic success includes the development of social and political skills to actively participate in a democratic society. For accomplishing student outcomes, every teacher should be knowledgeable about these dimensions; however, it may not be the case for some teachers. Culturally responsive science teaching (CRST)—asset-based and student-centered pedagogies of empowerment—can lessen the educational debt experienced by students who have been historically underrepresented in science disciplines (Ladson-Billings, 2006a, 2006b). One of the central reasons for Ladson-Billings to develop CRP is to respond to “school settings where student alienation and hostility characterize the school experience” (Ladson-Billings, 2001, p. 112). Ladson-Billings (2001) stated that some of the alienation that students experience can be attributed historically to racism because racism is deeply ingrained in American life where minoritized students are being categorized as biologically, academically, and culturally incompetent or inferior to students belonging to the dominant culture.

In her path-breaking book, *The Dream-Keepers: Successful Teachers of African American Children*, Ladson-Billings (1994a) writes that the classroom teacher has the power and responsibility to help students question “the structural inequality, the racism, and the injustice that exist in society” (p. 140). Ladson-Billings (1994a) reiterated that culturally relevant teaching can be realized when schools and teacher education programs

motivate teachers and change teaching practices in the following ways: (a) recruiting teacher candidates who are interested in working with African American students, (b) providing teacher candidates with opportunities to critique the system in ways that will help them choose a role as either agent of change or defender of the status quo, (c) providing opportunities to observe culturally relevant teaching by experienced teachers who have taught African American students for a long time, and (d) providing opportunities for prolonged student teaching time in more controlled environments.

Ladson-Billings (1994) also enlisted nine principles of CRP: (a) communication of high expectations; (b) active teaching methods; (c) teacher as facilitator; (d) inclusion of culturally and linguistically diverse students; (e) cultural sensitivity; (f) reshaping the curriculum; (g) student-controlled classroom discourse; (h) small-group instruction; and (i) academic-related discourse.

Culturally relevant teaching can only be achieved when students' home culture is honored and respected (Ladson-Billings, 1994a). Brown-Jeffy and Cooper (2011) developed a conceptual framework for culturally relevant teaching that fleshed out five themes of identity and achievement, equity and excellence, developmental appropriateness, teaching the whole child, and student-teacher relationships.

Before Ladson-Billings coined the term culturally relevant pedagogy, scholars in the early 1970s and 1980s, such as James Banks, Carl Grant, Christine Bennett, Geneva Gay, Kathryn Au, Cathie Jordan, Sonia Nieto, Glen Aikenhead, William Cobern, Olugbemi Jegede, Mary Atwater, and Joseph Riley called for multicultural education to become an integral part of school curriculum and instruction and school culture (Banks, 2004, 2015).

Nieto (1999) explained that culture is dynamic; multifaceted; embedded in context; influenced by social, economic, and political factors; created and socially constructed; learned; and dialectical. Gay (2000) claims that culturally responsive teaching validates students' values, prior experiences, and cultural knowledge, and that it is comprehensive, transformative, and emancipatory. Culturally relevant teaching, culturally responsive teaching, and multicultural education requires a strong knowledge base in the teaching methods with respect to cultural diversity (Gay, 2002). Gay's (2010) culturally responsive teaching focused on improving classroom practices, with specific attention paid to curricular resources, for African, Latino/a/x, Asian, and Native American students.

In their book *Affirming Diversity: The Sociopolitical Context of Multicultural Education*, Nieto and Bode (2018) talk about the need for understanding the sociopolitical contexts of teaching in diverse classrooms, the importance of developing a conceptual framework for multicultural education, and implications of diversity for teaching and learning in a multicultural society. Mullen (2021) also states that multiculturalism and multicultural education not only celebrates diversity in schools and society, but they also have advanced discourses on power and oppression relative to schools, education, and societies. Nieto and Bode (2018) provide ways for creating affirming environments for learning and various strategies for supporting diverse communities of students with several examples, case studies, and vignettes. Banks' equity pedagogy is the "instruction that provides all students with an equal opportunity to attain academic and social success in school" (Banks et al., 2001, p. 197). Culturally responsive programs, pedagogies, and measures are aimed at not only developing

students' learning capacity and skills but also tailoring them to their particular cultures, goals, values, interests, and needs (Castagno and Brayboy, 2008; Mullen, 2019; Mullen, 2021).

Roth (2014) reviewed a number of studies that examine science teaching, which is guided by a culturally responsive framework (e.g., Grimberg & Gummer, 2013; Johnson, 2011; Morrison, Robbins, & Rose, 2008). Culturally responsive teaching is the instruction that “makes sense to students who are not members of, or assimilated into, the dominant social group” (Klug & Whitfield, 2003, p. 151). In a review of research, Morrison et al. (2008) identified three key features of culturally responsive pedagogy: (a) Teachers have high academic expectations for students but not at the expense of losing their cultural identity, (b) students are supported in developing positive ethnic and cultural identities, and (c) students develop the ability to understand and critique societal issues and inequities. Grimberg and Gummer (2013) examined culturally relevant pedagogy in their work with teachers in 25 K–8 schools near or on American Indian reservations in Montana. In a 2-year professional development program, they engaged teachers in examining the intersection of three cultures: tribal culture, the culture of the science classroom, and the culture of science. The program built on the assumption that teachers need to help learners cross cultural borders among the various cultures to which they belong by identifying intersection points between science and students' cultures.

Critical Race Theory in Education

A critical race theoretical lens is essential to understand the educational inequities between White and non-White culturally and linguistically diverse students that have led to the “academic underachievement” of these students in the United States. CRT refers to

an overall examination of how the American legal system and social structures writ large have been shaped (in the past and present) by inherent White dominance and White protection of wealth and power from within (Delgado & Stefancic, 2001). CRT offers conceptual tools for interrogating how race and racism have been institutionalized and are maintained (Delgado & Stefancic, 2001). CRT is built on the five tenets of: (a) racialized power; (b) the permanence or centrality of race; (c) counter storytelling as a legitimate critique of the master narrative; (d) interest convergence; and (e) critique of liberalism (Brown-Jeffy & Cooper, 2011). A core premise of CRT is that racism is pervasive, ingrained, endemic, institutional, and systemic; racism is not an aberration but rather a fundamental way of organizing society (Delgado & Stefancic, 2001; Ladson-Billings & Tate, 1995).

Ladson-Billings and Tate (1995) argued for a critical theory of race in education that was related to the theory created in legal scholarship. They posited the concept of critical race theory in education, which is used to analyze social inequity that is covertly demonstrated through racist practices within academic institutions. Solórzano, Ceja, and Yosso (2000) define critical theory in education as:

a framework or set of basic perspectives, methods, and pedagogy that seeks to identify, analyze, and transform those structural, cultural, and interpersonal aspects of education that maintain the marginal position and subordination of [Black and Latino] students. Critical Race Theory asks such questions as: What roles do schools, school processes, and school structures play in the maintenance of racial, ethnic, and gender subordination (pp. 40-42).

CRT also provides a helpful lens for analyzing the Whiteness of teacher education

and conceptualizing how it might be addressed. This means that in the context of education in the United States, the continued production of teachers in teacher education programs, large proportions of whom are not well equipped to teach racially, ethnically, and linguistically diverse students well, is not an aberration; rather, it is a product of racist systems designed to meet White needs (Rogers-Ard et al., 2013). In colleges and in some cases in high schools, CRT provides an opportunity for students to have conversations around the issues of division within our communities and global society while also reflecting on the impacts of systemic racism that has hindered unity and growth within the United States. Hence, CRT helps teachers and students to understand why there exists an “opportunity gap” among different races in the USA. Moreover, educational research is also characterized by epistemological racism, which means that our current range of research epistemologies have negative results for people of Color and scholars of Color (Scheurich & Young, 1997). Ladson-Billings and Tate (1995) reject the present multicultural paradigm which only benefits the Whites and oppresses the minoritized population because the “current multicultural paradigm is mired in liberal ideology that offers no radical change in the current order” (p. 62). Ladson-Billings and Tate (1995) connect multicultural education and critical race theory in education as follows:

The “voice” component of critical race theory provides a way to communicate the experience and realities of the oppressed, a first step on the road to justice. As we attempt to make linkages between critical race theory and education, we contend that the voice of people of Color is required for a complete analysis of the educational system (p. 58).

When researchers use the analytical lens of CRT in education, they can review how curriculum is designed, how classroom instruction is delivered, how classes are composed and grouped, how assessment is determined and processed, how school funding is allocated and executed, and how school district lines are drawn (Ladson-Billings, 1998). CRT will provide the analytical lens to analyze my participants' stories about how they are influenced by their own K-12 racialized lived experiences, how they design their curriculum in an Indigenous school, how they use culturally and linguistically responsive science teaching strategies, how they assess their students located in a Native American Reservation, and how school funding matters for Indigenous students' academic success. CRT could also give me decolonizing insights into tribal sovereignty, self-determination, and returning Earth Peoples' land to its rightful stewards.

Why Science Education Research Needs Culturally Relevant Pedagogies and Critical Race Theory

Most chronic "achievement discrepancies" between non-White, Indigenous, minoritized students (culturally and linguistically diverse students) and White students in science are due to structural, systemic, historical, sociopolitical oppression and discrimination they have faced during the past few centuries of U.S. history. Dodo-Seriki (2018) states that culturally relevant pedagogies (CRP) fits in science education as a promising pedagogical approach that engages all students and not just a few elites. The author also reiterates that critical race theory (CRT) as an analytical lens gives voice and agency to students who are traditionally "underrepresented in or marginalized by Western science" (Dodo-Seriki, 2018, p. 98). In addition to giving voice, the use of CRT would

help to bring to light and might eradicate practices that perpetuate the status quo by subjugating the voices, experiences, and knowledge of students of Color within science classrooms. However, Parsons et al. (2011) state that since Ladson-Billings and Tate's (1995) introduction of critical race theory (CRT) to the field of education, its uses in science education as an analytical lens to examine racial inequities have been very limited. Parsons et al. (2011) state that CRT situates voice as counter storytelling or counter narratives. The authors add that "counter stories in CRT are more than voice, the inclusion of participants' perspectives, as it is typically used in science education research" (Parsons et al., p. 957). The authors conclude that CRT is radical, and since past and present efforts to address the racial inequities in science education are not successful in ensuring the future prosperity of the United States, it is time for science education take up the radical approach. Bettini et al. (2021) also report that most studies in their literature review on the experiences of novice TOCs used qualitative or mixed methods. These methodologies are aligned with critical race theory's focus on counternarratives (Ladson-Billings & Tate, 1995).

Smith et al. (2022) foreground the importance of articulating and enacting asset-based, culturally sustaining pedagogies (Paris, 2012) in science teaching and learning experiences for students, as culturally relevant/responsive and sustaining pedagogies (CR/SP) embrace a polycultural approach to science education with an emphasis on centering and supporting marginalized students' participation in science. McCarty and Brayboy's (2021) examined culturally relevant/responsive pedagogy (CRP) and its extensions, such as culturally based and culturally sustaining and revitalizing pedagogies, focusing on Native American/Indigenous education, and they concluded that

At its core, CRP and its extensions—for all students—is about recognizing and cultivating the individual, collective, and community strengths they bring to learning and teaching. It is a hopeful frame of thriving. For Indigenous students in particular, there must also be recognition and engagement with sovereignty and self-determination...with critical, accurate, and humanizing (re)presentations and rememberings (p. 439-440).

Critical Pedagogy and Anti-Racist Pedagogy

Scholars and theorists of critical pedagogy have offered different ways to consider critical pedagogy (e.g., Freire, 1998; Giroux, 1981; hooks, 1994; McLaren & Kincheloe, 2007). Critical pedagogy, as developed by Freire (1998), empowered Brazilian peasants through literacy to be advocates of their well-being and confront historical injustices. Critical pedagogy has contributed to different ways to explore social, political, cultural, structural, and economic inequities and fractures in society, particularly in the education of marginalized groups (Upadhyay et al., 2021). Critical pedagogy draws from critical theory in valuing “self-conscious critique” (Giroux, 1981, p. 27) of established discriminatory and oppressive values, rules, and practices that have historically marginalized those who are not in power, and critical pedagogy gives teachers a framework to examine present sociopolitical, structural, and economic conditions (Giroux, 1981) of teachers, students, and schools (Upadhyay et al., 2021). Critical pedagogy allows discourses of transformation and social change through critical reflective practices that equip teachers to give marginalized students opportunities to participate in classroom discussions of personal and local community importance (Upadhyay et al., 2021).

Students from marginalized communities around the world are struggling to gain access to better science education opportunities that are meaningful and engage them in science learning that builds their capacity to question, challenge, and take actions to better their future lives (Smith, 1999; Morales-Doyle, 2017; Upadhyay et al., 2020). Other than access to better science education opportunities, many students from underrepresented groups experience marginalization through the school science curriculum, science textbooks, science practices, high-stakes tests, language, epistemologies, and values and beliefs (Bang & Medin, 2010; Brown, 2006; Upadhyay et al., 2017). In the context of science teaching and learning, Upadhyay et al. (2021) consider critical pedagogy a form of “disruptive pedagogy” (Mills, 1997, p. 39) that advances the idea of identifying current structures of power relationships and challenging them for social-justice-oriented change. Critical pedagogy also engages teachers to consider science content as a tool for microscopically examining science content knowledge as well as the society that generated the knowledge, and critical pedagogy encourages science teachers to accept the discourses of the lived experiences of minoritized and Indigenous students (Tuhiwai Smith, 1999; Upadhyay et al., 2021). The merits of critical pedagogy are in the areas of critical thinking, critical reflection, and building connections between science learning and broader social and political issues (Upadhyay et al., 2021).

Social Justice Pedagogy and Antiracist Pedagogies in Science Teaching

Bell (2016) described *social justice* as a world in “which the distribution of resources is equitable and ecologically sustainable, and all members are physically and psychologically safe and secure, recognized, and treated with respect” (p. 3). Social

justice theory targets the systematic workings of power and oppression beyond schools, not just within them, and it is interrogative (Bogotch & Shields 2014). It gives students a critical lens for seeing where injustice and unfairness exist in the world. Social justice encompasses “macrolevel (in)justices and actual or material inequities that produce suffering for groups whose rights have been violated” (Bogotch & Shields 2014, p. 6). Dei (1996) defines antiracist pedagogy as “an action-oriented strategy for institutional [and] systemic change to address racism and the interlocking systems of social oppression” (p. 25). Upadhyay et al. (2021) state that antiracist pedagogy has its roots in critical theories and multicultural education. Even though antiracist pedagogy emphasizes race and racism, it also gives equally valuable attention to structure and agency (Brandt, 1986; Sleeter & Bernal, 2004).

As science is culturally mediated and socially constructed, underrepresented groups continuously experience structural and cultural discrimination in science contexts (Upadhyay et al., 2021). In antiracist pedagogy, history is central to understanding how science perpetuates discrimination in classrooms and curriculum (Mutegi, 2013). Upadhyay et al. (2021) also state that history shows that the actions of Western colonizers decimated and trivialized many Asian, African, Mayan, and other Indigenous groups’ contributions to Western science. Researchers exploring science teaching and teachers in Indigenous schools and communities have continuously found contradictions between science the students learn and the historical experiences of Indigenous people (Chinn, 2007; Tolbert, 2015). Engagement with racially discriminatory actions of schools supported by Western science leaves many Indigenous students questioning the value of learning school science (Aikenhead & Michell, 2011; Cajete, 2000; Tuhiwai Smith,

1999). Antiracist and critical pedagogies in science classrooms could immensely benefit native students' interest in science. Many scholars of race, social justice, equity, heritage, and Indigenous knowledge in science have shown that science teaching and learning cannot be neutral (Tuck & Yang, 2012; Tuhiwai Smith, 1999; Darder, 2019). According to many science education scholars, science learning must imbed political, sociocultural, and historical injustices caused and supported by science (Atwater et al., 2013; Brown, 2011; Cajete, 1999; Chinn, 2007; Johnson, 2011; Mensah, 2013; Mutegi, 2011; Szostkowski & Upadhyay, 2019; Tolbert, 2015; Tuhiwai Smith, 1999).

Calabrese Barton and Upadhyay's (2010) social justice pedagogy in science education commits to all students, regardless of race, culture, ability, language, and gender, having access to learning opportunities in science that foster personal and social transformation. Morales-Doyle (2017) introduced justice-centered science pedagogy as a theoretical framework built on the traditions of critical pedagogy and culturally relevant pedagogy to address these inequities as components of larger oppressive systems. Morales-Doyle's (2017) study findings are within the context of a "soil project" as an example of justice-centered science pedagogy. The author examined how a justice-centered advanced chemistry class in an urban neighborhood high school supported students to succeed academically while taking up urgent issues of social and environmental justice identified by their communities. In the soil project, students participated in a larger investigation of the lasting impact of the recently closed coal power plants on the community's physical environment by measuring the concentrations of lead and mercury in the neighborhood soil samples. The findings include evidence that a curriculum organized around an issue of environmental racism supported academic

achievement that exceeded the expectations of a typical high school chemistry course. Thereby, students in Morales-Doyle's (2017) study moved beyond academic achievement and became transformative intellectuals, and as transformative individuals, they demonstrated complex thinking about science and social justice issues, cultivated their commitment to their communities and cultures of origin, and developed a credibility as local youth knowledgeable in science (Morales-Doyle, 2017).

Culturally Sustaining/Revitalizing Pedagogy

Paris (2012) introduced the term culturally sustaining pedagogy (CSP) and posited that this “embodies some of the best research and practice in the resource pedagogy tradition...and supports the value of our multiethnic and multilingual present and future” (p. 93). Paris (2012) emphasizes that culturally sustaining pedagogy seeks to perpetuate and foster linguistic, literate, and cultural pluralism as part of the democratic project of schooling. Originating in the K-12 school literature, Paris and Alim's (2017) culturally sustaining pedagogy focuses on appreciating students' racial, linguistic, ethnic, and cultural differences as assets in the educational environment. Beyond simple appreciation, culturally sustaining classroom pedagogies require that faculty support students in sustaining the experiential knowledge-base and skill sets they bring into the classroom, while simultaneously providing access to the dominant cultural ways of knowing (Paris & Alim, 2017).

McCarty and Lee (2014) deepen and extend the concept and practice of culturally responsive education for Native students through their approach of critical culturally sustaining/revitalizing pedagogy (CSR). McCarty and Lee's (2014) CSR incorporated a reclamation of the language and culture when working with Indigenous youth (Smith et

al., 2022). As McCarty and Lee (2014) argued, in order to gain Indigenous education sovereignty, there has to be a concerted effort to reclaim the language and culture that have been stripped away from the people in the “ongoing legacies of colonization, ethnocide, and linguicide” (p.105). CSRP works from the position of Indigenous education sovereignty to transform ongoing settler colonialism reified in and that reifies unequal power relations, and CSRP reclaims and revitalizes Native languages, knowledges, and ways of being affected by settler colonialism and gives focus to community-based accountability through actions of respect, reciprocity, and relationship building (McCarty & Lee, 2014). Utilizing a critical lens discerning historical and contemporary power inequities and challenges to tribal sovereignty, CSRP is a strength-based approach to education for Native students and their communities that both rebuilds and reaffirms tribal sovereignty (Lee & McCarty, 2017).

Tribal Justice, Family Education Model, and Tribal Critical Race Theory (TribalCrit)

Mullen (2019, 2020, 2021) coined the term *tribal justice*, which refers to “Indigeneity-minded social justice”...“with focus intently on settler colonization and decolonization in all domains, including schooling and education” (Mullen, 2021, p. 18). Mullen (2021) states that tribal justice is a grand-scale initiative that is taking forms of advocacy such as the decolonization project. Impelled by settler colonization and genocidal outcomes, the decolonization project is an activist global approach to battling for tribal sovereignty, i.e., self-determination and self-governance for Indigenous people over land, natural resources, and education. Colonial injustices have displaced and dehumanized Indigenous tribes whose home/lands have been exploited, destroyed, through megaprojects of oil, gas, and mining industries that accelerate global warming

(Mullen, 2019, 2020). Even as I write this thesis, Indigenous peoples around the world are fighting for their rights for recognition, restoration, reparation, and accountability to ecosystems and their sustainability (Mullen, 2019, 2020, 2021).

While social justice has become part of mainstream education, tribal justice aims, perspectives, and discourse occupy “radical” spaces that aim to dismantle colonialism and the punitive, patriarchal, and exclusionary systems of the settler nations (Tuck and Yang, 2012; Mullen, 2021). Racism and other inequities (e.g., sexism, homophobia, and classism) are frequently experienced by Indigenous students in conventional public schools and classrooms, not only from non-Indigenous students but also teachers (Hare & Pidgeon, 2011). Critical educational scholars have studied the educational context of colonization of North American Indigenous communities through assimilationist education; and examined the widespread, inequitable, ineffective, and inappropriate schooling that have resulted in unemployment and underemployment (Mullen, 2021). Facing poor educational and occupational prospects, Indigenous high school students in the United States have the highest dropout rate of all racial/ethnic groups and disproportionate failure, with subaverage standardized test scores (Reyhner, 2017; *The condition of education 2022 at a glance, 2022*; *NAEP, 2022*; Mullen, 2021). In the Canadian Indigenous education context as well, Pidgeon et al. (2013) call for First Nations communities to re-establish ownership of their education to “...ensure the protection of the next seven generations’ rights to good quality education that truly honors Indigenous ways of knowing, being, languages and values, and culture” (p. 5). The theoretical frameworks that serve as analytical models to better understand issues facing Indigenous students and tribal communities are (a) Family Education Model

(FEM) and (b) Tribal Critical Theory (TribalCrit) (Guillory & Williams, 2014; Castagno, 2012). The FEM developed by Heavy Runner and DeCelles (2002) is based on principles of education and social work, and offers strategies on how to deal with AI/AN student attrition through the purposeful inclusion of such core cultural factors as family and a sense of belonging that promote academic success for AI/AN students (Guillory & Williams, 2014). However, since the FEM focuses on higher education and not K-12 education, I have not explained this model in detail because the contexts of this study are Indigenous elementary, middle-school, and high-school science classrooms.

Brayboy's (2005) TribalCrit theory has its roots in CRT, but it is uniquely different from CRT (Joseph, 2018). Mullen (2021) states that TribalCrit "brings to light the pervasiveness of colonization in society and racism against Aboriginal peoples that permeates US federal laws and policies, while sparking educational roadmaps for change" (p. 20). Guillory and Williams (2014) state TribalCrit addresses the differences and practices between dominant/mainstream groups and marginalized or disenfranchised groups, such as American Indian/Alaska Natives. A significant difference between CRT and TribalCrit is that CRT focuses on the pervasive nature of racism in society, while TribalCrit focuses on the pervasiveness of both racism and colonization in society (Brayboy, 2005).

Brayboy (2005, p. 429-430) outlines nine tenets of TribalCrit, which are as follows:

1. Colonization is endemic to society.
2. U.S. policies toward Indigenous peoples are rooted in imperialism, White supremacy, and a desire for material gain.

3. Indigenous peoples occupy a liminal space that accounts for both the political and racialized natures of our identities.
4. Indigenous peoples have a desire to obtain and forge tribal sovereignty, tribal autonomy, self-determination, and self-identification.
5. The concepts of culture, knowledge, and power take on new meaning when examined through an Indigenous lens.
6. Governmental policies and educational policies toward Indigenous peoples are intimately linked around the problematic goal of assimilation.
7. Tribal philosophies, beliefs, customs, traditions, and visions for the future are central to understanding the lived realities of Indigenous peoples, but they also illustrate the differences and adaptability among individuals and groups.
8. Stories are not separate from theory; they make up theory and are, therefore, real and legitimate sources of data and ways of being.
9. Theory and practice are connected in deep and explicit ways such that scholars must work towards social change.

As I explore the racialized and gendered lived experiences of Indigenous science teachers in this study, I consider TribalCrit to be an appropriate theoretical framework following Brayboy (2005), where he states:

TribalCrit endeavors to expose the inconsistencies in structural systems and institutions—like colleges and universities—and make the situation better for Indigenous students. TribalCrit practitioners take part in the process of self-determination and in making institutions of formal education more understandable to Indigenous students and Indigenous students more understandable to the

institutions...TribalCrit holds an explanatory power; it is potentially a better theoretical lens through which to describe the lived experiences of tribal peoples (p. 441).

The next chapter will detail my research methodology, rationale for adopting a qualitative design, rationale for the narrative approach, sub-approaches of narrative inquiry, reasons for adopting thematic narrative sub-approach, sample selection and recruitment of participants, details of the research site, data collection procedures and instruments, data analytic methods, IRB and ethical considerations, and trustworthiness in narrative studies.

CHAPTER 4

RESEARCH METHODOLOGY

The Rationale for a Qualitative Research Design

Merriam and Tisdell (2016) state that qualitative research is implemented when researchers are particularly interested in exploring how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences. Denzin and Lincoln (2018) illustrate that the role of qualitative researchers is to study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. Hatch (2002) advocates for utilizing a qualitative methodology when the purpose is “to understand the world from the perspectives of those living in it” (p. 7).

Hence, executing qualitative research is in-depth and contributes to the richness of understanding the unique experiences of the research participants. Having in-depth, rich data will provide a more holistic understanding as qualitative researchers can express their participants’ stories and what they consider important in their experience. Using a qualitative design will help me collect rich information about the Indigenous science teachers’ lived experiences and the CRP strategies they are using to help their Native students. I also hope to compare their lived experiences in a literary form of writing that allows the reader to explore the complexities of their lives (Creswell & Poth, 2018).

My qualitative study will heavily rely on human values, beliefs, emotions, and interpersonal interactions that are not possible to be quantified (as commonly found in quantitative research). This study would require human interpretations to understand the nuances, intricacies, and challenges that arise due to complex and interdependent

dynamics associated with Indigenous culture, language, students' funds of knowledge, and student-teacher relationships. Therefore, because of the need for deep understanding and rich descriptions of my participants' life stories, only a qualitative approach will align with the purpose of my study and its requirements. The following sub-section explains the reasons for adopting qualitative research approaches in science education.

Reasons for Adopting Qualitative Research Approaches in Science Education

According to the empirical evidence from my study's literature review, it was found that that science teachers and teacher-educators grapple with their everyday concerns, such as (a) providing quality education for diverse learners so that they become scientifically competent to be able to join the STEM workforce; (b) using various instructional strategies to scaffold students' science learning; (c) aligning with the national and state science standards; (d) creating equitable assessment policies for all students; (e) working towards improving their own domain-specific subject matter knowledge (e.g., physical sciences, life sciences, and earth sciences) and pedagogical content knowledge; and (f) navigating their professional interactions with students, parents, colleagues, local community members, and school officials, which are hugely influenced by their intersectional identities and added tensions due to their racialized and gendered lived experiences. These concerns influence their success as science teachers/teacher-educators and their prolonged tenure in the teaching profession. All of the above-mentioned topics are fertile areas for science educational qualitative researchers to explore in order to offer solutions for these complex human problems. Since science educational researchers most likely are teachers themselves, they display great interest to learn more about their practice so that it can be improved, leading them

to ask many questions that warrant rigorous research, and these questions could be better answered through different qualitative research designs and approaches.

Kim (2016) states that positivism is still very much alive and prevalent in academia. In fact, many U.S. government policies and grand narratives (e.g., No Child Left Behind [NCLB, 2001] and Race to The Top [RT3, 2009]) allude to a “long-term marriage between positivistic knowledge and power” (Kim, 2016, p. 3). A postmodern philosopher Jean-François Lyotard claimed that in the scientific, positivistic age, knowledge that is deemed worthy is the knowledge produced by scientific research that involves hard, measurable, and quantifiable data, and that knowledge is decided by people in power (Kim, 2016). However, despite the prevalence of this positivistic scientific epistemology and the resultant grand narratives of the nation, “researchers became increasingly aware of the flaws and limitations of applying solely scientific knowledge to the understanding of human phenomena fraught with complexity, uncertainty, uniqueness, instability, ambiguity, and value-conflict” (Kim, 2016, p. 4). Libarkin and Kurdziel (2002a) state that data, even from the most controlled scientific experimental study, are never purely quantitative because the context of the study and the perspective of the researcher will always affect the way data are collected and interpreted.

Due to challenges associated with understanding the complexity of human life, research community experienced a paradigm shift (Kuhn, 1962) that led to finding qualitative research approaches that are grounded in interpretive paradigms that uses words rather than numbers for data analyses (Kim, 2016; Devetak et al., 2010). So, by the early 1990s, qualitative research in STEM education became commonplace.

Libarkin and Kurdziel (2002a) claim that qualitative research approaches are

suitable for science education research because qualitative research data are typically rich in details and context, interpretations are tied directly to the data source, and research validity and reliability are based upon the logic of the study interpretations, rather than statistical tests. Kim (2016) adds that even though qualitative research processes are messy, complex, and time consuming, they focus on genuine attempts at understanding human action through interpretation rather than prediction and control as found in quantitative research (Kim, 2016). Furthermore, Libarkin and Kurdziel (2002a) also enlist the disadvantages of using the quantitative research approaches, such as (a) the analytical approach of quantitative research approaches could be constrained by established standardized methods, and so individuals may be artificially forced into categories; (b) by the time a quantitative study reaches the interpretation stage, the context in which the data was collected may be lost; and (c) establishing validity and reliability in quantitative studies could consume more time.

Devetak et al. (2010) conducted a comprehensive literature review of 12,524 articles published in respected international science education journals between 2006 and 2008 to identify which research approaches (quantitative, qualitative, or mixed methods) are more frequently used by authors in these three years. Devetak et al. (2010) concluded that the qualitative research approach was used most frequently, followed by quantitative and mixed methods approaches.

The marginalization of culturally, linguistically, and ethnically diverse students in science persists and can be observed in science course enrollments leading to careers in STEM (Garvin-Hudson & Jackson, 2018; National Science Foundation, n.d.). Garvin-Hudson and Jackson (2018) further state that CRP used in science instruction and

curriculum help minoritized students to foster a more positive interest in science and STEM careers because it provides them the opportunity to do science in meaningful and relevant ways. Furthermore, CRP is the most suitable strategy to employ because of an increasing number of ethnically, linguistically, and culturally diverse students in today's schools, and it is imperative that science classrooms meet the educational needs of these students (Garvin-Hudson & Jackson, 2018; *Racial/Ethnic Enrollment in Public Schools*, 2021). Furthermore, the history and tradition of science education are Eurocentric and Westernized and fail to acknowledge the dynamic tension and complexities of culture, language, and Indigenous knowledge (Aikenhead, 2006; Garvin-Hudson & Jackson, 2018; Lee, 2003).

The Rationale for a Narrative Inquiry Approach

Bhattacharya (2017) states that using narratives and stories as phenomena to understand what it means to be human, the *narrative inquiry* as a qualitative approach utilizes interdisciplinary interpretive lenses with diverse approaches and methods, all revolving around the narratives and stories of research participants. Narrative inquiry offers a way to frame how stories are being told and how stories are being reported and what is being selected as stories to be told and remembered (Bhattacharya, 2017). In narrative inquiry, the researcher sees and describes stories in the everyday actions of teachers, students, and administrators, and then retells and relives those stories in a narrative inquiry; hence, narrative inquiry is a process of collaboration involving mutual storytelling and restorying as the research proceeds (Connelly & Clandinin, 1990). Bhattacharya (2017) cites a personal communication with Jeong-Hee Kim in 2015 that best describes a narrative inquiry, which reads as follows:

Narrative inquiry is a storytelling methodology in which a story(ies) of a research participant(s) is researched as a way of knowing. Narrative inquiry has been established in different disciplines including psychology, education, law, medicine, sociology, anthropology, and more, opening the door for the synergy of interdisciplinarity. Using narratives and stories as phenomena to understand what it means to be human, narrative inquiry utilizes interdisciplinary interpretive lenses with diverse approaches and methods, all revolving around the narratives and stories of research participants. Etymologically, narrative means narrate (to tell in Latin) and gnārus (to know in Latin). Hence, narrative inquiry is used as a way of knowing that catches the two sides of narrative, telling as well as knowing” (p. 93).

Kim (2016) states that narrative inquiry is an influential research methodology in education, gaining popularity as the theory/practice/reflection cycle of inquiry. Kim (2016) further states that it is also used as curricular and pedagogical strategy in the field of teacher education, e.g., teacher educators intentionally reflecting on their own teaching and learning. In studying the lived experiences of teachers and students (Clandinin & Connelly, 2000; Clandinin et al., 2007; Chan, 2010, 2015), narrative researchers in education have strived to honor teaching and learning as complex and developmental in nature, while they seek connections and continuous engagement in reflection and deliberation in their inquiry (Kim, 2016).

Using Dewey’s theory of experience as the conceptual and imaginative backdrop, Connelly and Clandinin (1990) posit that “the main claim for the use of narrative in educational research is that humans are storytelling organisms who, individually and

socially, lead storied lives...teachers and learners are storytellers and characters in their own and other's stories" (p. 2). Kim (2016) states that "experience is the starting point and the key term for narrative inquiry" (p. 18). As an educational researcher, I agree with Connelly and Clandinin's (1990) declaration that education and educational studies are a form of experience because "education is a development within, by, and for experience" (Dewey, 1938, p. 28). Hence, "the study of narrative, therefore, is the study of the ways humans experience the world" (Connelly & Clandinin, 1990, p. 2). The narrative study design will align with a qualitative collection of data for a more rich and accountable data analysis to answer the research questions and fulfill the purpose of the present study.

Defining Features of Narrative Studies

Creswell and Poth (2018) enlist the key defining features of narrative studies, which are as follows: (a) narrative researchers collect stories from people, documents, group conversations about individuals' lived and told experiences; (b) narrative stories may emerge from a story told to the researcher, a story that is co-constructed by the researcher and the participant, or a story planned to express a particular message or point; (c) stories describe individual experiences and may reveal individual's identities and how they see themselves; (d) stories may occur within specific places or situations, so the researchers need to consider temporality to provide contextual details such as physical, emotional, and social situations; (e) stories are collected through different forms of data, such as interviews (which is the primary form), observations, documents and pictures (artifacts); (f) stories are heard and shaped by the researchers into a chronology; (g) stories often contain turning points, tensions, transitions, or interruptions; and (h) stories are analyzed using varied strategies.

Sub-Approaches (Variants) of Narrative Inquiry

While there are many types of narrative inquiry, Bhattacharya (2017) and Creswell and Poth (2018) discuss six different types of narrative inquiry: (a) thematic narratives; (b) biographical study; (c) autoethnography; (d) life history; (e) oral history; and (f) arts-based narratives.

(a) *Thematic narratives* “center around the idea that individuals live storied lives, and by recollecting these stories, they make meaning of their lives. Thus, the stories told are analyzed through an inductive process to identify themes of a storyline and represented as such” (Bhattacharya, 2017, p. 93). The dissertation works of Leslie Upson (2003) and Leslie Cook (2004) provide insights on how to thematically analyze narrative studies (Bhattacharya, 2017).

(b) *Biographies* are written records of the experiences of another person’s life. “These narratives are usually created through various data sources such as interviews, speeches, documents, writing, pictures, audio, video footage, media records, etc., to create a somewhat comprehensive narrative” (Bhattacharya, 2017, p. 93). An example of a biography would be “Ruohotie-Lyhty’s (2013) exploration of professional identity of two newly qualified language teachers in Finland” (Creswell & Poth, 2018, p. 70).

(c) *Autoethnographies* are narratives about the self, situated in specific cultural contexts. These narratives reflect on how personal stories are connected to social structures and normative discourses, and the aim often is to document a kind of social history that is otherwise not documented in the way the author

is presenting the information. The author is the researcher and the participant simultaneously, so there is an element of doing the work and observing the self while doing the work (Bhattacharya, 2017). A narrative study of an individual's personal experience may be found in a single or multiple episodes, private situations, or communal folklore (Creswell & Poth, 2018).

An example of an autoethnography would be Ellis' (1993) personal exploration of the family drama enacted after his brother's death in an airplane crash (Creswell & Poth, 2018).

(d) *Life histories* are narrative studies that portray an individual's entire life (Creswell & Poth, 2018). While autoethnography or thematic narratives could be around one incident or a few critical incidents, life history narratives span one's entire life (Bhattacharya, 2017). An example would be Fabricius' (2014) exploration of the life history of a Danish academic's position and perspectives regarding the complexity of internationalization (Creswell & Poth, 2018).

(e) *Oral histories* collect personal reflections of life events, their causes and effects from one or several individuals (Creswell & Poth, 2018). Bhattacharya (2017) adds that these types of studies involve a narrative shared by a person who witnessed a historical event as an insider or an outsider. Conducting oral history research creates room for narratives that might not be present in any documented spaces, and often oral histories offer ways in which people negotiated a historical experience in their everyday lives (Bhattacharya, 2017). An example would be Czarniawska's (2004) stories told about

organizations (Creswell & Poth, 2018)

- (f) *Arts-based narratives* are produced through some artistic formats, such as poems, ethnodrama, documentary, performances, etc. (Bhattacharya, 2017). Bhattacharya (2017) adds that given that narratives can exist in various spaces, it is important to think of narratives beyond the traditional format of representation. Some examples of these types of work are Saldaña (2005) and Cahnmann-Taylor (2006).

The Rationale for Using the Thematic Narrative Sub-Approach for My Narrative Inquiry

My narrative inquiry explores the lived experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogical practices to meet the needs of Indigenous students. A narrative inquiry will allow these individual science educators to share their stories and experiences and provide guidance on how to help educators meet the needs of the Native American student population. Because I have explored the lived experiences of three teachers and analyzed their life stories to find the common themes around teaching science using culturally and linguistically responsive pedagogies, I have adopted the “thematic narratives” sub-approach for my study. The thematic narrative approach follows an inductive analysis of data (using traditional inductive approaches of codes, categories, and theme identification) with the main themes being the headings of the findings elaborated with various examples from the data; the narratives read like an explanation of the emergent themes in elaborate detail (Bhattacharya, 2017).

I have adopted Clandinin and Connelly's (2000) three-dimensional narrative inquiry framework of temporality, sociality, and place for this study to describe the life of my research participants through their stories of experience and my written narratives. Temporality draws attention to the past, present, and future of events and people. Sociality draws attention to the relational aspect, i.e., the relationship between the participants and the inquirers. Place draws attention to the specific, physical location where the event takes place. In addition to Clandinin and Connelly's (2000) 3D narrative inquiry approach, I also strongly associate my narrative inquiry with "Dewey's theory of experience, specifically with his notions of situation, continuity, and interaction...personal and social (interaction); past, present, and future (continuity); combined with the notion of place (situation)" (Clandinin & Connelly, 2000, p. 50). I have also drawn upon Clandinin, Steeves, & Caine's (2013) "Stories to live by," and paid close attention to the social, personal, familial, and institutional narratives within which my participants' lives are embedded. In the epilogue of their book *Narrative inquiry: Experience and story in qualitative research*, Clandinin and Connelly's (2000) have quoted Dewey: "experience is a matter of people in relation contextually and temporally" (p. 189). I have also referenced Clandinin and Connelly's (1996) article on teachers' professional knowledge landscapes. They state that, "classrooms are, for the most part, safe places, generally free from scrutiny, where teachers are free to live stories of practice" (Clandinin & Connelly, 1996, p. 25). Clandinin and Connelly (1994) state that "it is in the research relationships among participants and researchers, and among researchers and audiences, through research texts that we see the possibility for individual and social change" (p. 425). It is my hope that my narrative study would

advance Indigenous science education as I forefront teachers' stories as we critically explore and interrogate colonialism and its pervasive effects and offer forward-thinking ways of conceptualizing, identifying, studying, and practicing Indigenous science education. I also hope that my narrative study would inform future research and aid in upholding social justice and Indigenous tribal sovereignty while improving the science learning outcomes for Indigenous students.

Procedures for Conducting Narrative Research

Creswell and Poth (2018) quote Clandinin (2013) where she states that narrative inquiry is a fluid inquiry and there are no linear steps to follow in this type of research. However, Creswell and Poth (2018) cite Daiute (2014) and provide the list of a set of practical techniques for conducting narrative research, which are summarized as follows: (a) determine if the research problem is best examined using a narrative approach; (b) select one or more individuals and gather their stories through multiple types of information; (c) consider how the data collection and recording can take different shapes; (d) embed information about the context of the stories into data collection, analysis, and writing; (e) analyze the participants' stories by using the process of restorying; (f) embed a collaborative approach in the collection and telling of stories; and (g) present the narrative in written form by adapting the general reporting structure as appropriate.

Challenges in Conducting Narrative Research

Given the procedures and the characteristics of narrative research, Creswell and Poth (2018) remark that this is a challenging approach to use because of several reasons. Few reasons are as follows: a) the "researcher needs to collect extensive information about the participant and needs to have a clear understanding of the context of the

individual's life" (Creswell & Poth, 2018, p. 73); b) active collaboration with the participant is necessary; c) issue of power relations is of principal concern; and d) multiple issues could arise in the collecting, analyzing, and telling of individual stories, and building awareness of this responsibility is crucial. Creswell and Poth (2018) quoting Clandinin (2013) state that "reflecting the embedded nature of these stories within the larger social, cultural, familial, linguistic, and institutional dimensions allows a more complex understanding to be attended to, yet is difficult to realize" (Creswell & Poth, 2018, p. 74). For example, the researchers' own reflexivity and keeping the personal bias in check while they are re-storying was challenging. The authors also mention emerging areas of promise for attaining more complex understandings, such as visual narrative inquiry (where images are analyzed along with textual data) and photovoice (Creswell & Poth, 2018).

Trustworthiness and Quality in Narrative Research

Loh (2013) examined a possible set of necessary criteria for evaluating narrative studies. Loh (2013) enlisted Lincoln and Guba's trustworthiness criteria (credibility, transferability, dependability, and confirmability) and summarizes the techniques such as prolonged engagement, persistent observation, peer debriefing, triangulation, member checks, thick description, dependability audits, confirmability audits, and reflexive journals. Creswell and Miller (2000) also add that researcher reflexivity, collaboration, and peer debriefing are important validation criteria to consider in narrative research. Loh (2013) mentions that there are two types of member checking: (a) peer validation is done by peers who are in the same field. They could check for narrative analysis and thematic analysis and provide their views to the author for his/her re-look or re-analysis, and (b)

audience validation is done by primary intended users and readers of the study. Loh (2013) describes the issues of verisimilitude and utility too. Verisimilitude is the quality of seeming to be true or real (or) there must be believability (Loh, 2013). The author also adds that Clandinin and Connelly (2000) considers verisimilitude as an important criterion to judge the value of narrative inquiries. Therefore, “in order to establish verisimilitude in a narrative study, the study must ‘resonate’ and seem plausible to the consumers of the study” (Loh, 2013, p. 10).

Sample Selection

Creswell and Poth (2018) have stated that the number of participants (sample size) in a narrative study is usually one or two individuals to ensure an in-depth and rich understanding of the unique experiences of the research participants. Having in-depth and rich data will provide a more holistic understanding of the participants’ lived experiences, as qualitative researchers can restory and co-construct their participants’ stories with the participants. Hence, participants in my study includes three science teachers (elementary/middle school and high school) from the selected research site. I utilized “purposeful sampling” and “criterion sampling” (Creswell & Poth, 2018, p. 159) for identifying my participants for this study. I have used “criterion sampling” as this is useful for quality assurance (Creswell & Poth, 2018, p. 159). To purposefully inform an understanding of the research problem in the study, “selection criteria” (Merriam, 2009, p. 77) with which I would identify and recruit my participants were established. The criteria integral to my research purpose and for recruitment of my participants are as follows:

1. The research participant is an adult (above 19 years of age) science teacher of Indigenous students.
2. The research participant should have at least five years of teaching experience in Indigenous school environments in order to provide distinctive stories of experience to inform my study.
3. The research participant should be accessible and willing to provide information when interviewed online (two interviews; pre-visit and post-visit) or observed in their classrooms for a period of at least two months (three days of classroom observations per participant). The participant should be willing to be interviewed briefly in informal settings after the classroom observations, as follow-up questions may arise after classroom observations.

Recruitment of Participants

The three adult participants (Indigenous science teachers teaching elementary/middle school and high school science) were recruited from Earth People Public School⁸ (EPPS), a public school located in a Native American Reservation in Nebraska, United States of America. A phone list, as well as a mailing list of EPPS, were explored from the school website for recruitment purposes. The potential participants were approached via the contacts that I made during the Teachers of Color summit and through my other networks. A letter was sent to the EPPS Superintendent to request permission to conduct the proposed research study on their campus (see Appendix A). I received permission from the Superintendent to conduct the proposed study in EPPS via email and a formal letter (see Appendices F and G).

⁸ Earth People Public School is a pseudonym given to the participating school in order to protect its identity.

Since the purpose of this study is to explore the lived experiences of Indigenous science teachers to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogies to meet the needs of Indigenous students, the participants were screened for eligibility using criterion (purposeful) sampling. Once I received my Institutional Review Board (IRB) approval (see Appendix E), I read my verbal script (see Appendix B) to them over the phone to request their consent. Once all participants gave their oral consent for the study, I emailed the “informed consent” to all the three participants, which explained the context of the research, purpose, and expectations from them as participants (see Appendix C), then had them sign the informed consent (see Appendix D). Then, the participants handed the informed consent over to me. All the consent forms were kept with the other confidential documents in a secure location. They were recruited in early October 2022 and participated in the study until the project ended in December 2022. Amy and Leigh⁹ teach elementary and middle school science in an outdoor science classroom, and Renee¹⁰ is a high school science teacher and the Director of Native American Education at EPPS.

Research Site: Earth People Public School

The research site is Earth People Public School, which is affiliated with the Nebraska Department of Education. The mission of the EPPS is to provide a student-centered education in a safe and respectful learning environment allowing their students to strengthen Native American traditions yet flourish in other cultures through positive interaction with the tribal community. According to EPPS district profile, the Earth People Tribal Reservation serves four tribal communities situated in northeast Nebraska

⁹ Pseudonyms were chosen by the participants.

¹⁰ Pseudonym was chosen by the participant.

with a population of approximately 7000 people. The meaning of Earth People in their native language is “against the current.”

EPPS has 624 students; the school district qualifies for 100% free lunch program, is fully federally funded. The majority of EPPS students are raised by single parents, grandparents, and extended family members, and several students face loss and grief because of unstable home and family lives (abandonment, imprisonment, substance abuse, neglect). EPPS suffers the highest mobility rates in Nebraska (four times the state average).

Due to the hardships faced by the students and in order to support them, EPPS has undertaken innovative projects such as the “Career Academy” where different career pathways are introduced to students and practical training for diverse careers are provided. There is a retail store, café, and a childcare center, which has received funding due to high rating by the community members. “Earth People Head Start Program” is a program launched to recruit certified teachers and teachers’ salaries are shared by the tribes and the school. The school is also improving in sports/athletics, such as football and basketball. The after-school science programs and outdoor classrooms are working on food sovereignty for the Earth People Tribal Reservation.

A private foundation dedicated to equity funds the outdoor science elementary/middle school classrooms at EPPS. These outdoor classrooms have a “house of learning,” a geothermal greenhouse, and a medicine garden. The students and teachers make a talking circle in the classroom cabin, and natural sciences are taught using culturally relevant nature-based, land-based pedagogies in outdoor classrooms. Another project is a seven-acre community garden that has sold its produce to the local farmers’

market.

The Title VI cultural director and coordinator of the school collaborate with the community Elders to prepare culturally relevant and linguistically responsive and sustainable curriculum and pedagogies so that students can learn the Earth Peoples' language through a language immersion program, which is working towards preserving and revitalizing this endangered Indigenous language. In another program, the students learn different cultural aspects of the Earth Peoples, such as archery, Lego League, and students also participate in cultural clubs, where students learn traditional ceremonies and create regalia for pow-wows, art programs, and music programs. Another project oversees Positive Behavioral Interventions and Supports (PBIS) and Multi-Tiered Support Systems (MTSS). All students are being trained on PBIS and MTSS procedures and know what to do, such as being safe, responsible, and respectful to one another, and the school conducts behavioral analysis for the betterment of student behavior. Another ongoing project in the school is restorative practices. The constructive plans for the future include building a recreational complex for sports (sports courts and baseball pits) and leisure activities for the tribal communities.

Data Collection Methods and Instruments

Data Collection Procedures

Qualitative data were collected from three science teachers via two individual semi-structured interviews (pre- and post-visit interviews via Zoom) (see Appendix H for the interview protocol) and three full-day classroom observations for each teacher. Data collection was planned for 10 weeks between the last two weeks of October to the last week of December 2022. Weekends were reserved for data review and exploration for

better understanding of participants' stories. The classroom observations were conducted in person at the chosen school site when school is in session, and pre-visit and post-visit interview sessions with both participants were conducted online (via Zoom), and they were recorded (videotaped). In addition, informal discussions and audiotaped conversations were held with teachers before school, during breaks, and/or planning time during the in-person observation visits. These visits allowed me to ask questions about what I had observed in real time, and allowed the participants to provide any extra information/context I needed in order to learn more about what I saw during the visit. Each interview lasted approximately 60-90 minutes. Classroom observations took place during the school day, and interviews took place after students have been dismissed for the day or during recess time. During the first week of my study, I commenced by getting to know the school setting, recruiting the participants, and getting the participants consent forms signed. All procedures were done based on participants' convenience. Pre-visit interviews took place during week 2. The first classroom observations started during the 3rd week of my study. After each classroom observation day, I created field notes with margin notes, and I member-checked with my participants for authenticity of my interpretation. No identifiable information about students were written down as part of my field notes. This continued for the remaining two classroom observation days in weeks 3, 4, 5, and 6. The post-visit interviews happened in week 7. Then, coding, data analysis, and final member-checking with my participants were done in weeks 8 and 9. Thank you emails were sent to participants during week 9. At the end of the study in Week 10, a compensation of Amazon gift cards worth \$50 were sent to each participant to express gratitude for their willingness to participate in my study. As a reciprocity

component, I have highlighted their voices in my dissertation study and invited them to become coauthors in my future journal publications or conference presentations after my dissertation study because all participants helped me in the co-construction of their narratives.

Data Collection Instruments (Multiple Data Sources¹¹)

1. Individual in-depth, semi-structured, online (and) in-person interviews (pre-visit and post-visit) with my research participants.
2. Three days of classroom observations of my participants' science classroom/laboratory.
3. Field notes with margin notes: Observer (my own) comments.
4. Documents: Lesson Plans and curricula highlighting culturally and linguistically relevant practices and samples of blank students' worksheets.
5. Photographs (without identifying faces of participants/students) and other artifacts from participants' classrooms/labs.

Data Analysis Procedures

I adopted Bhattacharya's (2011, 2017) inductive analysis of data using the thematic narrative sub-approach. Bhattacharya (2017) states that "data analysis involves creating processes that would allow for deep insights that reflect how the researcher integrated theoretical and analytical frameworks, previous understanding of literature, and the focus of the research purpose and questions. These deep insights can often lead to the identification of findings in a qualitative study" (p. 149). This is similar to Upson (2003) and Cook (2004) in which the stories are analyzed through an inductive process that identifies themes of the storyline and then represents them as such. Inductive data

¹¹ Table 4.1 links the research questions, data sources, and data analytic methods.

analysis is an iterative process, i.e., there is no defined linear format through which analysis occurs. The researcher moves back and forth between various stages and processes and writes around various chunks of data and makes connections among them (Bhattacharya, 2011, 2017). Interpretation of images along with words, combination of mapping and writing as inquiry, moving in and out of and study of values and plot will be the other foci of narrative inquiries. Bhattacharya (2017) states that inductive analysis in qualitative research refers to working “up” from the data. The process of inductive analysis assumes that the researcher is not starting the data analysis with any kind of preestablished testable hypothesis about the data. Inductive analysis is the process through which a qualitative researcher might look at all the raw data, chunk them into small analytical units of meaning for further analysis (usually called codes), cluster similar analytical units and label them as categories, and identify salient patterns after looking within and across categories (usually called themes). While conducting data analysis, the researcher often maintains a journal (to document observer comments during classroom observations) to reflect on subjectivities, emotions, hunches, questions that arise, and ways in which the researcher is making sense of the data in association with the theoretical, methodological, analytical framework, and research purpose and questions (Bhattacharya, 2017). Participants’ quotes are extensively while describing the themes.

My data analytic procedures follow the guidelines that Bhattacharya (2017) and Creswell and Poth (2018) enlist for inductive data analysis for narrative studies, which are as follows:

1. Different sets of transcripts were created for each interview with my participants.
2. Margin notes (i.e., field notes with observer comments for classroom

observations) were made.

3. After creating and organizing the data files, transcripts, artifacts, and field notes were read and re-read several times.
4. Writing was done iteratively as a form of inquiry for various questions that arise, for understanding data, for analyzing smaller chunks of data, for connecting various data pieces, etc.
5. The data were chunked into manageable units of analysis (codes) by pulling out and labeling phrases, sentences, paragraphs that stand out in the field notes and transcripts. The labels used were descriptive, theoretical, emotional, reflective of my subjectivities, etc.
6. Some analytical units were clustered into categories (broader groups with descriptive labels). The codes and the data categories were reviewed numerous times to identify dominant narrative themes.
7. The dominant narrative themes were identified based on meaning, critical incidents, theoretical constructs, and patterns from existing literature review.
8. Patterns that arose to the surface were identified by looking across and within categories. Methodological, topical, and theoretical questions about these patterns were documented to analyze these patterns in depth, i.e., emergent themes and patterns from the interview transcripts and field notes were analyzed using Bhattacharya's (2017) thematic narrative inductive analysis and Clandinin and Connelly's (2000) three-dimensional narrative inquiry framework of temporality, sociality, and place.
9. Reflexive writing was done paying full attention to pattern identification and the

connections to other parts of the study (research purpose, questions, theoretical framework, methodology, and extant literature in science education).

Contradictions and tensions were also identified.

10. Photos, documents, and other artifacts collected at the research site were also analyzed and included in the dissertation for “triangulating” the data

(Bhattacharya, 2017, p. 41).

11. Peer review of the data analytic process was done by discussing with my faculty mentors.

12. Member-checking with my participants was done several times to ensure

“trustworthiness” of my findings (Bhattacharya, 2017, p. 41).

13. The findings of the lived experiences of my research participants were

summarized and discussed while staying attentive to the social, personal, familial, and institutional narratives within which my participants’ lives are embedded (to ensure the “transferability” and “academic rigor” of my findings (Bhattacharya, 2017, p. 41).

Table 4.1 *A Table Linking Research questions, Data Sources, and Analytic Methods*

Research Questions	Data Sources (primary and secondary)	Analytic Methods
CQ: In what ways can the racialized and gendered lived experiences of Indigenous science teachers in K-12 school settings shape their culturally and linguistically relevant pedagogical practices to meet the needs of Indigenous students?	<ol style="list-style-type: none"> 1) Individual in-depth, semi-structured, online (or) in-person interviews with my research participant. 2) Classroom observations of my participants’ science classrooms/labs. 3) Field notes with margin notes: Observer (my) comments. 4) Documents: 	<ol style="list-style-type: none"> 1) Inductive data analytic procedures were followed in my “thematic narrative.” 2) Transcripts were created for interviews. 3) Field notes with observer comments were

<p>SQs:</p> <ol style="list-style-type: none"> 1) How do Indigenous science teachers' K-12 science classroom experiences influence the types of instructional strategies they use in their classrooms? 2) How do Indigenous science teachers navigate their own ways of knowing and the cultural, racial, and contextualized approaches to knowledge construction within the constraints of science learning? 3) How do Indigenous science teachers use their own/their students' funds of knowledge to teach science to Native American students? 	<ul style="list-style-type: none"> ▪ Lesson Plans/ curricula/syllabi of my participants that outline culturally and linguistically relevant practices. ▪ Students' worksheets/ assignments/project samples. <ol style="list-style-type: none"> 5) Photographs and other artifacts from the participants' science classrooms/labs. 	<p>made.</p> <ol style="list-style-type: none"> 4) Transcripts and field notes were read and re-read several times. 5) Writing as a form of inquiry was done iteratively. 6) Data were chunked and labeled into codes. 7) Analytical units were clustered into categories. 8) The codes and the data categories were reviewed numerous times to identify dominant narrative themes. 9) Patterns that arose to the surface were identified by looking across and within categories. 10) Emergent themes and patterns from the interview transcripts and field notes were analyzed using Bhattacharya's (2017) thematic narrative inductive analysis and Clandinin and Connelly's
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		<p>(2000) three-dimensional narrative inquiry framework of temporality, sociality, and place.</p> <p>11) Reflexive writing was done paying attention to pattern identification and the connections to other parts of the study. Contradictions and tensions were also identified.</p> <p>12) Triangulation of the data was done by analyzing photos, documents, and other artifacts.</p> <p>13) Peer review of the data analytic process was done.</p> <p>14) Member-checking with my participants was done.</p> <p>15) The findings were summarized and discussed.</p>
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IRB And Ethical Considerations

I received approval on September 30, 2022, from the Institutional Review Board (IRB) of the University of Nebraska-Lincoln before commencing my data collection procedures (See Appendix E). My faculty advisor and I have completed all of the required CITI course training for the University of Nebraska-Lincoln IRB committee. As the participants were chosen purposefully using criterion sampling, I ensured that all participants met my criteria and are adult teachers (above 19 years of age) who were interviewed individually. It was emphasized that there were no identified risks to the participants, and the study does not pose any harm/discomfort to the participants. However, as Neuman (2011) has pointed out, several procedures were followed to ensure privacy, anonymity, and confidentiality during and after the study was completed. All the participants were sent a recruitment email, requested to sign an informed consent form, and were given opportunities to ask any questions related to the project (Creswell & Poth, 2018). It was stressed that participation was completely voluntary. All participants were given the option to choose a pseudonym in the study to protect their identities and locations, and any information that was collected that could potentially identify the participants was left out of the final research report. All audio, video (Zoom), or phone voice recordings were done on my laptop and were saved on a UNL-licensed version of OneDrive, to which only my faculty advisor and I have access. All traces of recordings shared with me on a daily basis were erased from my devices to minimize the risk of exposure to the information collected from my participants. All other data will be archived for three years in a UNL-licensed OneDrive folder after the dissertation paper is produced and defended in May 2023 to comply with UNL IRB requirements related to research records retention, after which the data will be permanently destroyed.

For this particular study, to ensure that I am conducting an ethical study, I went over limits of confidentiality, used pseudonyms, and obtained consent for recording the Zoom interviews with my participants before commencing the interviews. At the end of the study, Amazon gift cards worth \$50 were offered to the participants as a token of appreciation and to express gratitude for their willingness to participate in the study. As a reciprocity component, I have highlighted their voices in my dissertation study since all participants helped me in the co-construction of their narratives. I have invited them to become coauthors in my future journal publications or conference presentations after my dissertation is defended and published.

Trustworthiness, Academic Rigor, and Transferability

After data analysis, qualitative researchers should ensure to follow up their research work with strategies to support their data and to make their study rigorous, trustworthy, and transferable (Lincoln & Guba, 1985). Truth value, applicability, consistency, and neutrality also were described as critical to the evaluation of the worth of qualitative research (Krefting, 1991). Creswell and Poth (2018) have tabulated eleven different validation perspectives and corresponding terms used in qualitative research. They also present nine generally accepted validation strategies through the lenses of the participant, researcher, and reader (Creswell & Poth, 2018). I will primarily use Bhattacharya's (2017) acceptable words/phrases (given in italics below) in the following validation strategies to ensure the trustworthiness, academic rigor, and transferability of my study:

1. Multiple interviews with each participant, with “repeated listenings to taped interviews and readings of transcripts,” and a focused analysis of the critical

“episodes” were done. This is to verify “internal consistency” (Loh, 2013, p. 9). Hence, *triangulation* of data was done in my study by including multiple sources and adding multiple perspectives. This improved the study’s *subjectivities*.

2. Peer validation/review was done by requesting my faculty mentors (who share the common field of research with me) to review my writing and research.
3. *Academic rigor* was checked by verifying whether the findings are consistent with the data collected.
4. I have generated *rich, thick contextual details* of my participants’ lived experiences (participants were selected using purposeful and criterion sampling) and the setting (research site) to allow the reader to make decisions about *transferability and subjectivities*.
5. I have disclosed my own biases, values, and prior experience of teaching science in three different countries (*reflexivity*) so that the reader can understand the assumptions that may impact my inquiry.
6. After arriving at the research findings, *member checking* or seeking my participant’s feedback was done several times.

Researcher Positioning and Reflexivity

I identify myself as a non-Indigenous, immigrant-origin educator of Color (South Asian) who has worked with Indigenous students in pre-service teacher education programs in the American Midwest. While I am familiar with barriers faced by Indigenous students as documented in the literature review, I am also aware of the commendable work being done by Indigenous schools, teacher education programs, and

the growing number of Indigenous teachers who are graduating from teacher education programs including ITEPs.

My experience as a former high school and middle school science teacher of Color in three different countries in several public/international schools serving diverse student populations has allowed me to build a strong network with my potential participants, who are also science teachers. I have a Graduate Certificate in Social Justice and Diversity Education from UNL and have taken several courses that specifically focus on race, gender, and ethnicity, including Indigenous education in the United States. I have been an instructor of record for Multicultural Education (TEAC 330) several times since 2019 at UNL, where I have taught about the historical and contemporary schooling experiences of marginalized and underrepresented groups, including Native Americans. I also built strong relationships and networks with Indigenous people during and after the Teachers of Color Summit that I facilitated in at the University of Nebraska-Lincoln. It was during this summit that I got to meet one of my participants.

To immerse myself and learn extensively about Native American tribal communities in the Great Plains, I have been participating for over 1-1/2 years in various conferences and summits that centered the achievements of tribal reservation schools and the Office of Indian education, such as the Native American Heritage month celebrations organized by the Office of Indian Education, Indigenous Day celebrations and virtual education summit organized by the Winnebago Tribe education department, and the Reckoning and Reconciliation Center for Great Plains Studies Conference at the University of Nebraska-Lincoln. During this time, I have had interactions with many Native American teachers, scholars, leaders, innovators, and students, which have helped

me understand about the detailed history of tribal communities; their culture, spirituality, and language; present-day conditions of Indigenous education; their efforts at language preservation and revitalization; and all the other great things happening at the respective schools and communities. All of this motivated me further to explore the lived experiences of Indigenous science teachers and work with them for my dissertation. While I worked in this context with my participants and the school site, I was very respectful of Indigenous culture, traditions, and customs during the entire study and beyond.

Moreover, as I identify as a science teacher of Color from India, which is considered the nation-state in the Global South (Upadhyay et al., 2021), my countrypeople and I have experienced British colonialism and the pervasive effects of westernization of education systems that discredit Indigenous knowledge. Hence, I consider myself an “insider” or an “ally” to the Native American people, thereby I want to explore, learn, and understand the oppression, deculturalization, exploitation, dehumanization, discrimination, and isolation they have faced in their lives, and how these racialized and gendered lived experiences have shaped their use of culturally and linguistically relevant pedagogies to teach science to Native American students.

Despite what I have mentioned above, I am also an “outsider” to the Native American community that I worked with because I am not from this community even though my background is one that has been subjected to colonizing experiences. According to Smith-Gilman (2018), Indigenous people possess values of listening, and the “pedagogy of listening focuses on careful listening...to provide insight into how young children think and how they make connections that are meaningful to them” (p.

346). Smith-Gilman (2018) further states that culturally sensitive approaches needed to go beyond Western research practices; relationships, conversation, and listening have to take on significant roles. Tuhiwai Smith (1999) underscores how effective communication gathers the skills of talking and listening in order for a researcher to receive privileged knowledge and develop significant relationships. Even though I am an “outsider” in this way, I worked towards developing the value of listening in solidarity, a value that is considered important by the Indigenous people and developed strong relationships with them.

I also would like to acknowledge my own privilege coming from a middle-class home in India, and a person who has had multiple privileges in being able to attend schools that have allowed me to take my education to the highest levels (a terminal doctoral degree). I am also aware that I have enjoyed many privileges in India and the Democratic Republic of Congo as a respected teacher and one who had access to power and education, so I have been very mindful of these privileges when I listened to the stories of my participants and co-constructed narratives with them. This allowed me to reconcile my privileges during this study.

Researcher-Participant Relationship

Clandinin and Connelly (2000) have stated, “relationship is key to what it is that narrative inquirers do” (p. 189). The authors talk about the negotiation of entry and exit and the ongoing negotiations of the narratives between the researcher and the participant, the union of their narratives or experiences shaping the inquiry. Zinga and Styres (2019) state that Indigeneity and working within Indigenous contexts is first and foremost about reciprocity and relationships, and these relationships involve an acknowledgment and

understanding of cultural positionalities and relations of place. So, it was important that I locate myself in terms of recognizing both the traditional lands on which I stand and do this work and also be mindful of the backgrounds informing my individual perspectives. The chosen narrative inquiry design allowed me to be a part of the study. I played the role of a researcher, who collaborated in every stage with my participants since relationships play a key role in collaborative research such as narrative inquiry. I established an ethical and positive relationship with the participants that enabled me to have effective and fruitful conversations about their experiences. The interviews and classroom observations were held at school premises and via Zoom. Follow-up conversations (member-checking) occurred over the phone and by email. I have tried my best to honor and respect my participants' life stories by highlighting their voices as Indigenous science teachers which could help them heal from traumatic experiences via sharing in solidarity and also help in restoring the Indigenous ways of learning in science classrooms.

CHAPTER 5

EWITHE WOⁿGITHE: AMY'S STORY

Amy¹² is a Santee¹³ woman married into the Umoⁿhoⁿ tribe¹⁴ of the Great Plains and a descendant of the Chief of the Little Crow Dynasty by bloodline. Native American tribes were named based on where they lived, and Amy's lineage is from the Mdewakanton Dakota or the Mystic Lake Dwellers. Amy was born in Omaha, Nebraska, and has lived most of her life in the reservations, except for a brief period when she was studying in an off-reservation boarding high school operated by the Bureau of Indian Affairs (BIE), serving Native American high school students (Grades 9-12), where many tribes from the Great Plains¹⁵ enroll to complete their schooling.

Amy has worked as an elementary and middle school science teacher, a substitute teacher, and a teacher's aide during her 11 years of teaching at K-12 Indigenous reservation schools. Amy is currently working at the Earth People Public School¹⁶. The following paragraphs will chronologically re-story Amy's lived experiences¹⁷.

“Remembering the words of my father”: How Amy became a teacher

Amy's childhood and the development of her Native American identity were

¹² Pseudonym of participant's choice.

¹³ Isanti or Santee Sioux people speak the Dakota dialect of the Great Sioux Nation. The word “Isanti” means “to live under the knife.” The knife that is referred to here is the bayonet attached to the end of the guns of U.S. soldiers during the U.S.-Dakota War of 1862. The word “Isanti” was attributed to Amy's grandmother's generation because they were prisoners of war (Amy, interview transcript, October 25, 2022).

¹⁴ The Umoⁿhoⁿ people are a Midwestern Native American tribe who reside on the Omaha Reservation in northeastern Nebraska and western Iowa, United States.

¹⁵ Great Plains Region of the United States includes the states of Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming.

¹⁶ Pseudonym that was chosen by my participants.

¹⁷ Since there is an exhaustive number of stories that each of my participants shared with me, I have only described the salient elements from the interviews, field notes, and artifacts (added on an as-needed basis), while retelling my participants' stories. Chronologically arranged narratives will begin with my participants' backgrounds, stories about their childhoods that influenced them to become teachers, and culminate in stories about their pedagogical decisions and culturally and linguistically responsive practices for teaching science and meeting the needs of Indigenous students.

heavily influenced by her grandmother, mother, and father. According to traditional practices, the family members used to forage, look for food in the reserve, plant gardens, and make home remedies using plants. They used to go on hunting and fishing trips, and since Amy's grandfather was a farmer, her grandmother used to harvest corn from their farm. They had a deep connection to land, and a lot of that involved looking up to nature with respect, knowing how to identify plants while drawing from traditional tribal knowledge, learning things needed for survival, and understanding what was good to eat, and how to preserve those things. As a result, Amy used to spend a lot of time outside playing, swimming in the river, observing nature, and being part of it. Amy explained to me that for about 100 years (from the 1880s to the 1980s), Native people have been suppressed and their religious expression was banned. Amy's mother's generation fought for religious freedom, then got it back after the Longest Walk to the Wounded Knee during the 1980s. Then, Congress passed a law freeing Native people to practice their religion. Amy said that her mother's generation participated in tribal ceremonies in the sweat lodges, singing, telling stories, and praying with all their relatives. They believe that they are a part of nature, that animals and plants have stories to tell them, and that these living beings are helping them in their lives. Amy also shared that when there is enough snowfall that it covers or sticks to the ground, that's when the Indigenous people start storytelling with their children, and she experienced this firsthand during her childhood. Amy also added that each season has a cultural event, as in the spring season, they start planting, gardening, and foraging.

We learn[ed] from nature, the animals and the plants, the wind, the rain, Mother Earth, and Father Sky; they are all ours. They are there to help us, protect us, and

interact with [us]. And we've forgotten that when we were colonized. We've forgotten our stories.

(Interview transcript, November 16, 2022).

Amy's childhood experiences were not always happy memories. They are also replete with horrific and poignant stories that her father shared with her about her family going through the dehumanizing boarding school era, forced subjugation, the genocide that took place, food sovereignty that was taken away from them, the Treaty of Rights that the U.S. government made with them, the American Indian Movement that the family members participated in, mass hanging of 38 Santee men during the Santee Sioux uprising (one of them was Amy's great-grandfather), and the Wounded Knee Massacre in 1890. Hence, given her family history, Amy is very committed to helping the younger generation of her tribe heal from this historical trauma because the younger generation inherited the mentality of racial oppression, which is problematic for all Native people

Teaching is generational in Amy's family. Her father was raised by his grandmother who was a teacher that went to Hampton Institute in the 1800s. She had always stressed to Amy's father the importance of learning about the white man's world. She explained to him that he had to learn how to read, write, and do their education to survive in their world and to be successful. She also told Amy's father to get educated for the good of their people because she was born as a prisoner of war, and she has struggled a lot due to the inhumane treatment by the U.S. government.

The main reason that Amy became a teacher is because of her father. During the time she was at the intertribal boarding high school, she met her husband, an Umoⁿhoⁿ gentleman. Then, she dropped out of school and got married. She was 16 years old when

she had her first child. Throughout her childhood and adolescence, her father told her all about the history of their people. He had a master's degree in media communication, so he was well read to be able to document stories about his life, his parents' lives, his grandmother's life, and the hardships they had to endure. Amy's father urged Amy to get an education in order to balance all of these hardships and have success and peace in their lives. Just like his grandmother, Amy's father also urged her to learn the white man's world. The following quote strongly highlights Amy's motivation for becoming a teacher:

¹⁸He [Amy's father] told me that "I'm going to be ashamed of you, my girl, if you don't make anything of your life. I know that you have the strength and the spirit of your ancestors walking with you." So I did...I kept remembering those words of my father. It's hard for me, I was there when my father passed. So those memories are with me...watching him lay in bed in the hospital and die...I kept promising him over and over that, I was gonna continue his work, what he wanted for me and for his people.

(Interview transcript, October 25, 2022).

Unfortunately, Amy's father did not live long enough to see her become a teacher. After her father passed away, she went back to study and completed her General Educational Development (GED) test. She then went to community college and got her two-year associate degree. During the same time frame, she raised her family too and gave birth to eight sons and four daughters. After she got her associate degree at a community college, her mother wanted her to go into nursing, as her mother was a

¹⁸ All words in italics except for those enclosed in brackets are my participants'. Bracketed words were changed or added for clarity. I have used this stylistic convention throughout the dissertation.

Certified Nursing Assistant (CNA). Amy did one year of nursing school, but it wasn't meant for her, as she was soft by nature and cried too easily on seeing people in pain. It was very difficult for her. Moreover, she was already traumatized by watching her father die, so she dropped out of nursing school. However, she kept remembering the big promise she made to her father and wanted to follow through with it. Since she was already married to an Umo^{ho} gentleman and was living on the reservation at that time, she started working at EPPS as a janitor. In 1998, one of the teachers at her school started her master's degree, and she was completing her thesis on behavior disorders of four Native children. These children were orphans, who lost their mothers to alcoholism. This teacher asked Amy if she could become a teacher's aide in her classroom; she and Amy had become friends because she knew Amy's children, and Amy readily accepted. The school wanted to address the needs of children with behavioral disorders, so these orphaned children with behavioral disorders were struggling at school because they were so traumatized. They were put in a special isolation place called the behavior disorder room, and they needed to be separated from the other children because their needs were different. That was when Amy became a teacher's aide and worked for a year (1997-1998) with the teacher and these kids, watching how they behaved. Amy specifically told me about the setup of the school. It was rundown and old, and the restrooms, no matter how much Amy cleaned them, smelled like urine. Sometimes, teachers would scream and yell at kids; kids would run all over; and there used to be little learning going on. That got her thinking as to why that was happening and what was going on. She was already thinking of ways in which she could become a good teacher to help the students learn something because she had already gotten her two-year degree in college. Moreover,

compelled by the promise she made to her father and the gruesome past that her community endured, she decided that their children deserved better. She believed that since her nation made treaties with the United States government, the school should not be in this condition. So, she stopped working at EPPS and joined the first cohort of 10 students of the Indigenous Roots Program at a large midwestern university in 1999. Only three students graduated out of the first cohort in 2001, and Amy graduated with a bachelor's degree in science education, with an ESL endorsement. Immediately after her graduation, she worked in another reservation school for one year (2001-2002). Then, Amy went back to her hometown and her family to work again at EPPS and has been working at the same school since then.

Connecting stories and legends with teaching: Amy's Teaching Philosophies and Teacher Knowledge Grounded in her Lived Experiences

One of Amy's mentors at the university was a fine teacher who taught her about storytelling as a pedagogical tool and how to use it in the classroom. Amy, during that time, was a soft-spoken, quiet housewife who was happy taking care of her children because, in her culture, people were taught to be polite and not talk in public. Families used to go to the person in charge of social gatherings and tell them their grievances, so only the person in charge was allowed to talk on behalf of the family/clan. So, Amy never spoke in public or in a classroom. As such, it was a difficult transition for her to be able to use the age-old Indigenous way of storytelling with her students. However, she followed through with this pedagogical decision due to her own childhood lived experiences of storytelling and living in nature. She then began using those stories in her lessons, as she believed that there is a great connection between these stories of nature

and science.

Our creation stories and our legends...for me, they do have a point of truth. And it's so mystical. But it happens all the time. Fantastical, mystical things happen in our world that we don't understand but they do, and we learn from them. And we make a connection and we respect them. And one of ours is the trees. We call them our elder brothers. And we teach the kids about having respect for those trees and learning from them. But one of them is our Grandpa Cottonwood Tree.

(Interview transcript, October 25, 2022).

Amy's quote directly ties in with one of the tenets of TribalCrit (Brayboy, 2005) which states that "tribal philosophies, beliefs, customs, traditions, and visions for the future are central to understanding the lived realities of Indigenous peoples, but they also illustrate the differences and adaptability among individuals and groups" (p. 429-430).

Amy had always been interested in gardening, as her mother taught her to plant gardens. As a young mother in the 1990s, she started planting gardens and growing vegetables. She also started realizing that a lot of the health issues (e.g., diabetes, obesity, mental illness, alcoholism, drug addiction, etc.) that her tribe suffered could be attributed, at least in part, to not having access to their own Indigenous food. So, she made it her lifelong goal to help her people gain food sovereignty and become self-reliant and sustainable with Indigenous food cultivation and harvesting.

Her culturally and linguistically responsive pedagogical practices were also shaped by her in-laws' family with many elders who could speak the Umo^ohoⁿ language fluently, and Amy learned the cultural and linguistic aspects from these elders. Amy learned that science is studying our world, so it came naturally to her to just be able to go

out and teach kids about nature because that was what she learned from her parents and grandparents, to reflect on her life and make connections and become educated. As a science teacher, Amy pondered why and how things happen, and what are the results. Hence, it was natural for her to encourage her students to interact with nature, and collect data using the trial-and-error method to discover things. Amy's confidence in teaching nature-based education to students grew, as she believed that this was the best way to teach science to the student population she served. The majority of the children at Earth People Public School are Umoⁿhoⁿ, but they are of mixed race/ethnicity/tribes, such as Santee, Winnebago, Hispanic, and Black, as people have intermarried quite a bit among tribes or outside the tribes.

“Just let them be children”: Amy’s Account of the Unique Needs and Challenges of Indigenous Students

Amy shared with me that her students face a lot of challenges in their lives and attending school is the least of their worries, but it is gradually changing now compared to Amy's mother's generation where they had to struggle and work to meet their daily needs such as putting food on the table. Amy recounted that some of her students are traumatized because they live in foster homes; are raised by grandparents, aunts, and uncles because their parents are divorced; live in poverty; see a lot of violence and abuse in their lives; are on individualized educational plans (IEPs); and suffer from mental health disorders and disabilities, such as autism, attention-deficit hyperactivity disorder (ADHD), and depression. They struggle emotionally, psychologically, and academically, so aggressive behaviors and truancy in her school are very common.

We see the struggles of our students with a traditional education system where

we've noticed something, where the ones that really struggle in class, the ones that have trouble sitting still, the ones that are always getting in trouble...they're having to pull them out. Because their natural way of what their body wants to do is to move around and explore. And they don't have that opportunity in a regular classroom where they're expected to sit in their chair and do their work on paper.

(Interview transcript, October 25, 2022).

Also, the people in Amy's community are having to consume processed food that is high in sugars and carbohydrates, which can cause serious medical conditions, such as diabetes and obesity. This dependence on state-provided commodities was forced upon the Native people because their ability to grow their own food and hunt Indian buffalos was taken away from them and they were purposefully made dependent on the white man's food as another way to subjugate them. Renee Sansom Flood, an award-winning author, historian, educator, and speaker writes in her historical nonfiction book, *Lost Bird of Wounded Knee*¹⁹ about the systematic government-sponsored slaughter of the American Bison to ensure the subjugation of Natives by the U.S. government. The article "Kill Every Buffalo You Can! Every Buffalo Dead Is an Indian Gone"²⁰ also details how this slaughter was accomplished. Phippen (2016) states that many things contributed to the buffalo's demise. One factor was that for a long time, the country's highest generals, politicians, and even then President Ulysses S. Grant saw the destruction of buffalo as a solution to the country's "Indian Problem." The U.S. government wanted the Native

¹⁹ *The Lost Bird of Wounded Knee* (Flood, 2014) is a chilling and powerful account of a young girl, Zintka Nuni, "Lost Bird," who was taken from her native land in South Dakota after the 1890 massacre of Lakota men, women, and children. This book describes the story of Lost Bird and the destruction of life for a Native American orphan being raised as a white child outside of her tribe.

²⁰ "Kill Every Buffalo You Can! Every Buffalo Dead Is an Indian Gone" (Phippen, 2016) is an article from the national archives of *The Atlantic*, that specifically talks about the intentional killings of the American bison, which is the new U.S. national mammal, but unfortunately its slaughter was once seen as a way to starve Native Americans into submission.

people to become docile, take up farming on the reservations, and stay put. However, nearly all the tribes of the plains lived alongside buffalo herds and took from them their skins for tents and their meat for food, so they could not be subjugated, and hence the Indians were re-positioned as “savages” and a huge “problem” for the government. During this time, American settlers and hide-hunters killed the animal to near extinction to cut off the supply of meat to the Indians, and tourists shot the animals from the windows of trains as if the slaughter could last forever. Buffalo had once numbered more than 30 million, and by the end of the 19th century, there were only a few hundred in the wild (Phippen, 2016).

Amy sadly agreed with this story and teaches her students about this gruesome past in her science classroom to explain to her students the importance of gaining food sovereignty for their tribal community. Amy said:

I asked my students when we [were] teaching about seeds, how many here in the classroom have eaten buffalo, [students said] maybe one or two. And that's very sad because that was our main source of protein. That was our food... We are known as the Buffalo People, the People of the Great Plains, we take pride in that. But we have no connection to them anymore. So looking at that, I'm always looking at ways of trying to bring Indigenous food back into our students' science, how can we do that? One of the stories that I use is about the buffalo. I have a lesson that I teach about buffalo and it's called the “Bison Returns.” [based on the video called The Return of the American Bison]. It's a 13-minute video and it talks about the destruction of the buffalo and how their destruction came about. [It] was the largest mass destruction of a species in the history of the

world...you're talking about 60 million buffalos, intentional destruction. It was all geared [toward] taking away the Native American food that was done to conquer us. A lot of problems that we're dealing with today [are] because of that, and then the historical trauma.

(Interview transcript, November 16, 2022).

Analyzing Amy's quote using Brayboy's (2005) TribalCrit theory, it can be inferred that Amy's racialized experiences and the historical trauma that she talks about corroborate TribalCrit's focus on the pervasiveness of both racism and colonization in society. As Amy mentions in the above-mentioned quote, the "intentional destruction" of buffalos took away the traditional food source from Indigenous people and forced them to rely on the U.S. government for food and other commodities, thereby forcing them to assimilate into the "mainstream American culture." This validates the important tenets of the TribalCrit (Brayboy, 2005) that state "U.S. policies toward Indigenous peoples are rooted in imperialism, White supremacy, and a desire for material gain" and "governmental policies and educational policies toward Indigenous peoples are intimately linked around the problematic goal of assimilation" (p. 429-430).

Amy further added that some other negative effects of consuming processed food are that some children in her school are having to be treated for diabetes, and a good number of kids are either overweight or suffering from obesity. A few of them even have trouble walking, so they stay at home and never go out and play. Amy sadly told me that at one point during the 2000s, they were having at least 3-4 funerals each week, and they lost almost 90 people in their community within a six-month period due to health-related complications.

Even in her own family, Amy's husband is diabetic and one of her daughters also started showing signs of becoming diabetic (her daughter changed her ways of eating and is continuing to be careful of what she eats), so she is very mindful of what her family consumes. She told me that she totally cut out bread and rarely consumes refined sugars in her diet. She learned from her husband's dietician that Native American people don't have the enzymes in their stomachs to digest carbohydrate-rich foods like high-fructose corn syrup, milk, refined white flour, etc. So, if they have to eat food made out of flour, it has to be made out of brown rice/flour. She even limits salt intake for all her family members.

Amy shared with me that most of the physical, psychological, and social-emotional challenges that the children of this generation face in their daily lives are direct results of the historical trauma that the Native tribes have endured for decades, which has translated into intergenerational trauma.

A lot of problems that we're dealing with today [are] because of historical trauma, we have a high rate of suicides and suicide attempts in our community...It was eight or more kids...couple of them did commit suicide and the other ones all attempted. So, it affected every household on the reservation and the kids came and they were so sad. [One day], Leigh got off [her desk] and we played games with them, and we made them happy. We did a little scene...just being kids, playing with them. That's part of our intent... is taking them out and playing with them and just thinking of silly games. And that's part of why Leigh got the tube, we got in playing, just letting them roll in the tube, rolling others back and forth. Just let them be children and put those things aside.

(Interview transcript, November 16, 2022).

Thus, to meet these unique needs of her students, she began her quest for nature-based education. She had the opportunity to work on this with Leigh, who gave her the idea of teaching science using the cultural lens. Amy explained the connection between nature-based education and the Indigenous sense of spirituality as follows:

Trying to teach children [about] nature, automatically comes spirituality, especially the way that we teach it, that spirituality is a central part of teaching through the cultural lens.

(Interview transcript, December 8, 2022).

The nature-based education that Amy and Leigh employ for teaching science through the cultural lens is very similar to the study conducted by Hogue (2016) at Blackfeet Nation Reservation in Montana, where middle school students participated in an experiential 5-day science, math, and technology summer camp and “learned from the land.” Hogue (2016) stated that Indigenous people have “a historically oral culture; this cultural lens includes learning through narrative, story, music, ceremony, mentorship, traditional practice, and learning from the land” (p. 168).

“Like-minded people”: Amy and Leigh Cocreators in “Bridging the Gap”

In 2018, Amy gained a great partner and co-teacher in Leigh²¹, with whom she has been co-teaching elementary and middle school science in the “outdoor classroom” for four years. Amy calls Leigh Wagónze²², as Leigh is the senior partner. They have created a new nature-, arts-, project-based science curriculum called *Áshita thewathe*²³ at EPPS. Amy’s quote given below shows how they balance their duties and responsibilities

²¹ Pseudonym of my participant’s choice.

²² Wagónze means “teacher” in the Umoⁿhoⁿ language.

²³ Áshita thewathe means “let’s go outside” in the Umoⁿhoⁿ language.

to integrate science, language, and culture in their classroom:

Leigh and I really are like-minded people, and we know how to hand things off to each other. I do the cultural things and the language, and she brings the science, and then we teach about the stories together. When I got the opportunity to work with Leigh, I [felt] so at peace with the way that we conduct our teaching with the kids. It [is] all connected to nature, all of it. So, to be able to share that and then make those connections to science, helps them to appreciate the realm of science. This is my people over here, this is what we do, and our ceremonies, our traditions, and our stories over here. It kind of gives it a technical breakdown...So, doing little things like that, helping them look at the world, to see how it changes and stuff. It's bridging that gap. It bridges that gap of understanding, that it's just another way of explaining nature, so it's been able to do that and help our kids understand.

(Interview transcript and field notes, October 28, 2022, and December 8, 2022).

Due to shared commitments to meet the needs of Indigenous students, Amy and Leigh cocreated *Áshita thewathe*, which provides experiential hands-on, culturally and linguistically responsive education to Native students, while improving their academic outcomes. Leigh and Amy shared several documented benefits of nature-based education, such as healing from adverse childhood experiences; enhanced health; improved physical activity that reduces the risk of obesity; social-emotional well-being that reduces stress, anger, and aggression; healthy eyes and increased vitamin D levels due to observing and working outdoors; increased self-esteem; improved grades; pro-environment behaviors; and stronger emotional connections to people and nature (*Benefits of Nature Archives*,

Children and Nature Network, 2019). Amy once shared:

When you [give the kids] the opportunity to get outside and experience that hands-on and feel that living spirit of this earth, that hands-on experiential experience makes it a memory, make it a moment where they can have that. Leigh always says that [as] the moment of awe and wonder of nature. And it's always gonna stay with them. We have days [when] children are so happy, we have helped them to enrich their world, their knowledge of science, the world around them, and then do it through the culture and the language. I see that as fire is ignited in their hearts. They need to have a sense of peace, they need to feel empowered with who they are; they need to have some self-determination.

(Interview transcripts, November 8, 2022, and December 8, 2022).

Áshita Théwathe (let's go outside), the outdoor science classroom for grades K-8, consists of four main components and is housed in four distinct physical locations at EPPS: Greenhouse, Medicine Garden, Little House of Learning (arts-based learning), and seven-acre planting gardens. The Áshita Théwathe provides a K-12 culturally relevant experience of learning, exploring, and understanding nature through traditional science. Áshita Théwathe is an innovative nature-based education program that takes place in an outdoor setting. The curriculum has been developed to infuse all academic areas and Indigenous wisdom into the lessons. Multiple sites have been developed for students to have a nature-based, culturally relevant, hands-on experience. The cultural foundation of the curriculum is based in part on the Umo^hoⁿ Tribe's "Tade Duba" or "Four Winds" (four seasons). UNPS has created outdoor classroom areas for learning. Food sovereignty and sustainability concepts are implemented through gardening projects. The

students learn about mending the soil and how to care for plants in the medicine garden. During the past two years, the students have had the opportunity to harvest some of the plants and prepare them for use. Elementary students grew cabbage, lettuce, radishes, tomatoes, carrots, onions, and a variety of flowers. The sixth-grade students grew green beans in the greenhouse. They also grew some herbs such as lemon balm, parsley, cilantro, and dill. Middle School students had the opportunity to grow, harvest, and process dill and parsley, where the students weighed and measured each plant's produce. They learned different ways to use herbs. The vegetables harvested were given to the kitchen staff who used them for lunches and salad bars. Students harvested over 1500 pounds of cucumbers, 250 pounds of tomatoes, and 200 pounds of squash during the past year. Students and staff processed and dried over 50 quarts of Indian corn.

High school students built a scarecrow for their garden, and the students who worked in the garden were paid wages from a school grant. Through the generous donation of seeds from many partners and philanthropists, the students planted a wide variety of plants during the past two years, and the harvest was blessedly bountiful. They planted cucumbers, tomatoes, bell peppers, watermelons, cabbage, onions, beans, squash, sweet potatoes, potatoes, hot peppers, jalapenos, pumpkins, kale, Swiss chard, and eggplant. Amy told me that students loved being there. During the winter months, the students would collect snow to melt and use for watering the plants in the greenhouse.

All of the vegetables grown in the garden were labeled with the Umo^oho^o words to help reiterate language and culture to their students. They also planted a traditional “the three sisters²⁴” garden with the help of representatives from partner organizations. While planting the lands, the Umo^oho^o Elders offer traditional prayers and blessings to

²⁴ Amy educated me that according to their culture, “the three sisters” are corn, beans, and squash.

the whole community. The Elders also take an active part in classrooms, helping teachers implement language and culture in an appropriate manner. Traditionally, the Umoⁿhoⁿ people perform a corn ceremony and rituals before and during harvest. They believe that spotted eagles flying over their congregation is auspicious while the prayer is being rendered. According to their Native culture, this is a sign from Wakoⁿda, the Creator, that He has heard their prayers and given them His blessing.

The EPPS students and staff helped prepare meals for over 100 people at the Umoⁿhoⁿ Tribe's annual powwow²⁵ ceremonies. They used vegetables grown in their garden, and the students were able to be a part of the tradition of sharing what is grown locally and preparing a feast.

For the high schoolers, the outdoor classroom is called “*Onba Udo*,” which means “Good day.” EPPS has partnered with *Jobs for America's Graduates*²⁶ (JAG) Nebraska. JAG 9-12 program represents a culturally relevant solution that has a long-term vision and purpose. EPPS is dedicated to regaining the Indigenous ways of farming and nurturing, self-sustaining ways of being. In the spirit of collaboration at EPPS, the K-8 and 9-12 outdoor science programs have become very strong initiatives to serve the students of EPPS and the community by promoting food sovereignty, food security, child and community nutritional health, traditional farming and gardening practices, culture and language preservation, career exploration, leadership development, project-based learning, and JAG Nebraska Core Competencies. Below are some photos (artifacts) of Áshita thewathe and Onba Udo that Amy and Leigh shared with me:

25 Traditionally, the annual powwow is a harvest celebration for the Umoⁿhoⁿ people.

26 JAG Nebraska helps students overcome challenges to achieve personal and career success after high school and empowers the state's young people with the skills and support to succeed in education, employment, and life. (*Jobs for America's Graduates Nebraska*, 2022).



Image 5.1. Greenhouse



Image 5.2. Medicine Garden



Image 5.3. Planting Gardens



Image 5.4. Little House of Learning

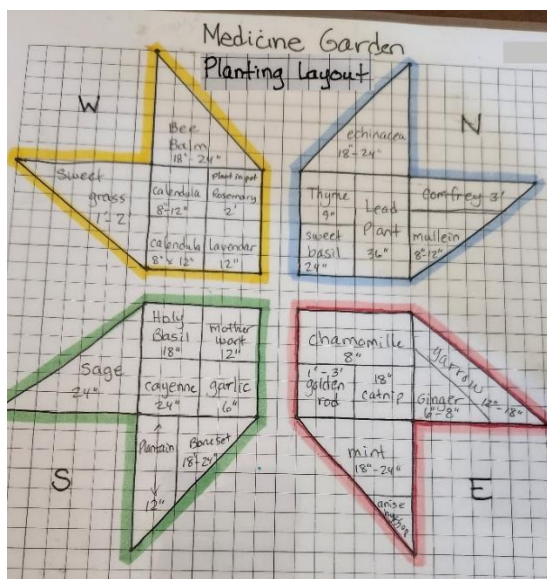


Image 5.5. Medicine Garden Layout

Amy and Leigh take students on nature walks during the class time where they interact with nature, listen to traditional Indigenous stories about animals and plants,

work in either the greenhouse or the gardens, and engage in projects such as the habitat loss project and calculating the tree age project.

We taught the kids about the six leading causes of habitat loss and then they did a slide project on it. They also did the tree-age project. They called it the “story of my oak tree.” So, they had to find out the age. After they found out the age, they had to find out what was going on [at] that time in history...What was going on with the tribe? What's going on in the state? What was going on [in] the United States? And then what was a historical event in the world for that year?

(Amy, interview transcript, October 28, 2022).

Another project Amy and Leigh will do in the winter months is the habitat loss project, as the school campus grounds are littered with lots of acorns because there are very few squirrels to eat/store for winter due to habitat loss. Amy explained that since there are so many acorns scattered all over the place, they are planning to create an art project in science, where they can make musical instruments like maracas (something that jingles) for their dancers in the powwow celebrations. Amy said:

We harvested the acorns, we took the kids on a trail walk over to the powwow grounds, teaching them about habitat loss, because they disrupted the habitat over at the powwow grounds, taking down a bunch of trees, and they covered the watercourse for the squirrels, so the squirrels all left the area, and all the acorns were laying on the ground. There [are] these great big, amazing oak trees out there, and all the years that we go over there, we rarely see any acorns left. The squirrels take care of all of them, they just put them all away for the year, for the winter. [But now], everywhere we walk, it is crunch, crunch, crunch, crunch

because there [are] so many of them. There [are] so many over there...and teaching them about science, we're going to make something out of this, we're going to create some kind of art project out of this. I was thinking about making [for] our dancers, they have those things...like the bells that jingle. The tribe, they make them out of...pine nuts, and [they] make a real nice rattling sound when they shake together. So, I was thinking about making something like that with the kids. So, we saved them, and we just got to get to them yet, but that'll be something we'll probably [be] working on this winter, making something with those acorns.

(Interview transcript, November 16, 2022).

These projects provided holistic learning opportunities to the students, as they were encouraged to make connections between subjects, participate in civic engagement activities, learn about their culture, and develop critical thinking and awareness about local and global issues. Amy said that their students participate in all activities of the outdoor classroom actively and enthusiastically and derive immense satisfaction and happiness while connecting with nature. Amy said that when she watches students' engagement levels in the outdoor classroom, it is always powerful and amazing for her.

Amy shared this experience as:

I [am] always amazed by it because it happens every time. It's when the students have the opportunity when we're teaching them about the foundations of plant growth, of taking care of the soil. Each time, as soon as they start digging, shoveling, and getting [their] hands in the earth and connect to that, they always say it's so satisfying...just feeling that earth, there's something that just lights

their spark up, invigorates them. And they don't get tired of it, they want to get more of it. And it makes them so happy.

(Interview transcript, November 16, 2022).

I asked Amy how she and Leigh meet the needs of their students in their outdoor science classroom. Amy said that their science teaching is based on their lived experiences and scientific and cultural knowledge. Creating lessons based on nature involves a lot of practice and revising before it gets better, and it is always done on an as-needed basis depending on real-life conditions and the needs of their students.

Meeting the needs...we are thinking about that all the time about meeting the needs and making the program, the curriculum, and the scope and sequence to fit our kids, and lots of times, it's playing with them playing in and making it fun. So, Leigh has all these great games that she thinks of, how to incorporate science. Then I say, "Oh, what about this? and like she [Leigh] said, it becomes intuitive...our life experiences of what we know...they [students] need to understand about the changes of the seasons, the changes of the trees, and the animals and the plants, understanding that this is a living being, [a] living entity that we are on. And it's a lot of practicing, doing one lesson over and over to get better. Like, the weather, that's very important for us to know because we live in a place where the weather can become deadly. Our snow in our freezing temperatures, and then our hot summers, and then the tornadoes that come through. So, Wagoⁿze, she's always wanting them to learn about the weather...there's a lot to it, the different issues. "Now look at those skies, look at those skies" ...she'll tell those kids. One day, I remember she was talking with

those girls, "In about six hours, it's going to rain." [students asked] "Ah, how do you know that?" Leigh said, "That's just how the weather is." And sure enough, in six hours it rains, and it's science!

(Interview transcript, November 8, 2022).

“Ewithe woⁿgithe”: Creating a Safe Classroom Community for Native Students

Amy told me about the special relationship she shares with Leigh and how they teach hands-on science using culturally and linguistically responsive practices, emotionally connect with their students, and create a safe and inclusive classroom community. Amy shared with me that the Umoⁿhoⁿ people’s cultural view of the world or their teachings are that the Creator gave them two roads in this world to walk on, a red road and a black road, and they must learn how to keep their balance in order to stay on that red road. Otherwise, they will fall onto the black road, which leads to the destruction of their lives and happiness and leads to confusion and chaos, and possibly even death. Amy said that this comes from the teachings of Black Elk, who had a vision that had to do with the medicine wheel. Hence, the medicine garden was designed in the shape of an 8-pointed star which represents the morning star. Students are taught the cultural meaning of the morning star. It represents the beginning and the end of life here on earth. Native people believe their spirits travel from the spirit world through the Milky Way before they are born and travel back when they die. The medicine wheel (or the four colors in a circle) represents “Táde Duba” or the “Four Winds” or “Four Directions,” which correlate with the four seasons of the year. The east is represented by red color, the west by yellow color, the south by green color, and the north by blue color. The morning star design of the medicine garden at EPPS was designed by Amy and is aligned with the

four cardinal directions where each of the four winds resides. Amy said that the circle represents the way that they think their society was created. According to Amy, these are the ways through which she tries to find peace and balance in her life and live within that circle. Amy connected her philosophy beautifully to the phrase Ewithe woⁿgithe by reasoning that we are all related to everything in a circle. She also stated that this Native way of thinking conflicts with the western view because the westerners think in a pyramid way, where there is only one person at the top, such as the kings, queens, and leaders, and everybody else is subservient underneath them. Amy also added that in the circle way of life, they can live in balance with everything and everything renews itself, which even has to do with death. They don't fear death because they know they will all be going back to the spirit world. She said that this way of thinking brought a lot of mental peace to her people. She shared that this way of thinking even made their warriors of the past even take death as a good day to die because they were not afraid of dying for their people. After explaining the Native philosophy of life, she said that her life's work is in her teaching and in her career so that she can help in reclaiming Native wisdom and revitalize their culture and language. Amy also said that because this wisdom has worked for their ancestors, they had a way of living in this land in balance with nature, and what that means is that they have to find a way back to that. Amy sadly told me that when they were colonized, their "Sacred Hoop of life" (circle) was broken and they lost their language and their culture. They were forcibly taken away to boarding schools and during the assimilation period, people were sent from the reservations to go to the cities to look for work, eventually losing touch with that circle or the sacred way of life.

Now at EPPS, Amy and Leigh are not trying to find something new like a new

invention or something in the outdoor science classroom while connecting with their students. They are just trying to reclaim the traditional way of life of the Umoⁿhoⁿ people, and they are trying to go back to what worked for their ancestors and their way of living. That is why they lay emphasis on the traditional “medicine wheel.”

Amy shared with me some pictures of the medicine wheel and Umoⁿhoⁿ-language-integrated student worksheets to teach them the culturally sustaining concept of “Four Winds,” which is intricately linked to teaching science.

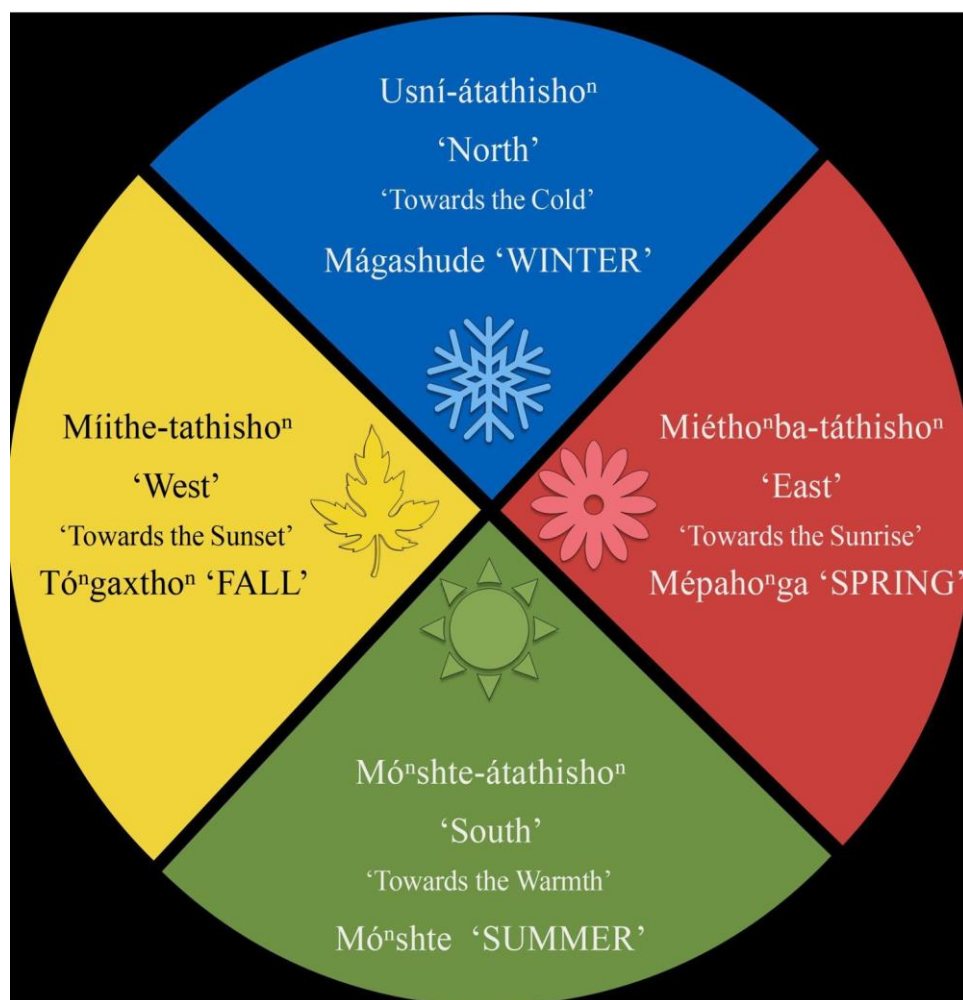


Image 5.6. *Medicine Wheel*

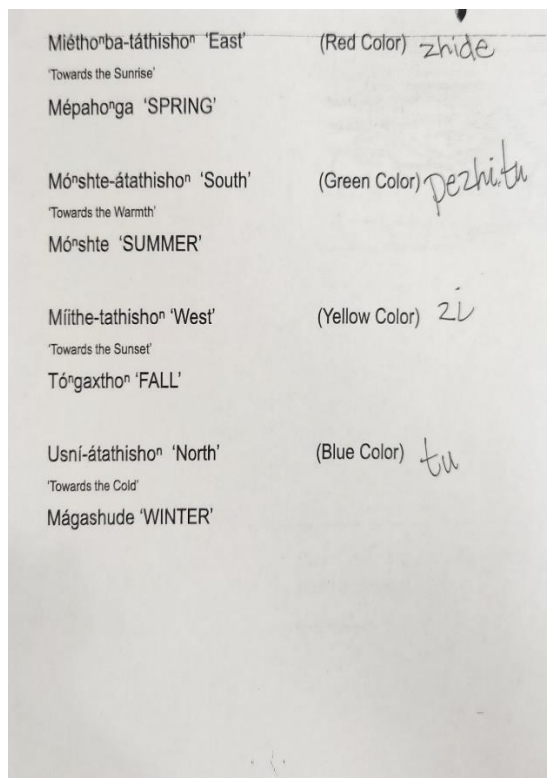
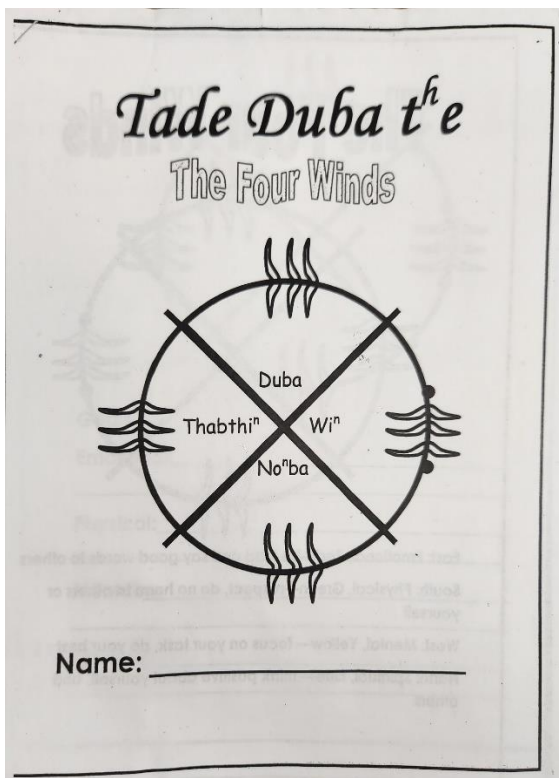


Image 5.7. Four Winds Worksheet - Page 1 **Image 5.8.** Four Winds Worksheet - Page 2

According to Amy, teaching science using the Umoⁿhoⁿ language is essential for her students since it bridges her students' worlds with the science world that has complicated terminologies. Amy explained this as follows:

Well, yesterday, we were talking about "hypothesis" ...None of the students knew what that word was. So, in also trying to teach the Umoⁿhoⁿ language, we have to teach science language to them. So, we talked about that...I explained that as two worlds. I said, all right, now we're in a science world over here, and this is how they talk over here in this world. Now we would come back over here in this world, you know, I did have them envisioning, but traveling back and forth in two different worlds. But we're still in one world, though. So yeah. Um, we're really working hard on doing the weather terms and incorporating everyday sayings because I think when they're learning a language, it's going to help them

transition and learn those science terms, that terminology that they need to learn and build their science skills at the same time. So that's what we were talking about yesterday. We always tried to think of the terms of whatever we're teaching, you know, think of things that we can, this helps to get them just say those [Umoⁿhoⁿ] words and get it in their mind and begin to develop those skills of learning new words in the language. And the kids never resist, just once in a while, we get one in a day that doesn't want to participate. But you know, the majority of them are participating. They're saying the words. We still have to work on [the word] "hypothesis."

(Interview transcript, November 16, 2022).

This quote made me realize the way in which language and thinking are connected (Hermes, 2007), where Mary Hermes points out that one must learn the content through the language in order to truly decolonize the learning. I have focused on the language revitalization efforts happening at the school later on in this chapter and in Chapter 7 where I describe Renee's (one of my other participants) story. Amy's and Renee's efforts are much more than them trying to revitalize the Umoⁿhoⁿ language, they are helping students to navigate two worlds of science and Umoⁿhoⁿ culture and bring them together through Umoⁿhoⁿ language.

All of these practices worked their way naturally to help the students heal from historical and intergenerational trauma.

Leigh and I have worked so hard to try to have hands-on exploring experience. And the school has been really great about building this new classroom for us outside, where they can have that. Leigh's always explaining the natural world to

me with her science terminology, which she's really good at. And then I can relate to it in my experiences and my knowledge of the history of our people that lived on the plains. Me and Leigh, we can teach our kids to learn to overcome those things, I mean, to make a better future for themselves. There's science everywhere, so getting them out there, and then relating it to their culture...because Native people were sustainable people at one time. They had vast knowledge of their world of science, of mathematics, all of these things that helped them to live a good life, and they were thriving at one time. So, we need to look back to that. Being able to observe and get close to nature, and those elements, those beings, they become relative[s]. All Native people believe that we are all related, and they all have a saying for it. In Dakota language, we say "mita kuye oyasin," and in Umo"ho", they say "ewithe wo"githe." "Ewithe wo"githe" means that we are all connected to each other; you are my relative. I am you and you are me.

(Interview transcript, October 25, 2022, and November 8, 2022).

Amy shared the reason why she does the prayer song and sage ceremony in class. This is because she has always worked towards developing a deeper bond with them by becoming their relative and creating a safe, inclusive place for all children.

[students] coming to school...in that jittery stage...in [their] mind, fragile and frazzled, and maybe they stayed up all night or whatever, and then they're expected to come to this beautiful school, which is totally opposite from their home. And then they don't feel like they belong, you know, but we take the time to include everybody. So that's why I started doing the ceremony because then we all

become relatives, and we're all one together. So that's a need they have...they need to know that they are all one.

(Interview transcript, November 8, 2022).

Amy also gave me specific examples of how she and Leigh connect with their students on a personal and emotional level.

This young boy here, Bruce²⁷, the big, tall one, has major behavioral problems...he has to take medication. He has severe ADHD. He sits right by me; he calls me grandma. I made a connection with him. I'm your relative, and I'll help you when I see you're having a hard time...I don't push him. I don't put that authority figure on him and talk about things. He's in foster care...he is taken from his mother, his father, you know, he has a lot of issues going on. But to have a grandma that loves and cares for him is a safe thing. Being a native person, I had permission to do that because that's one of our beliefs. So, I was able to help mend that. So, now he's able. He does have some learning disabilities; he's on IEP, but he always attempts to do his work. Miranda²⁸ is another one, she has autism. [She] and I have allied together...she always wants to participate [in] what we're doing in the outdoor classroom, but the kids would tease her... for a couple of years, she was being continually teased by the other kids. But now, Leigh and I always give our attention when she's asking for it.

(Interview transcript, December 8, 2022).

This quote explains how Amy connects with her students and tries to help them as their grandmother might. The familial-type bonds that Amy has built with her students

²⁷ Pseudonym

²⁸ Pseudonym

help them forget their everyday worries and tensions and in the long run, would help them improve their academic outcomes, prevent student attrition, and ultimately aid them in recovering from intergenerational trauma. This aligns with Guillory and Williams's (2014) study on incorporating the culture of AI/AN students into the classroom, where they mention Heavy Runner and DeCelles's (2002) Family Education Model (FEM) that is based on principles of education and social work. The FEM model offers strategies on how to deal with AI/AN student attrition through the purposeful inclusion of core cultural factors, such as family and a sense of belonging that promote academic success for AI/AN students. Hence, the unconditional, grandmotherly care and support that Amy provides her students follow the FEM model that has been shown to improve the academic outcomes of her students.

Description of a Typical Day in Amy's and Leigh's Classroom

Amy teaches science to children in grades K-8. I observed two whole days of classes on October 28, 2022, and November 8, 2022, and compiled field notes based on my observations. According to the grade levels (K-8), the science class duration ranged from 30 minutes to 50 minutes. Since it was the fall season when I visited the classroom, the entrance of the classroom was beautifully decorated with fall leaves and butterflies made out of paper. The classroom was a square-shaped room with circular tables and chairs arranged on the perimeter of the classroom leaving a wide space in the center of the classroom. Amy's desk was right in front of the entrance of the classroom and Amy's co-teacher Leigh's desk was at the other end of the classroom, so there was ample space for students to interact with both teachers. Around the classroom, there were neatly arranged cupboards, cabinets, incubators, weighing balances, writing and coloring

instruments for students, pencil-sharpening tools, student-created Indigenous artwork such as the paper and stick teepee tents²⁹, several potted plants on the windowsills and counters, seed storage jars, and trash bins at convenient locations for students. There were several illustrated posters stuck on the walls that are typically found in a science classroom, such as “how seeds grow,” “different types of leaves,” “life cycle of a plant,” “food chain,” “invertebrates,” “vertebrates,” “reptiles,” and “birds.” These posters were printed in English. There were also posters that remind students of the classroom rules and weather- and season-related stories that were written both in the Umoⁿhoⁿ and English languages. Some photos that I took in Amy’s classroom are given below:



Image 5.9. *Amy and Leigh’s Classroom*



Image 5.10. *Umoⁿhoⁿ Story for Seasons*

²⁹ Teepees are conical tents usually made of animal skins, where Native American tribes of the Great Plains lived before White people subjugated them. They used to live there when they traveled or when they were on a buffalo hunt (Renee, interview transcript, November 8, 2022). Although Native American people don’t live in teepees anymore, it has become a sad stereotype that some people still have about Native American people.



Image 5.11. Science Posters and Supplies

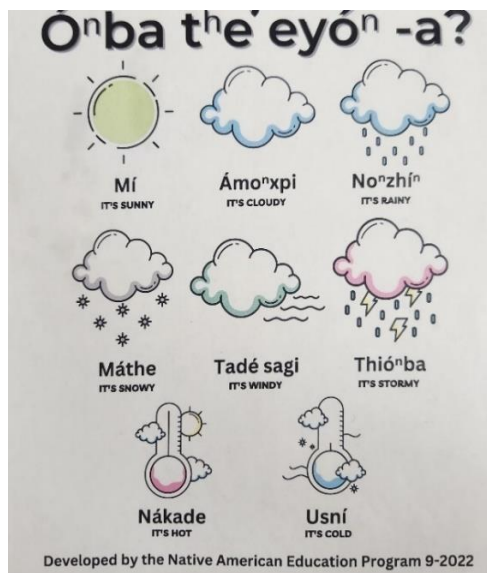


Image 5.12. Weather terms in Umo'ho'



Image 5.13. Plants Grown by Students



Image 5.14. Students' Models of Teepees

The first class that I observed started at around 9:10 a.m. when a cheerful group of eleven 4th-grade students walked into Amy's classroom. Amy was bustling with energy, and her classroom management skills were apparent as she skillfully and respectfully instructed students to sit around in a circle in the center of the classroom. She passed around a small cup with dried sage leaves to each of the students and told all of them to take a leaf and smell it while bowing their heads for the prayer song. She sang a

melodious and peaceful Umoⁿhoⁿ prayer song while all the children complied with her request. I asked her the significance of this cultural practice/ritual and how it meets the needs of her students, to which Amy answered that many of the students have experienced traumatic events in their lives, so when they come into her classroom, she wants to make it a peaceful place, and so they can learn to put that trauma away. That is why she prays and uses sage, so they can smell it, which calms the kids down. The sage ceremony (or smudging) reminded me of the Indian Hindu tradition of burning camphor and incense to invoke God's blessings. Camphor signifies positivity and peace and removes all the negativity from one's house. According to a few Hindu beliefs, it is used to please the Gods as well. The burning of the camphor signifies unification with the Almighty. Burning incense also has a great spiritual meaning for Hindus like me, as this ritual represents human sacrifice to society. The incense sticks burn totally to ashes, their influence is felt via the pleasant smells that last in a place. This ceremony depicts the sacrifice of a human being for the greater good. This is just one of many things I learned from Amy and other participants that I felt I had a connection to in my own cultural background, and that helped me bond in solidarity with my participants. After the prayer, she switched on the projector and read out the weather terms such as sunny, cloudy, snowy, rainy, etc., both in Umoⁿhoⁿ and English, and the students repeated the words after her. Then, Amy went around the class and asked a question in Umoⁿhoⁿ, "how is the weather today?" for which each child had to answer her in Umoⁿhoⁿ (see photos given above). Then, both Amy and Leigh took the children outside in an orderly fashion to visit the 182-year-old Tigóⁿhoⁿ³⁰ Cottonwood tree. Amy told chime that Indigenous people believe that all animals, plants, and natural elements like wind are also related to us, so

³⁰ Tigóⁿhoⁿ means "grandfather" in Umoⁿhoⁿ language.

they respectfully call them “grandpa,” “father,” “mother,” etc. Since it was the fall season and the leaves were dry, Amy and Leigh played a game with the students called “catch the leaves before they fall to the ground.” However, there was not much wind blowing that day. So, the children were instructed to call out to the wind by reciting *tadé sagi*³¹ multiple times until the wind blew. Lo and behold! The wind suddenly started blowing as soon as the children repeated the word four times, and they gleefully and energetically ran to catch the dried leaves before they fell to the ground. Amy said that since her childhood, she has heard a lot of Native stories about animals, plants, and nature, and she wants to create the same mystical experience for her students. Then, as a way to say thanks to Grandpa Cottonwood tree and the forces of nature (wind), the girls said *Wíblaha*, and the boys said *Wíbthaho*ⁿ. I did not understand why there are two different words in the Umoⁿhoⁿ language for the English word “thank you.” Amy cleared my confusion by explaining that in the Umoⁿhoⁿ language, linguistic and tonal differences exist when females and males pronounce words and phrases of command. Female sounds are softer for command words/phrases, and male intonations for the same words/phrases sound forceful. I was amazed to watch the smooth and effective melding of science, culture, and language during this classroom exercise! After this exercise, the time was up to go back to the classroom. Both teachers led the children back to the classroom, and Amy did not forget to mark the attendance of all the students present for the day.

The next group of students that walked into the “outdoor classroom” was nine 6th-grade students. The prayer song and sage ritual were the same for this class too. However, since they were older (middle school students), this class was taken directly to the greenhouse and the medicine garden where they weeded the garden beds and moved

³¹ *tadé sagi* means “it’s windy” in Umoⁿhoⁿ language.

around the dirt and compost. As a veteran science teacher, Amy did not forget to remind the students about safety precautions while using wheelbarrows and gardening equipment. Attendance for the students was marked by Amy at the end of class.

During the next two consecutive periods, the classes that came into the outdoor classroom were a Kindergarten class of 16 students and then a combined class of 23 students from the 2nd and 3rd grades. These classes were not on the original schedule for Amy and Leigh. Since some teachers couldn't make it to school, their students were sent to the outdoor classroom following an alternate schedule. A paraprofessional supervisor accompanied the kids and was present in class for the entire duration and helped Amy and Leigh with classroom management. The prayer song and sage ritual were the same, even for alternate-schedule students. To engage these students, they were given Halloween-themed coloring worksheets, crayons, markers, and pencils, as it was October, the month of Halloween. They were also taught the weather terminology in Umoⁿⁱhoⁿⁱ and English. As there were too many children in the 2nd and 3rd grades for that day, Amy and Leigh decided to take them to the playground and played an interesting and fun-filled science game called "tree, moth, and bats" game. The rules of the game were simple. The students were told to make a big circle at arm's distance; they were supposed to be "trees" and they were not supposed to move from their place, as trees cannot move about. Amy and Leigh picked two students randomly from this "tree" group and named them "moth" and "bat." Leigh explained to the kids that since bats are nocturnal animals and have poor vision, the "bat" needs to be blindfolded and the "moth" can freely run around the trees. The fun part of the game is that the "bat" has to catch the "moth" just by hearing the sound that the "moth" makes every time the "moth" runs between the trees. If

the “bat” is successful in catching the “moth,” then the “moth” gets the chance to become the “bat” and the game goes on. The students seemed extremely excited and were squealing with delight! Almost all of them were impatiently requesting Amy and Leigh to make them the “bat.” Amy was actually running around with the kids and was actively engaging and talking with them. It was very interesting for me to watch children learn science and enjoy it at the same time! Finally, when the time was up, all the children were escorted back to the classroom by Amy, Leigh, and the paraprofessional supervisor. Amy again marked attendance for all the kids present for the day.

The last class that came into the outdoor classroom was three students from the 8th grade. As they were older students, there was a visible change in the rigor of the outdoor science activities. They were mature and responsible students, and after participating in the prayer song and sage ritual, Amy took them to the greenhouse. The students spent more time there working on weeding, composting, and preparing the field for planting for the next Spring season. Amy shared with me that they had planted “the three sisters” garden last season and that they are currently preparing the field for sowing the seeds again in Spring. After rigorously working in the greenhouse for around 35 minutes, the students and the teachers came back to the classroom. Amy was mindful of students’ health and hygiene and gave cleaning supplies and a small brush to the students so that they could clean their hands and under their nails to get rid of dirt and grime. Then all three students spent the remaining 15 minutes coloring Halloween worksheets, watching YouTube videos about animals, and learning about their culture.

“The sun comes up every day, but the mind moves at a slower pace”: Standing Up for Native Peoples

As an elder now in her community, Amy has fully transitioned into a matriarch and a veteran teacher who has used her voice and stood up for herself and her tribe on grave issues that are plaguing the Native American population to the present day, such as equitable education, food sovereignty, community nutritional health, language preservation and revitalization, and healing from intergenerational trauma. Speaking up has empowered her. Amy emotionally said:

As a race, when you go through genocide, it leaves a lot of emptiness in your heart, because you have these things, the sadness that you carry, sometimes that means a lot of physical violence, all of the trauma that my people endured, the sadness that they carry, they turned to alcoholism, they turned to drugs, they have a lot of depression. This is shown by research that we are at higher risk of all of these ailments. And even though we're a small population, we're at higher risk for all of these ailments compared to the rest of the population, the whole world, the genocide that we have to go through, then a lot of people don't understand that because they've not, they don't, they haven't been through that. And they kind of think that it's a figment of our imagination...but it happened, these are facts, and people don't know the history of my people because it's obscured away. Because it's a shame on the United States government. It's a shame on the people who came into this land and took our land, and then treated us with racism and bigotry and oppressed [us]. And then we are left oppressing ourselves now, we're on the reservation, you know, we have opportunities, but still, to come out of the state of mind that you were in for over 100 some years, it's very difficult, because the mind processes and the changes are slow, you know, the sun comes up every

day, but the mind moves at a slower pace than that, and to heal to overcome those feelings is generational.

(Interview transcript, October 25, 2022).

After Amy spoke these sad and thought-provoking words, I took some time to pause and process this out of respect for Amy and her people. After calming down, Amy emphatically told me that her personal goal in her lifetime is to see her people gain food sovereignty and become sustainable again. She said that one of the main reasons for this food sovereignty journey is that the traditional Indigenous food, such as Indigenous corn (high in fiber and healthier than sweet/yellow corn), buffalo meat, deer meat, and dried berries that their people ate historically is not in their diet anymore. Amy laments that even the way that they eat was changed, it was colonized.

We're expected to sit down and eat a meal with our family. Prior to that, our ancestors only ate when they were hungry. We didn't sit down together as families and eat, you know, we just only ate when we were hungry. So even that is part of the way that our culture was changed.

(Interview transcript, November 16, 2022).

She reiterated that she is always going to be teaching the kids about eating healthy because they're at more risk for health problems than the widespread alcohol and drug problems and mental illnesses in her community. She added that the main thing is their food because it affects even the ones that don't have mental health problems. Amy reasoned her stance on teaching about the health benefits of Indigenous food to her students by stating:

I take that up to myself to teach that to our kids, because not only is that

something that's affecting...impacting our whole community, it is science because there's a lot that's related, that we can always bring to that, and teach to it every time. I'm always looking at ways of trying to bring Indigenous food back into our students' science; how can we do that? We were able to go and find some wild plum trees that were down by our house, and we now cultivated them, we are growing [them] in our garden. We've been very blessed, we have been able to grow different kinds of corn now...we've grown the Oneida white corn, we have grown popcorn, we've grown blue corn, and colored corn, and so now I brought that to the school and the kids sorted it out. We can start looking at doing some genetic selection ourselves to try to help bring that back...This is something I'm doing on the side with my family, it's with the corn, and it's for the community. Then try to grow that Indigenous corn again and make it accessible to our community. We're working with the Center for Rural Affairs and Farm to School Program³² through the state to try to address that, and to get that food in here into the school [for] the kids [to] have that in the community and then to create [new] recipes.

(Interview transcript, November 16, 2022).

“By bringing back our language, we can be a whole person again”: Preserving and Revitalizing the Umoⁿhoⁿ Language

Amy is also passionate about preserving and revitalizing their Native language and culture so that the future generation can take their rich Indigenous culture, language,

³² The Farm to School Program helps child nutrition program operators incorporate local foods in the National School Lunch Program, the Summer Food Service Program and Child and Adult Care Food Program and all associated programs. In addition, Farm to School Program staff work with tribal communities by promoting food sovereignty and the integration of traditional food ways into tribal meal programs (*Farm to School Program, U.S. Department of Agriculture, n.d.*).

and traditions forward. Amy said that the Umoⁿhoⁿ language is facing extinction, so there is so much work to be done. Nevertheless, Amy believes that at EPPS, they are slowly but surely moving in the right direction.

Our major language [now] is English. ... We would want to, we would like Umoⁿhoⁿ to be the first language because it should be [our] first language. My great-grandmother, her first language was Umoⁿhoⁿ, my grandmother, her first language was Dakota, and now, fourth generation, our language is almost gone...there's 20 people or less that speak the Umoⁿhoⁿ language [now]. We are interconnected to our language and culture, and when that was taken away from us, we are lost. When we bring that back in, then we can be a whole person again. We're helping the Umoⁿhoⁿ language, to revitalize this, and to try to preserve it. ...Being able to bring that language [back] and to speak two different languages helps strengthen their brains and their thought processes. So that's part of it also. Having the permission to bring my culture into my teaching, I felt like that's freedom, I felt like some chains were taken off of me; I don't have to hide who I am anymore. I can really be me, you know, and share who I am, and it's been wonderful. When we have full-immersion schools, then I'll say, okay, now we're really heading somewhere, now we're picking this up, gonna move in a good direction.

(Interview transcripts, November 8, November 16, and December 8, 2022).

As Amy is working on incorporating the Umoⁿhoⁿ language into her science classroom, she is employing translanguaging pedagogies that many scholars, such as García and Wei (2015), Otheguy et al. (2018), Cenoz and Gorter (2021) have

recommended for Indigenous student success by teaching them words of science in Umoⁿhoⁿ that help students view the science concepts from an their cultural lens (see Hermes, 2007). Translanguaging pedagogies have been found to have huge potential for for language-minoritized students because they build on students' linguistic strengths, and they also reduce the risk of alienation at school by incorporating languaging and cultural references familiar to them (García & Wei, 2015). Furthermore, research has shown that Native students become enthusiastic and engage more with science content if they are given opportunities to do science activities that promote the usage of their native languages (Demmert & Towner, 2003; Stephens, 2000; Demmert, 2001; Demmert, 2011; Pease, 2004). As I listened to Amy's story and revisited it as I wrote this, it struck me that not only has using the Umoⁿhoⁿ language in science classes helped students, but it has also helped Amy emancipate herself and her own identity as a Native teacher so she doesn't have to "hide anymore". Thus, this type of pedagogy is a form of social justice for Native teachers just as much as it is for the students.

“Fighting for the rights of the land”: Decolonization, Tribal Sovereignty, Self-Determination, Environmental Justice, and Reclamation of Native Land

I had learned about the stark realities of the conditions in Native American communities and reservations, especially how their tribal lands have been exploited; how they live in abject poverty without even basic utilities such as running water, electricity, and telephones; how they have been forced to move out of their traditional lands or housed in areas reported to be environmentally unsafe; and more importantly, how health disparities in Native American communities are disproportionately higher than the rest of the population in the United States (*Demographics NCAI, 2023; Native American Living*

Conditions Today, 2022). So, I wanted to learn Amy's opinions on decolonization, tribal sovereignty, self-determination, environmental justice, and the reclamation of Native land, and how she uses those in her science teaching. Amy said that she is equipping herself with the knowledge she needs to continue working on her lifelong mission and to improve her science education teacher knowledge. She shared with me that she is mid-way through her master's degree in science education from a large midwestern university. She also attends professional development programs that her school sponsors for her and Leigh. She has also presented about Áshita thewathe at conferences, summits, partnerships with other Indigenous communities, and events, such as the 2022 Virtual Education Summit³³ and Native American Heritage Month Celebration.³⁴ Amy said that she is also a part of some groups on Facebook too where people talk about decolonization. She said:

That's [decolonization] a big word in Indian country and our native country. People that are activists, a lot of it was derived from fighting for the land, for the rights of the land, trying to keep the land, like when they started the Standing Rock up there, and they were trying to put these oil pipelines through there and whatnot. It has made me want to grow leaders for our community, leaders that are aware of these problems, and that they'll as they go on through their education and their mind is sparked. It's our view that, in [the] inherent teaching

³³ The 2022 Virtual Education Summit was sponsored by the Winnebago Tribe Education Department, the College of Education and Human Sciences at the University of Nebraska-Lincoln, and the Spencer Foundation on Indigenous Day in October 2022. Amy presented about Áshita thewathe at this summit, which I attended.

³⁴ Native American Heritage Month Celebrations were organized by the Office of Indian Education (OIE) in November 2022, which I attended. This event celebrated the efforts and achievements of OIE grantee schools (K-12) and their contributions to Indigenous education, such as the revitalization of Native languages; the improvement in academic outcomes of Native children; STEAM programs that incorporate Native art and craft into science, engineering, technology, and mathematics courses; and incorporation of culture into teaching. Amy presented about Áshita thewathe during this event too.

that we have, we are the caretakers of this land that was given to us when the creator put our feet on the earth, and [told] “this is a gift to you.” Our spiritual people say that this was God's paradise, this was the creator's paradise, and we were given the opportunity to come here and be a part of it, [and] we had to take care of the blessing that we were given. So, we have that part of what we teach our children; we carry that with pride. And I'm going to grow the leaders that are going to...ensure that they're going to fulfill those treaty obligations so that we can continue to have these kinds of programs. We have the opportunity, even though we've lost that connection to the past through colonization, we still can start over. [We] can start building that for future generations. That's one of my goals. So, achieving sovereignty is also preparing these generations to be stewards of the land, caretakers of the land...That's a big thing for me.

(Interview transcript, November 16, 2022).

Amy's words confirmed her resolve to help her community and attain true sovereignty, and this is obviously an example of how Amy is developing the science curriculum to support the goals that she has for her students and her community. This also conveys the passion she has for preparing her students to take up leadership positions so that their Native children can take care of the sacred land gifted to them by the Creator. Amy's quote also ties in with one of the important tenets of the TribalCrit which states that “Indigenous peoples have the desire to obtain and forge tribal sovereignty, tribal autonomy, self-determination, and self-identification” (Brayboy, 2005, p. 429-430).

Amy's Suggestions for Science Teachers Outside of Reservations

According to the recent census report on the AI/AN population in the United

States, out of 9.7 million Native Americans³⁵, 86.8% of people live outside of AI/AN areas (or) tribal reservations, i.e., in cities and towns other than the reservations (*Census.gov*, 2020). The states in which the AI/AN population is more than 9% of the total population are Alaska (21.9%), Oklahoma (16%), New Mexico (12.4%), South Dakota (11.1%), and Montana (9.3%), and in Nebraska, 2.8% of people are Native Americans (*Census.gov*, 2020). Given the number of Native Americans living outside of reservations is so high, I asked Amy if she has any suggestions or advice for science teachers in public and private schools across the United States so that they can meet the needs of Native American students in their classrooms. For this, Amy was very forthcoming in saying that,

They need to find elder[s]. They need to have somebody from their community or somebody that they can reach out to, to share stories. That's where I got all of my cultural information, it was from my elders, listening to them tell stories.

Teachers that are in the inner city, working with students in the city, they need to be able to find a place that they can go...I know they have a lot of parks and places, even just going outside around the school and looking at different things.

Find a place that they could at least try to go and have that connection. I know in the city, they have lots of squirrels. We can learn a lot from squirrels if [we] sit and watch. People think that they're pesky, but actually, they have high intelligence, if you are looking for that, so that's what I do. As a teacher, for people that are living in the inner city, [get] Native American students exposed to some of their legends, some of their teachings. If they don't understand it, there is a backstory to it, and it's usually in nature. So, [teachers] have to be able to not

³⁵ American Indian and Alaska Natives alone or in combination.

just find a cultural person...there's a lot that lives in the city to help explain that and help make that connection. I know that's probably a struggle for people who live in the inner city, so I would say that they need to be resourceful, be innovative, make connections with people, and [have] collaborative connections, because a lot of what we have is through collaborative projects. We couldn't have done all this on our own.

(Interview transcript, December 8, 2022).

Amy's suggestions could serve as excellent advice for teachers who are struggling to find ways to support Native American students who live in cities or towns other than the reservations.

Chapter Summary

In this chapter (Chapter 5), I have presented Amy's stories which are her racialized and gendered lived experiences that have shaped her teaching philosophies, pedagogical decisions, and culturally and linguistically responsive pedagogical practices to teach science to Indigenous students and meet their unique needs. Some of the themes that surfaced in Amy's story include the ways to connect Native culture, language, and storytelling while teaching science; the health benefits of nature-based education; the importance of preserving and revitalizing Native languages; the urgent need for culturally and linguistically responsive teaching for the traumatized Native student population; the importance of helping Native students in becoming self-reliant in Indigenous food cultivation; and helping students become aware of the real-world issues so that they will become self-determined leaders in their tribes. I now turn to Leigh's story.

CHAPTER 6

MASTER NATURALIST: LEIGH'S STORY

Leigh is a white lady, an elder, a mother of four children, and a veteran elementary and middle school science teacher with 25 years of experience teaching in K-12 Indigenous reservation schools. Leigh is currently working at the Earth People Public School. The following paragraphs will chronologically re-story Leigh's lived experiences.

“I learned science from being outside”: How Leigh Became a Science Teacher

Leigh was born in a small village situated on Cape Cod, Massachusetts, on the lands of the Wampanoag Confederacy³⁶. She grew up right next to the ocean, in an area that was about 65 miles long that was never more than three miles away from the ocean. She spent her childhood in her village during the 1950s-1960s (before the advancement of technology), and she was raised in a tiny cottage spending time with her parents and grandparents. Leigh was by herself a lot, and she loved being outside. They had woods behind and in front of their house, surrounded by fields, so they were really isolated. So, they were always outside and always looking for resources and looking at how to put scarce resources to good use. Leigh learned a lot of things about nature and science from her grandparents and her father; she said, “*I learned science from being outside*” (Field notes, October 28, 2022). Her grandmother taught her how to identify different berries, such as bird berries, huckleberries, blueberries, and little strawberries that used to grow wild in the woods.

³⁶ The Wampanoag Confederacy was a coalition of over 30 Algonquian-speaking Native American tribes, also known as the People of the First Light, who lived in the region of modern-day New England, specifically from Rhode Island down through Massachusetts and parts of Connecticut, and they are best known in American history as the natives who helped the pilgrims of Plymouth Colony survive in the New World (Mark, 2021).

Leigh's educational journey was one of steadfast perseverance and extraordinary hard work. While talking about her formal education in K-12 schools, Leigh said that she studied in her hometown in Massachusetts. She told me that she had a hard time in school since it took her a little longer to process things; she did not know then that she had learning disabilities. While talking about biology classes that she had taken in school, students were told to dissect frogs when they were alive; they did give chloroform to numb the frogs. However, Leigh just could not do that, and it freaked her out. She got into big trouble for that, but somehow, she got it done with the help of a friend. Eventually, she became a first-generation high school graduate in 1974. Soon afterward, she got married. Between 1974 and 1990, she was raising a family of three kids in Massachusetts, never expecting to go to college. However, fate had different plans for her.

Leigh shared with me that her college enrollment happened by accident in 1990. By then, she was a single mother with three kids, and she did not want to be on welfare, and she definitely did not want that for her kids. She always wanted to become a teacher. When she heard there was a workshop called "Women in Transition," which helped women to make decisions to get them out of poverty and help them get better jobs, she called her friend, and they went there and filled out some paperwork. Once she was done with the paperwork and handed it to the lady in charge, the lady congratulated her saying that she was now a full-time day student at Cape Cod Community College. She was taken aback, and she turned to her friend and asked what did she do? Her friend asked her if she did not hear what was going on, and Leigh replied that she did not know, as she was too busy filling out the paperwork. Nevertheless, despite their unexpected entry into a

community college, Leigh and her friend started working hard to pursue their Associate of Arts (AA) degree. Leigh was determined to continue her studies and become a teacher to realize her dream. But again, it took more time for Leigh to write her college papers as compared to her friend since it took longer for Leigh to figure out how to lay her thoughts out and then complete her papers. Finally, Leigh was the first generation to graduate from college too with an AA degree. Leigh shared with me that she has been in college almost constantly for 32 years since 1990. Every time she finished a degree, someone would encourage her to go on and get another degree, then a master's degree, and so on and so forth. She started her bachelor's degree in psychology and education in Western Massachusetts, but she had to transfer her credits to another university in Connecticut to receive a bachelor's degree. However, when she moved to Nebraska, she applied to a large midwestern university, as she wanted to get her teaching certification. This university advised Leigh to retake education classes in order to endorse her as a teacher and award her a teaching certificate, which she did successfully. Then during the 2012-2013 academic year, one of her professors told her to participate in a research fair, where she was encouraged to enroll in the master's program. Then, she went on to complete her master's degree from the same university majoring in teaching, learning, and teacher education. She kept on studying until Leigh realized her full potential by successfully graduating with her doctorate in education in 2022 majoring in teaching, curriculum, and learning from the same midwestern university.

“I’m a master naturalist”: Leigh’s Science Pedagogical Knowledge Grounded in her Lived Experiences

Leigh’s lived experiences had a huge say in how and why she became a science

teacher. As she was telling me about her high school, college, and university experiences, she kept on repeating that she believed in nature-based education because she has always marveled at nature and how plants, animals, and natural elements such as rain, clouds, wind, and her own inner spirit have taught her and guided her teaching.

I was just learning about what was around me as a kid because...I was outside all the time. There are a lot of things that I learned from my grandfathers and my grandmothers, more so [from] my grandparents and my dad. My dad was all into the awe and wonder of nature. And I didn't have a lot of friends that want[ed] to do the things I wanted to do. So, I would spend a lot of time out in the woods, the fields, down by the ocean, the frog pond, the pond, wherever I was more interested in being. I lived out in the woods and fields and everywhere else, and I talked to the birds. The way that I'm learning about a lot of things is, they teach me; the plants are teaching me. I believe when the spirit tells me things, they're never bad things...it's always a gentle nudge like, "come, look at this; come, see this." That guides my teaching as well because I come out and I'm usually looking around, I'm looking for birds. I'm looking for signs in the weather, I'm looking for anything because that's how I work. I'm very sensory.

(Interview transcript and field notes, October 25, 2022, and October 28, 2022).

While she was studying and raising her three children, she started her teaching career too. To begin with, in 1998, she was a substitute teacher teaching in after-school programs at elementary schools. Then, Leigh started working full-time in different reservation schools. Her first contracted job was working as a Head Start teacher at Winnebago. During the time she worked for the Ho-Chunk language school at

Winnebago, in order to be able to better support her students, she started taking culture and language courses in college. She worked on a bilingual grant on literacy with a Ho-Chunk friend, whom she calls a “sister,” and they were successful in getting the grant for the school. Then, the language program recruited both Leigh and her Ho-Chunk sister. Leigh worked on curriculum development and materials development, learning the language as well. She would substitute sometimes for teachers. Soon, she was partnered with an Elder to work with, who was a fluid speaker that taught Native students the language. Leigh helped the Elder write lesson plans, did the attendance, and wrote what they did in class until 2007. Then, since someone at their school felt that a person who is not a Ho-Chunk should not be in the language program, this issue was brought up at the tribal council and her boss told her that she should look for a job elsewhere. Nevertheless, Leigh, being so committed to her job, said that she would rather stay there and finish writing all the lesson plans for the rest of the year, and that's what she did. So, after serving in the Ho-Chunk school for around four years, she had to move to another K-12 public school nearby as an art teacher, as she was just three classes away from receiving her art credentials. Then, she worked with an Indian Mission school for seven years. She started teaching at Earth People Public School in 2016. When I asked her about how she became a science teacher and how she began teaching science using nature-based education, Leigh said:

I didn't become a science teacher...I'm a master naturalist and gardener, and I'm an elementary teacher. I learned science from being outside...I was lucky enough in elementary school to have one teacher all the way to sixth grade that actually took us outside. It's important, and I learned outside like that, like seeing the halo

around the sun, that brings rain. Being able to spend my time working with the kids is really important to me, this is the way that I think as a teacher; this is the way that I am. You know, to be going out and doing things outside. So, when I came here, when I applied for a job here [at EPPS], while I was at my interview, I put it right on the table and said, I want to do this [outdoor classroom]. And they made it happen... So, coming here was a nice fit for me. I'm not trying to be Umoⁿhoⁿ; I'm not trying to be Ho-Chunk, but it complements...we're all on the same page. We're all living on this planet, just trying to help it survive. We don't live on an inert ball of dirt. We live on a living organism that provides life for all of this stuff and asks nothing in return. And sometimes as a country or society or whatever we forgot that. Because we all knew it...it doesn't matter where your people came from, they all knew this at one time. They all knew the respect.

(Field notes and interview transcript, October 28, 2022).

After listening to her comment about EPPS being a nice fit for Leigh and knowing that she is a white lady teaching Indigenous students, I asked her how she feels about this and how she positions herself as a White woman teaching Native children. I also asked her if she is supported by the Indigenous schools she has worked for and if there are any criticisms directed towards her. Leigh was quick to say that the people out there don't view her as a White woman. She feels that they just view her as an ally because she is a descendant of people who shared the same land as the Wampanoags and that she also has an ongoing understanding of Indigenous communities. Leigh said that this was her impression based on the way that she has been treated amongst the Ho-Chunks, as they were the ones that took her in as a family member. She said that she has not been treated

like a White woman per se because when someone says, “White woman,” it implies an outsider. She agrees that she is an outsider. However, Leigh passionately stated that when she does her work with Indigenous students, her concern is always for the children and the best that they can have, which implies that she believes that she is an “insider.” Leigh said to me that this is the reason why she spoke with the EPPS superintendent at the initial planning stages of building an outdoor science classroom. She had told the superintendent that she was going to need someone from the community to work with her. So, she was very happy when she gained a competent partner in Amy. She knew that she just couldn’t come into the school and say, “I have the best idea for you. I know how to fix you.” Leigh said that that is not the way she works. Leigh claimed that this is really about the whole project, not just the outdoor classroom at their school. Leigh strongly believes that the whole concept of an outdoor classroom is important because it will tell teachers how kids view their world and the connections they make with nature. Leigh confidently stated that this could happen everywhere, not only at their school. Leigh stated that the Native students at their school are so out of touch because they are so much closer to the disconnect. She also said that their disconnect is far more recent than the disconnect in the communities of immigrants who came to the United States, such as immigrants from the Highland Clearances,³⁷ immigrants from World Wars I and II, the people that came over to the United States between the 1600s to the 1800s, and the people who came in long ago but do not even know where their people came from. Leigh said that the Umoⁿhoⁿ people are different from them, as they still live in their tribal communities in the same area, and it means they know where they came from. They have

³⁷ The Highland Clearances were the evictions of a significant number of tenants in the Scottish Highlands and Islands, mostly in two phases from 1750 to 1860.

access to their stories, access to their songs, how they celebrate, and how they perform their ceremonies. She said that she is also completely open to the Umoⁿhoⁿ educators and administrators in her school giving her input to fit the needs of their students, such as adding some cultural elements to make it richer and make it specific to the Umoⁿhoⁿ learning community. Leigh reiterated that she is just sharing an idea and approach with the school administrators, and they have been very supportive.

Leigh with her positionality as an “outsider” and an “insider” in the community and the school’s support of her could be viewed as a successful role model for schools that serve Indigenous students and also for White teachers who consider themselves allies and those that want to work with Indigenous students to meet their needs. Unfortunately, there aren’t enough teachers from the local communities to fill all the teaching positions at schools such as EPPS, so there will always be teachers that don’t identify as Indigenous working in these schools. Leigh hopes that White allies who are unsure if they should or can do this work might find her story helpful, given that some Native communities are suspicious of the White allies due to their bitter experiences with the White people in the past. Leigh’s allyship with the Indigenous communities was developed because of her deep knowledge about the history of the Native people she has worked with and her genuine care for the Native people, not to mention the years of her life she has dedicated to this work. This is very similar to O’Connell’s (2017) statement, where she states that white teachers could become allies to Native people by learning about the true Native history, different from the one they were taught in American History courses, which could in turn provoke a desire to speak in support of Native initiatives moving White people from friendship to being an ally.

On asking further about why she has such a deep interest in science education, Leigh told me that she has a lot of science background and took many science courses because they interest her. However, she was not happy with how she had to align her science lessons with the state-mandated science standards in reservation schools because she noticed a gap. She feels that Western science doesn't conform to her own teaching philosophy and the Indigenous ways of holistic learning.

It's sad to have to align it with standards because standards focus on averages. They don't focus on what goes above and beyond. We micromanage science, down to these little bits. And sometimes that's just hard. It's just hard pulling it all together, it takes two of us because I couldn't do this by myself...and it's not mine to do by myself. The standards are there, but it's like the state standards for Nebraska has no biology for second grade. So how? So, would you not teach anything that has to do with the natural world when they're in second grade, that's a gap. And I'm not willing to allow that to happen. [They] say that we add on each year in the standards, so you're going up a little bit, a little bit, but how much are they retaining when they can't just be immersed in it each time and naturally being brought through the process? When I was working at the St. Patrick Indian Mission School³⁸, I was given sixth, seventh, and eighth grade for [teaching] science. We had this massive book that we were supposed to use. So, I found that if I divided them into Earth science, biology, chemistry, and physics [each year], that [will make] more sense to me than giving them half an inch of Earth Science each year. When they had Earth Science, they became Earth science experts. That didn't mean they [lost] it the next year, but then they added

³⁸ Pseudonym

onto that, you know, with biology. Biology came on top of what we already know about Earth Science and things like that, and then chemistry and physics. And it was! I was doing chemistry with no chemistry lab in eighth grade. They had people [students] come from St. Mary's Academy³⁹, they were visiting, and one of them [students] was in 10th grade, and one was in 11th. And the 10th grader goes, "Oh, my Gosh, we haven't even done this yet. We're [still] working on taking apart compounds, so when you see this compound that something is made of, break it down into its primary elements.

(Interview transcript, November 16, 2022).

Leigh's comment above made a lot of sense to me as a former high school science teacher because it made me realize that holistic engagement with one science course in a particular grade level would help students in retaining the concepts better and even help them master the content. I realized that this is way better than giving them bits and pieces of all streams of science at each grade level. This way of holistic learning is in perfect alignment with Indigenous ways of living and is most helpful for Indigenous students who relate to the comprehensive and holistic way of life and learning, which has been highlighted by Haynes-Writer and Valdez (2021). They state that Native science is comprehensive, holistic, sacred, complete, and is a way of life, which contrasts with a linear-oriented Western modern science that is compartmentalized into various branches or specialties. Moll et al. (2009) also state that since Native science is a way of being and knowledge sharing benefits Indigenous student communities, drawing from students' funds of knowledge is highly effective in improving the academic outcomes of

³⁹ St. Mary's Academy (Pseudonym) is a top-rated, college-preparatory high school for girls from a nearby large city in the Midwest.

Indigenous students. Leigh wanted to bring something different to science teaching in an outdoor classroom with the wholesome engagement of her students, at the same time valuing their funds of knowledge, and she was lucky to gain an able partner in Amy to run this nature-based science classroom.

“Two peas in a pod”: Leigh and Amy Create *Áshita thewathe*

Two years after Leigh’s appointment as an elementary and middle school science teacher at EPPS, she wanted a competent science co-teacher, who complements her passion for nature-based education and also who is well aware of the Umo^ohoⁿ culture and language. She asked the culture director of the school, and she suggested Amy’s name.

We came across each other. I'd said, “Wendy⁴⁰, I need someone to be a co-teacher, somebody who's got science, and she [said] "hey, Amy," and we've been like two peas in a pod. Yes. It's just worked for us.

(Interview transcript, October 28, 2022).

Since 2018, Leigh and Amy have been happily working together in the outdoor science classroom. Leigh started working on designing the complete curriculum for an outdoor classroom and is currently serving as the program director for *Áshita thewathe* at EPPS. When I asked Leigh about her progress in writing the science outdoor classroom curriculum, *Áshita thewathe*, Leigh said:

I'm still working on it. I have a lot of it. I did the scope and sequence. I've mapped it all out. It's based on the seasons.

(Field notes, October 28, 2022).

However, Leigh and Amy had to stop working in their outdoor classroom for a

⁴⁰ Pseudonym.

year because of the COVID pandemic. When school reopened, Leigh could not rejoin the in-person school right away because she was told that the reservation was a COVID hotspot, and there were no vaccines yet. However, because some parents requested her, Leigh did teach her students online. Leigh used to go outside with her daughter holding the phone and following her, while she taught about the signs of the fall season, and her students used to look out their windows. Leigh then rejoined school after she was fully vaccinated.

Leigh said that an understanding and trusting partnership with Amy has helped them both to teach science in a culturally and linguistically responsive manner to students at EPPS.

When it comes to science...here [EPPS], they want the kids to learn their way, which makes it perfect when she [Amy] brings up [cultural] things, then I say, I got it.

(Interview transcript, November 8, 2022).

While talking about her pedagogical decisions and practices that she and Amy follow in the outdoor science classroom, Leigh said that most of their decisions are intuitive and improvisational.

I come to teaching; I want [students] to see those sundials, I want [them] to see the first frost in the morning that makes long needles on little blades of grass. I want them to see those kinds of things. Because when they see those, every time they do that, it's a buy-in, it's a buy-in for them to make a connection. I want them to be able to see those things like when the skies turn green, it's real ugly, and we're gonna get some crummy weather. That's a sign to watch for, the green

clouds, that's a sign to watch for because I want them to understand the danger element, but not put them in danger's way. Yeah, I'll dash them out there real quick, just out on the playground, and say, "Look, see this. Look what the wind is doing. It's coming from what direction?" Because it's switching, [students] start to think about, "is it coming in this direction?" "Watch where the clouds are going, look for some stationary like a tree, and if you're looking at that tree, then you'll be able to tell which way the clouds are going." That's what all those walks are really about. It's about getting them to see the bigger picture, you know, and say, what does that mean? Or what is that? Or to be able to ask those things. Some of it's just intuitive. Yeah. Some of it's just improvisational, you know, it just comes to you [Amy] and it comes to me, and we just follow that lead.

(Interview transcripts, October 25, 2022, and October 28, 2022).

The above examples provide evidence as to how Leigh has developed an extensive teaching skillset that has led to the creation of a separate, culturally relevant, outdoor classroom as an adjunct to the school curriculum, during her several years of teaching in Nebraska.

“Animism missing in Western Science”: Leigh’s Philosophies Align with Indigenous Science

Since Leigh has been positively influenced by the Indigenous ways of teaching and wants to continue teaching science to her students in a holistic way like the Native people, she discussed why Indigenous ways of science teaching resonate with her teaching philosophies. Because of her several years of teaching experience in Indigenous reservation schools, she expressed her opinions on how western science would not be

beneficial for Native students. So, Leigh articulated the differences between Western science and Indigenous science and her own school science experiences in the following passage:

I did quite a bit of research about Western versus Indigenous science... I think it's Leroy Little Bear [who said] western science has the knowledge; Indigenous science has the wisdom, and I remember that...that makes sense to me. Because when I took science, it was interesting [to learn] what I was learning about, but I was [just] learning about the objectifying of things, and I think Western science does that. It takes the spirit out of it.

(Interview transcript, October 28, 2022).

Other than “taking the spirit out of” learning, Leigh said that western science lacks “animism.” When I asked her to elaborate on what she means by animism and how it relates to her teaching philosophy, Leigh replied:

For instance, it's fall and so things are changing. For them [students] when [they] come to a tree and the leaves are starting to change color, and some of them are falling off and then there [are] no leaves left on the trees, they say "the trees are dead." I say they're not; they're just sleeping. I had a teacher say to me, please don't say that to kids; use the word "dormant." And I thought [for] kindergarten, no. Because all children are raised on stories full of animism that the world is alive and all of this...and then they get to the science, and it becomes an object. It kind of falls away from that, and I think that's objectifying...When we're out there with Tigó"ho and playing Tadé sagi, that's the word for wind, and when the kids wanted that wind to come, they were singing that – “tadé sagi, tadé

sagi.” And they were really getting into it, that's the animism of it, that's because they were becoming the wind. They were calling the wind, you know, when they were, they were feeling that connection between the wind responding to them. That animism, and that's a powerful thing. One part that I feel that's missing with science, Western science, is...animism. But Western scientists say...we can't allow that in schools. I think that we're losing something or giving something up, especially for the youngest kids. And it's through animism that I bridge what I'm teaching. You want to engage them; you want to make sure...that's a culturally relevant thing. That animism is what makes that pull, you know, all of those, for them [to be] believable...So, when we don't do that, I think that we miss out a little bit. So, for me being able to go out and do that and talk about the birds as little relatives and that little ant and all of those...to make that connection, that's animism. It's not just the ant, the object. It's the ant, the living being, the sentient little thing. Then they engage; then they invest themselves into something in the world. We also have a “Do No Harm” policy, which means if you see an ant, leave it alone. If you see a spider, just leave it alone. Just let it be, it's just trying to live, just like the rest of us.

(Interview transcripts, October 25, 2022, and November 8, 2022).

What Leigh shared with me about the objectivity of Western science and its lack of animism valued by Indigenous people reminded me of Aikenhead and Elliott's (2010) statement that values, assumptions, and ideologies embedded in Eurocentric science content can conflict with values, assumptions, and ideologies of Indigenous ways of living in nature. Leigh's philosophy of bridging the gap between science and Indigenous

culture through stories, animism, and engaging students in culturally relevant science supports a few other researchers' claims too. Some of their claims are that culturally based education/curricula are based on Native culture incorporating legends, oral histories, songs, and fundamental beliefs and values of the community (Demmert & Towner, 2002) and Indigenous students having trouble finding meaning in decontextualized one-size-fits-all curriculum and instruction that does not relate to their cultures, communities, and homes (Demmert, 2011).

“Super sciency”: Outdoor Classroom Builds in Rigorous, Grade-Level-Appropriate Scientific Inquiry

During one of my classroom observation days, Leigh explained the features and medicinal properties of every plant in the medicine garden to me. I could immediately sense her expertise in the botanical names of the plants and what they are used for. She patiently showed each plant to me, such as peppermint, mullein, milkweed, calendula, plantain, yarrow, etc., and explained their distinct anatomical features, the seasons that they grow in, medicinal properties, and the great value the plants hold for the Native people. Leigh said that before she and Amy began the outdoor science classroom, Native students in their school were not aware of what is going on around them and did not notice the beauty of nature, so she and Amy started teaching their students to look out and care for nature and respect the natural elements by doing hands-on learning in their outdoor classroom. She states that students feel a sense of calm and peace while working in the medicine garden and they feel confident as science learners. She categorically stated that students can develop conscientiousness and care for our planet only when they spend time outside and observe things to understand real-life situations.

They didn't see the snow cranes migrating, they didn't see butterflies, they didn't notice the birds, the rabbits, they didn't even notice the cow or anything...The first thing I do is always look up because I want [them] to see what's going on. And so by taking them [outside], over time, and start making them see the crane and talk a little bit about it, instead of saying now we're going to talk about sandhill crane...you pass it upon them. And then you talk about them, they see them, [and] you're in that moment. That's a teachable moment. How can you get the kids to care about the future and care about the planet when they don't spend time in it? You can say, we need to help the planet in a classroom, that's a box like this [Leigh gestures drawing a box in the air], you can say that. But if you're outside, you're looking at things.

(Interview transcripts, October 25, 2022, October 28, 2022, and November 16, 2022).

This teaching philosophy of Leigh's aligns with the Umoⁿhoⁿ culture, as they respect and revere every living being on Mother Earth. I asked Leigh what specific instructions she gives to her Native students to help them care for plants and learn about their culture. I was also interested to know what Amy's and Leigh's overarching goal is to make students learn in the outdoor classroom, such as the medicine garden and the greenhouse. Leigh replied by giving an example:

Well, in order to take something from the plant, you have to give something back. They are giving us medicine; we have to give them something back. And we wouldn't give them a rock or something like that because it's not something they can use. So, I always use water. Some people use tobacco, some people have

other sacred things that they put down. And for me, the relationship has always been to use water, water poured at the roots. Only take what you need. You know, and be quiet and reverent when you're doing this work. So, I showed all of them how to do this. It's not our goal, to teach kids how to make medicine, it's for them to become aware that plants are medicine, that plants have something to give, they're not just things that grow, they have a function, and they should be respected. I think that using actual experiences rather than reading and having it be didactic...I think that that's one area that we do really well in, giving them experiences rather than just talking about them.

(Field notes and interview transcripts, October 28, 2022, and November 16, 2022).

Leigh shared another example of a longitudinal scientific study project that elementary and middle school students from 2nd grade up until 8th grade have been doing for the past three years. This science project uses the scientific method to challenge and validate the weather folklore⁴¹ that correlates the first snowfall date and the number of days it will snow during the entire winter season in a particular year. This project is conducted in wintertime, which is storytelling time for the Umoⁿhoⁿ people. The teachings of the Umoⁿhoⁿ people say that people can start telling stories only when there is *accumulating snow*⁴². Leigh shared the details given above about the weather folklore, how she incorporated the folklore into a guided scientific inquiry on snowfall dates in the outdoor classroom, and how it beautifully integrates culture into science teaching.

⁴¹ Weather folklore is a collection of several sayings people in New England believe about the weather (Leigh, October 28, 2022).

⁴² Accumulating snow is the snow covering the ground, so no ground is visible; also called snow depth, which is the actual depth of snow on the ground at any instant during snowfall.

[If] the first snow falls on the 17th of the month, then there'll be 17 snow days with measurable snow. The first has to be measurable snow...it needs to be like an inch or two or whatever so that you can't really see the ground. Culturally, amongst the Ho-Chunks that I worked with, that was a sign to start telling stories, and same thing here, [it is] the time to start telling stories...creating stories... That's an old one [folklore]. I've known that one for a long time. And so, is that true? Well, we did this for three years, and each year, if it wasn't dead on, it was one on either side. I thought, you know, and this is folklore versus weather...There's also weather wisdom...this is colonizing weather wisdom [science weather facts]. So, one kid [did] background research, Farmers' Almanac, things like that. [I asked] "What do you think will happen?" The hypothesis that they need to do, and this is the data collection. A lot of it has to be a guided thing. They understood that a hypothesis means what you think is going to happen. I had to put it as simply as I could put it. So, they learned how to develop a hypothesis in second grade. I think that giving them those opportunities to flex those muscles even that young and keeping a tally of "did it snow today? was it measurable snow? or...did it make a difference?" They go out and measure how much it snowed that day, maybe they can't read it on a ruler, but over time with you working side by side, they start to get it, even if they don't get the depth of that. They're still gonna get the experience. And it doesn't get much more sciency. Then [they] analyze the data. This year, the first snowfall date, number of snow dates, any notes that you want to go along with it, a written article or printed articles in a local newspaper, photo gallery from the longitudinal study

period, so each year on the first snow, or whatever. And then the appendix area is for any supportive documentation that doesn't fit in one of the prior categories, such as contact information of participants of the class, or correspondence received. It can also include a journal created by the students during the process. If a pen pal were included to compare data obtained in another area, this can also go here; be creative and have fun. Yes, [it is] super sciency.

(Interview transcripts, October 28, 2022, and November 16, 2022).

Leigh and Amy's culturally relevant, academically rigorous inquiry-based scientific activity is very similar to Gilbert's (2011) Culturally Based Education (CBE) model which is an academically rigorous, culturally responsive curriculum and instruction model that is based on the Native Science Connections Research Project and funded by the National Science Foundation. Gilbert's (2011) CBE model is action- and inquiry-oriented as well as culturally based, and it integrates/connects Native students' traditional cultural knowledge with Western science for fifth-grade students in public, contract, and B.I.A. schools on the Navajo, Hopi, San Carlos Apache, and Zuni reservations. So, Amy and Leigh's pedagogical strategy of incorporating weather folklore into inquiry-based science is actually well supported by extant literature.

The photos of the documents that Leigh shared with me about this science project are provided below:

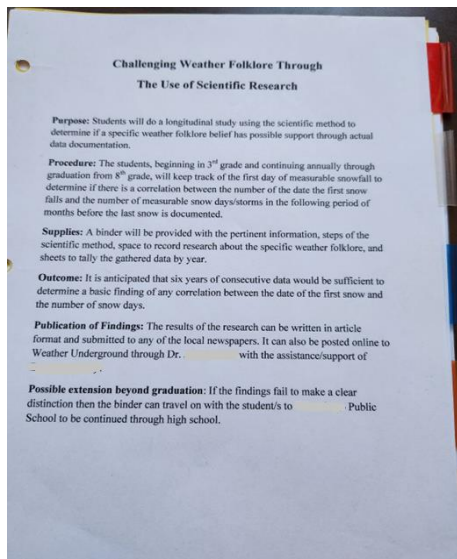


Image 6.1. Weather Folklore Scientific Inquiry

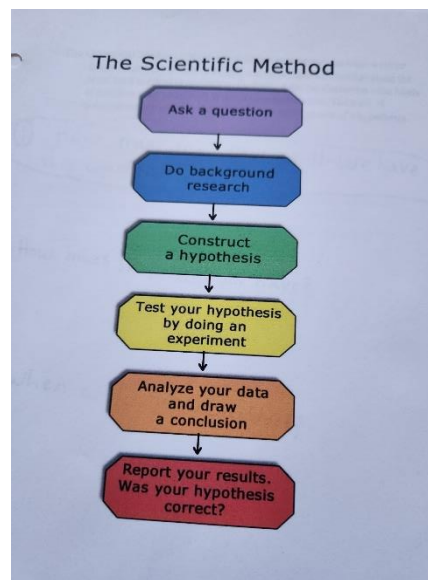


Image 6.2. Scientific Method

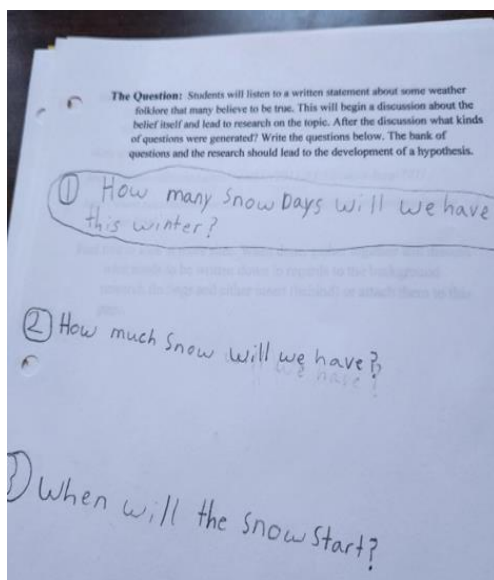


Image 6.3. Student Worksheet

Analyzing Data and Drawing a Conclusion

Students will tally up the number of measurable snow days per snow season (late fall into spring) and compare that to the date of the first measurable snowfall. Is there a correlation between the two items each year?

Year #	1 st snowfall date	# of snowy days	Notes
1) 2015 - 2016			
2) 2016 - 2017			
3) 2017 - 2018			
4) 2018 - 2019			
5) 2019 - 2020			
6) 2020 - 2021			

Image 6.4. Data Analysis Sheet

“I’m big on puppetry”: Arts-Based Approaches in the Science Classroom

In Leigh’s and Amy’s outdoor classroom, the students at EPPS have the opportunity to experience performing arts and traditional storytelling through puppetry. The teachers not only teach hands-on science in the outdoor classroom based on projects, but they also use several multimodal and arts-based approaches that are culturally and

linguistically relevant to Native students. Leigh and Amy are not alone in harnessing the power of arts-based approaches in science. Krajcik and Sutherland (2010) and Liao (2016) discuss similar examples of arts-integrated STEM projects in their work and Crawford (1995) emphasizes *creative* ways of knowing for Indigenous students.

The Umo^oho^o language is implemented throughout the curriculum and classroom areas. Leigh said to me that she incorporates storytelling, uses puppets, and integrates literature into science teaching. She explained to me how she uses puppets to explain the daily lives of animals, such as night (nocturnal) animals, and how students can relate themselves and real-life situations to these animal puppets through animism. Leigh actually does fun games and plays/skits, helping her students learn science while acting in a puppet show (see photo given below).



Image 6.5. *Puppets Used for Arts-Based Science Teaching*

Through art integration using puppetry, Leigh integrates also language arts into science teaching.

I'm big on puppetry and using puppets. Yeah. And I know kids love them. So, I amassed this huge collection of puppets which are out in the "Little House of

Learning”. I think that it is looking for things that appeal to children, and then bringing that into science, whatever it happens to be, I think that the puppets, in order to learn about those animals, if you have one on your hand, it goes from there to there, you become that, and kids do that, they pretend all the time. When the puppet is on your hand, your responsibility is you are that squirrel, or you are that porcupine. So, I teach kids what they're like so that the kids can understand that all of these are different kinds of animals, and some are related. They're surprised at which ones are related and some of them are afraid of each other: If you are the wolf, don't try to eat everything in the class, because people won't want to be around you. And that's what happens in real life.

(Interview transcripts, October 28, 2022, and November 16, 2022).

Leigh also uses videos (another multimodal instructional strategy) to teach life skill sets to her students. Some videos caught her attention in which a gentleman carves and drills acorns adding some twigs as limbs to make a tiny person called “Becorn,” and then he takes natural-life photographs with real-life birds and animals. Leigh explained this in detail because these videos sparked her teacher’s mind to think about the habitat loss project⁴³ in the outdoor classroom because of the abundance of acorns on their school grounds:

There's a guy named David M. Bird, and he worked for Lego and then he left, and he came back to the United States...he made these little acorn people, he calls them Becorn, like acorn, Becorn. He makes them and he puts them on like a branch, and then he photographs [them]. He puts his cameras there, but he goes at a distance and does remote control for his cameras, and he takes photographs

⁴³ Habitat loss project is explained in Chapter 5.

of them like he's got this little acorn person, and they're holding a hollowed-out acorn like a bowl and there [are] little seeds in there, and birds will come over and feed out of that. He has a little expression on his face.

(Interview transcript, November 16, 2022).

This is another way Leigh and Amy use art and encourages their students' creativity in their science classroom.

“It's tailoring to the specific culture”: Leigh’s Views on Cultural and Linguistic Relevance and Standardization

Since Leigh has worked with Native American students in different reservation schools for a long time, she shared her opinions about the tensions teachers face while adhering to national and state standards, meeting students' needs, and having to align with the cultural norms and standards of Indigenous schools. I specifically asked Leigh how she connects the nature-based classroom with the culturally and linguistically relevant pedagogy, to which she answered:

[Nature-based science] is generalized and then putting it through the cultural lens is making it specific. It's tailoring, it's specific to the place, specific to the culture. And that's what she [Amy] does. And that's what they do down at the Umoⁿhoⁿ Language and Culture [department]. We get our information [from them], like the weather and things like that they bring those materials to us, because they know we'll use those kinds of things. So, they're supporting us by bringing us and sometimes they even develop stuff because they know we'll use it. For the science part, we kind of share, I'm good with some things and she's [Amy] better with other things. I hear because of the loss of traditions and loss of

culture, it's very important to focus, to make sure that that gets supported so that the kids' identity, not just as children, but as Umoⁿhoⁿ children, Native children, gets supported, but outside it would be just as important to whatever is relevant. But it's good to talk about what other people do too because we all share the same world.

(Interview transcript, October 28, 2022).

Leigh also was clear in her stance on the use of science standards in a nature-based program and why cultural relevance is more important for their Native students.

She said:

Standard-based...it gets in the way of innovation in a nature-based program. That's two different ways of looking at the same thing. I have a hard time with standards. There should not be gateways. There should actually be milestones or something, or benchmarks or something. We try the best we can to align it with science standards. [We] use the Nebraska science standards which I would rather use the Next Generation Science Standards because with the Nebraska one, [the] second grade gets no biology, and this is like meteorology, biology, geology, and things like that. So, yeah, that's too bad. We're trying to develop standards of our own, and I think that this is most comfortable, not being fettered, not being tied down. It's more about the experience than worrying about do they fit in this category and that category. As a teacher that hobbles me, that ties me down. We don't worry about that. We don't let that hinder us. It doesn't drive us, we don't keep to the standard, we keep to the bigger picture. We're new to this, we're new to this level of teaching science, the experience of science to 442 kids, and this is

big, and so right now, we're finding out what works, what doesn't work. Our overarching goal is for them to be experiencing, rather than talking about, rather than reading about, rather than watching the video, and go out and see it in real life. The cultural standards we're just starting to look at now because that's mostly about language and tradition, which we are trying to do like what we're doing with the Grandpa Cottonwood Tree⁴⁴. We're trying to use some of this year, this year is our big nudge, figuring out how to make everything work.

(Interview transcripts and field notes, October 28, 2022, and November 16, 2022).

Leigh's perspective on standards-based science teaching getting in the way of nature-based education is exactly what Castagno and Brayboy's (2008) stated in their study that increased emphasis on standardization and high-stakes accountability under the NCLB Act of 2001 has eventually resulted in less culturally responsive educational efforts and more Indigenous children left behind in our school systems. Moreover, Leigh and Amy's creation of their own science curricular cultural standards (Umoⁿhoⁿ) is similar to what was discussed by Castagno and Brayboy (2008) about the Alaska Native Knowledge Network (1998), which provides an exemplary model for developing Indigenous people's own cultural standards for curriculum. The Yu'pik communities have adopted Alaska Native Knowledge Network curricular standards to complement the standards set forth by external governmental agencies to ensure that local cultures and languages are represented in school curricula (Castagno & Brayboy, 2008; Stephens, 2000).

⁴⁴ Grandpa Cottonwood Tree is a 182-year-old tree on the EPPS school campus. See Chapter 5 for details of the tree-age project and "tadé sagi," a culturally and linguistically relevant science activity with the EPPS students.

“Makes them gentler, kinder”: Social-Emotional Learning and Healing from Trauma

When I asked Leigh how she and Amy help Native children in their social-emotional learning through the outdoor classroom, Amy was quick to point out that Leigh is always aware of children with special needs, and that's why she always does the life skills sets with them. Amy added that Leigh is always thinking about how to meet their needs. Because Leigh had undiagnosed learning disabilities as a child, she is sensitive to the needs of students with disabilities. To answer my question about the beneficial effects of the outdoor classroom on children with special needs, Leigh said:

It has to have some kind of chemical reaction of that soil in their bodies going on for them to get so invigorated. Yeah, I mean, yes, this is continuing...it's just like, a natural process going on. For them to have the opportunity to do that at school here, and then be teaching them some science about the Earth and, you know, the nutrients and the microorganisms that are in there, the living beings that are so small that we can see them, the worms, the insects, all of those things that go along with that soil, that's going to help support our plant life, you know, we get the opportunity while they're so happy. In social-emotional learning, [they] start with a child, the child is the center, and they work their way out. The child learns to feel and care for themselves, and out, and out, and out. What we do is we start [outside], connect to the outside, connecting to the plants, connecting to that bumblebee, connecting to whatever, we start there about caring for that and learning to care for that, and then it comes in, and it feels this way, instead of trying to do that way because some [students] don't want to let anyone in. It's too

sensitive...too painful...So, experience learning in whatever capacity, whether it's a walk, whether it's looking at the clouds, and it takes them out of themselves, it just puts them out there in the world. What's needed is to be present and helpful in ways that they assume are helpful...so, it can be good.

(Interview transcript, November 16, 2022).

Leigh's pedagogical practice of honorable harvest and respecting the plants provides social-emotional learning to students who are struggling due to the painful life events they experience and helps them heal from trauma. Skewes and Blume (2019) support this practice saying culturally appropriate, effective interventions are sorely needed among these populations. Similarly, Hobot (2017) states that AI/ANs in urban areas experience higher rates of poverty, unemployment, low education, homelessness, and health disparities compared to the general population. Hence, Leigh's unique intervention of revering plants and performing an honorable harvest calms her students down and makes them kinder. Leigh's culturally relevant practice that promotes social-emotional learning for her students also nicely ties in with Ladson-Billing's (2009) definition of culturally relevant pedagogy, which "empowers students intellectually, *socially, emotionally*, and politically by using cultural referents to impart knowledge, skills, and attitudes" (p. 20).

“Feeding the family”: Outdoor Classroom Offers Nutritional Health, Self-Dependence, and Food Security to Native Students

Because a few of their students are obese and even struggle to walk, Leigh reminisced on an instance when one of her Ho-Chunk friends told her why Indigenous people are biologically predisposed to certain ailments. Being a science teacher, she

believes that she needs to teach her students about this undeniable connection between Native people's anatomy and their health.

Ho-Chunk people have large hearts and large organs because they were very busy. They were always on the go, always doing...[in] genetics, these large organs are made for moving and doing things. And now we're sedentary and we're getting diseases in those organs. That's complex because when you're talking about traditionally what they ate, they were more mobile, so it was more fats and meat and berries, and things like that. So...we need to do the changing of diet, supported by teaching gardening, and things like that, and how to use it in better ways. Also, the getting up and moving around and being more mobile, getting kids [to] do that. Because we have some kids, it's a strain for them. We have one boy that's in the fifth grade, and he has a hard time walking.

(Interview transcript, November 16, 2022).

After re-reading the transcript of my interview with Leigh I noticed how Leigh addressed Ho-Chunks as “they” and then transitioned into using “we” as in “we’re sedentary and we’re getting diseases.” By this statement, I understood that Leigh feels that she is one among the Indigenous communities that she has worked with and considers herself a true ally to Native communities. This also supports Amy’s true feelings toward Leigh. Amy calls Leigh Wagónze⁴⁵, as Leigh is the senior partner, and also stated that they both were “like-minded people.” Amy also said that when she got the opportunity to work with Leigh, she felt so much at peace with the way that they conduct their teaching with the students.

⁴⁵ Wagónze means “teacher” in the Umo^ohoⁿ language.

I then asked Leigh about her take on the food sovereignty of Native people, and she said because of her experience working with Native students for a long time, she wants to help her students become more self-dependent by learning to garden, which could ensure food security for them. Leigh and Amy explain to their students the scientific benefits of eating nutritious, healthy Indigenous foods. They teach them how to cultivate vegetables so that they can learn agriculture as a skill and be able to feed their entire family.

We [Amy and Leigh] would always remind them that we're teaching [them] the skills. Because once you have those skills, you always have those skills, that's a life skill. So, you don't have to be hungry, you know how to plant a garden, start small, two tomato plants or tomato [and] cucumber, and just start and each year make your garden a little bigger. And after a while, you'll be feeding your family, you know. And that's our hope, their engagement is in there.

(Interview transcript, November 16, 2022).

“It's not treating people like people”: Standing Up as an Ally for Tribal Sovereignty and Self-Determination

As mentioned in the introductory paragraph of this chapter, Leigh's ancestors lived on the lands of the Wampanoag Confederacy. Leigh said that her connections to the Wampanoags go way back to the beginning of colonization, and she said that they have lived in the same place as the Wampanoags, as they were all living within the same 15-mile radius, “*tied to the land.*” Hence, she is a huge supporter of tribal sovereignty and expresses great concern for the Wampanoags and all Native American people.

For the Mashpee Wampanoags to be fighting for recognition, because they had it, the Obama administration granted them, it was over 20 years...fighting for it, the elders who were in the very beginnings of that were already gone when they finally got recognition. And then Trump came into power and took it away...they still haven't been able to get past that and get full recognition, which I think is awful, which is even worse than awful. I think that it's a horrible practice of putting people through that. And there was a senator from Connecticut that was pushing for the status quo of not recognizing [Mashpee Wampanoags] because they were not on 1934 rolls or whatever it was, and weren't recognized at that time. But when you have a history of being disenfranchised and not being recognized, it goes way back to colonial times...so, it's such a horrible practice and it still goes on, and it goes on with other ethnicities, you know, that "you're not included" kind of thing. I find that unconscionable. This whole thing of other people deciding what you should have and needs to happen, it's still pervasive now...it's not treating people like people, we forget about humanity in all of this, and we treat people like objects and it's unacceptable. I think that that's really important to [know] the community's and kids' feelings about how we treat the world around us. It grows stewardship. I do feel that that's important that the land should be returned to [Native people]. I do feel that definitely there needs to be more Native people in government making decisions. If that's how things happen here, then they need to be at the table with everybody else. It's time that people realize that it was the Indigenous people here that took care of the land, and we need to start listening to them.

(Interview transcripts, October 28, November 8, and November 16, 2022).

Despite having a rough personal and professional life with a lot of setbacks, challenges, and difficulties, Leigh remains a kind human and a scholar with a big heart and strong resolve. Leigh's passionate description of Native American people and her actions as a longtime teacher in various Indigenous communities in Nebraska provides evidence that she is a true ally to Native people and why she believes self-determination for Native people and returning their land back to them are so important. Leigh and Amy help in growing stewardship in their students through their teaching in the outdoor classroom encouraging civic engagement through culturally and linguistically relevant student-centered projects, such as the habitat loss project, Indigenous healthy food cultivation projects, greenhouse and medicine garden projects, and the puppet theater.

Chapter Summary

In this chapter (Chapter 6), I have narrated Leigh's story that explains how her lived experiences have shaped her teaching philosophies and culturally and linguistically responsive pedagogical practices to teach science to Indigenous students and meet their unique needs. Some of the themes that surfaced in Leigh's story include her own positioning as a White teacher in Indigenous schools; the urgent need for culturally and linguistically responsive project-based and arts-based teaching for the Native student population; ways to connect Native culture, language, arts, and storytelling in science classrooms; the differences between western science and Indigenous science; the importance of helping Native students in becoming self-reliant in Indigenous food cultivation; and helping students become aware of the real-world issues so that they will become self-determined leaders in their tribes. In the next chapter, I turn to Renee's story.

CHAPTER 7

A TRUE UMOⁿHOⁿ AT HEART: RENEE'S STORY

Renee is a Umoⁿhoⁿ woman, a direct descendant of Chief Blackbird, a very famous chief in the history of the Great Plains. Her bloodline on the other side comes from Chief Yellow Smoke. Her clan is Moⁿthiⁿkagaxe, which means the Earth maker.

Renee is a veteran teacher and scholar with three master's degrees, majoring in five different streams of study. She has been working at Earth People Public School for 18 years⁴⁶. She is currently the Director of Native American education, and she teaches the Umoⁿhoⁿ language and culture classes for K-12 grades at EPPS. She also teaches science to high school students in grades 9-12, partnering as a co-teacher with a high school social studies teacher at her school.

“I grew up learning about nature from my family”: Renee's Upbringing and Development of her Umoⁿhoⁿ Identity and Spirituality

Renee was born and raised in the Umoⁿhoⁿ Nation reservation. Hence, every part of her Umoⁿhoⁿ identity and her spirituality have been shaped by the Umoⁿhoⁿ creation story and other traditional stories that she heard from her family while she was growing up. *Blackbird Family* (n.d.) describes the Umoⁿhoⁿ creation story as follows:

At the beginning, all things were in the mind of Wakoⁿda. All creatures, including man, were spirits. They moved about in space between the earth and the stars (heavens). They were seeking a place where they could come into a bodily existence. They ascended to the sun, but the sun was not fitted for their abode.

They moved on to the moon and found that it also was not good for their home.

⁴⁶ Renee has worked 16 years as a full-fledged teacher, before which she was working as a paraprofessional for two years at EPPS.

Then they descended to the earth. They saw it was covered with water. They floated through the air to the north, the east, the south, and the west, and found no dry land. They were sorely grieved. Suddenly from the midst of the water up rose a great rock. It burst into flames and the water floated into the air in clouds. Dry land appeared the grasses and trees grew. The hosts of spirits descended and became flesh and blood. They fed on the seeds of the grasses and the fruits of the trees, and the land vibrated with their expressions of joy and gratitude to Wakoⁿda, the maker of all things.

In fact, Renee said that while growing up, she learned all the stories from elders in her family and the community which shaped her becoming a true Umoⁿhoⁿ person at heart.

I was raised up more traditional, so I was always told to listen to my elders when they have something to share with me if they have a story to tell me...be respectful and listen to it. I really don't know any other way...I grew up with this way of life, that my elders are my teachers, they're the ones that pass the knowledge down that we need to survive. In our culture, it's all of our elders' jobs to teach us, to share knowledge with us, to tell stories to us. I grew up learning about nature, from my family and learning in the field and learning to observe everything and try to figure out why, what works best, and being in this land and having those elders that knew about the edible plants in the different areas. My mom [and] the females [taught] me how to prepare them and make sure they're safely prepared, so nobody gets sick, and preserve them and stuff. So...I grew up...we didn't really separate it like science. It was part of our way of life or way of being...Our

spirituality isn't separate from who we are either, you know, everything is all one big, holistic picture.

(Interview transcript, October 25, 2022).

The above-mentioned quote describes how Renee's Umo^oho^o identity is inextricably linked to the Umo^oho^o creation story and spirituality. Renee explained about spirituality or the relationship her people have with their Creator by saying that their languages were given to them by Wako^oda so that they could communicate with Him via prayers. So, when they do their powwows, they beat a big drum which she likens to her people's heartbeat. Renee said that when they dance around the drum with prayerful minds, their heartbeats communicate with Wako^oda. She said that they dance and move clockwise around the arena to follow the path of the Sun. Renee explained that everything her people do is related to the path of the sun or the "Four Hills of Life" and "Seven Directions," which are the north, south, east, west, sky, earth, and inside of themselves. She further explained that according to the Umo^oho^o culture, the circle of life, the "Four Hills of life," means that everything is in a circle. The "Four Hills" correspond to the stages of life, such as the infant stage, adolescent stage, adult stage, and elder stage, which are in fact the natural progression of life for all humans. What Renee shared about their people's daily activities relating to the path of the sun while navigating their "Four Hills" is related to the proven scientific fact that people age as the years go by, i.e., the Earth rotating on its own axis producing the 24-hour day and the Earth revolving around the Sun producing the 365-day year. Renee supported her claim that she learned everything from nature and based her learning on different seasons and directions by stating that:

Our new year has more meaning to us. Ours is the first thunder in the spring when the...The Big Dipper is ready to pour out its content. Once you hear the first thunder, that's when our spring starts, but that's also when our new year starts because that's when everything is starting to come back to life...we don't share stories until after the snow sticks to the ground. So, this is our season for telling stories. So that's why we have them out now [wintertime]. But then [we] even learn that there are specific times of the year [when] we do specific things.

(Interview transcript, December 8, 2022).

Renee is not alone in stating that Indigenous people value their cultural stories and spirituality and that they learn from nature and yearly seasons in a holistic way. Studies by Barnhardt and Kawagley (2005) and Burgess (1999) and many others also document how Indigenous people comprehend things in relation to the whole (holistic), and the “laws” are continually tested in the context of everyday survival. Barnhardt and Kawagley (2005) have found that Indigenous people engage in a form of science when they are involved in the annual cycle of subsistence activities. Extant literature, such as that of Sparks (2000) also relates to Renee’s lived experiences of learning from her elders and how elders in the community can serve as invaluable and resourceful role models to Indigenous children and youth.

While talking about elders, Renee also added details about her family and clan. Renee said that as far as lineage goes, her clan follows a patriarchal system, so the last name of the Umo^oho^o people comes from their father's clan. However, Renee also said that they were traditionally matriarchal because they consider women sacred because they escort life into the world. As to the traditional social responsibilities and role of

women and men in her tribe, Renee said that the women took care of the home and did the gathering and the harvesting, and the men went out to hunt. Renee also said that the women were the leaders in the home and were called matriarchs. If men want to go to a female for advice, it is going to be either their mother or their older sister. Renee concluded that the role of the matriarch is to give advice and to have that knowledge passed down.

Regarding her own family, Renee's mother was a teacher, and her father was in the military. Renee sadly shared a poignant story about her mother's childhood. Renee's maternal grandmother had epilepsy, which caused her to have seizures. Unfortunately, Renee's maternal grandfather fell off the roof and passed away. Because of these circumstances, the U.S. Government's foster care system unilaterally determined that Renee's grandmother was an "unfit mother" because she had seizures and "could not care for her children." So, they unfairly took away Renee's mother and her siblings from her grandmother, as they have done for many more children. Renee's mother was put in a Catholic orphanage, even though she had family who could have taken care of her, such as her older siblings, aunts, and uncles. The Catholic orphanage/convent gave Renee's mother training to become a nun and a teacher. When her mom finally was old enough to understand the unfairness meted out to her by the U.S. Government that forced her to spend her childhood in an orphanage/convent despite having relatives, she was already indoctrinated to become a Catholic teacher, in the process losing her tribal identity and family heritage. The sad situation that Renee's mother had to endure is what Givens and Ison (2022) and Lomawaima and Ostler (2018) term "natal alienation" to explain the rupture between children and their tribal identities and family heritage. Durbar-Ortiz

(2014) and Lomawaima (1999) also document the negative impact of missionary schools on Native American family dynamics and traditional culture and language, which also explains Renee's mother's condition that was enforced upon her by the U.S. Government. The U.S. Government had a specific agenda and enforced violent strategies of pulling children out of their families, disrupting Indigenous people's ties to their land that resulted in the shedding of their tribal identity (Noel, 2002; Givens & Ison, 2022).

The following explanation brings clarity to Renee's mother's forced removal to a foster home and also explains the current-day conditions at Indigenous settlements. After a century-long forceful removal of Native American children from their families and stripping away of their traditions and Native identity by placing them in boarding schools, the U.S. Congress put a stop to this inhuman practice by passing the Indian Child Welfare Act in 1978, which forbade the separation of children from their families, relatives, and tribes and urged states to do everything they can to keep Native families together (Sullivan & Walters, 2011). Unfortunately, 32 states are failing to abide by the act in one way or another, and a National Public Radio (NPR) investigation has found that this practice is all the more apparent in midwestern states, such as South Dakota and Nebraska. This practice of forcibly taking away children from their families, which resulted in "lost children and shattered families," is prevalent in the Crow Creek reservation in South Dakota with the pretense of "foster care" (Sullivan & Walters, 2011). Native American children are overrepresented in nonnative South Dakota foster care homes, where almost 50% of the children in foster care are Native American (Sullivan & Walters, 2011). The situation is no different in Nebraska, where a recent Omaha World-Herald Newspaper article states that Native American and Black children

are overrepresented in the Nebraska child welfare system, the disproportionality index in 2020 being as high as 3.93% for Native American children as compared to 0.77% for the White children (Stoddard, 2023). According to Sullivan and Walters (2011), nearly 700 Native American children in South Dakota are being removed from their homes every year by the South Dakota Department of Social Services, sometimes under questionable circumstances. The circumstances can be complex in the ways in which “neglect” is worded in state laws, such as in Nebraska, and in the ways how the law is being interpreted and enforced by government officials. The broad definition of neglect in the Nebraska law includes a child being “deprived of necessary food, clothing, shelter or care,” conditions that typically result from poverty rather than from parents who don’t care about their children (Stoddard, 2023). As larger numbers of Black and Native children live in environments or reservations in abject poverty and prevalent substance abuse as compared to White children, it makes them more likely to be involved in neglect cases, so the state government’s child welfare workers deem it “necessary” and “beneficial” for the children to be taken away from their families. Child welfare workers also bring their own potential biases and blind spots along with the lack of knowledge of Native cultures to the job of investigating reports and deciding how to handle Native children and families (Stoddard, 2023; Sullivan & Walters, 2011). However, Sullivan and Walters (2011) claim that the state government’s ulterior motives and powerful forces at work for encouraging such an inhumane practice are money and politics; the federal government sends thousands of dollars to state governments for every child they take away from their homes with the pretense of providing them with “safe and financially stable homes with good educational opportunities” within the foster care system. Another

important point that Sullivan and Walters (2011) make is that foster care in South Dakota has become a powerhouse for private group home providers who bring in millions of dollars in state contracts to care for Native kids, who are also classified as “special-needs children” according to state and federal institutions. Some providers have close ties to government officials, so they receive tens of millions of dollars in no-bid state contracts, highlighting the unusual relationship and the powerful role money and politics play in South Dakota’s foster care system (Sullivan & Walters, 2011). After a year-long NPR investigation, the authors sadly state that “even Native American children who grow up to become foster care success stories, living happy, productive lives, say the loss of their culture and identities leaves a deep hole they spend years trying hopelessly to fill” (Sullivan & Walters, 2011).

Unfortunately, Renee’s mother passed away when Renee was a young adult. So, Renee is the oldest female in her immediate family and has been the matriarch of her family for several years. Renee added that she was raised to be Umo^hoⁿ and has always remained spiritual and followed the footsteps of her ancestors.

“I am a reservation Native American”: Renee’s Umo^hoⁿ Identity Guides Her School Experiences and Pathways to Higher Education

After learning about her family history and her Umo^hoⁿ identity, I asked Renee about her formal school and college experiences that led her to become a Native American science teacher and the Director of Native American Education in a reservation school. Renee told me that she frequently moved schools because her father was in the military. She started off studying in her own tribal reservation school, where science was not a core subject. It was every other-day-type subject. Renee added that science and

social studies were on the back burner, whereas they did math and English every day for longer periods. She then transferred to a private high school in a nearby city. Even in that school, her science learning was no different. The learning was all in the classroom and predictable, with the little chemical vials that the teacher had ordered, and her teacher knew what color the results were supposed to be. Hence, Renee's science experiences were less student-centered and more lab confirmations. She never did any kind of field study in science. Renee told me that she took physics in high school, and she did not see the connection between formulas and life, and it didn't make sense to her at that age. However, Renee said that she related to the study of biology and genetics since these science subjects seemed closer to nature, and they made sense to her Indigenous self.

Honestly, I kind of hated science for a while. I really, really did. It was not fun. I didn't see how it related to the world. I didn't really like the chemical equations, and balancing chemicals and stuff like that didn't make sense to me in the world. So, it seemed removed from the world. But then the other stuff, you know, like, biology and genetics, and, you know, all that stuff made more sense to me...that's because that's what I had been basically exposed to biology and stuff like that. So, there was a time when I didn't really like science, but I obviously got over it because then I went on to pre-med.

(Interview transcript, October 25, 2022).

The Western ways of learning physics and chemistry concepts that did not make sense to Renee are explained by many scholars, such as Jorgensen (2020) who stated that Indigenous people have different ways of seeing, viewing, and interacting with knowledge systems. Incongruities between Western modern science and the knowledge

systems of Indigenous students like Renee make it difficult for them to make sense of highly Westernized and technical science content and curricula. Moreover, Renee's comfortability to learn a more nature-based subject, such as biology, supports the fact that Indigenous students learn from nature in holistic ways that are rooted in Indigenous cultural and linguistic beliefs. Aikenhead's (2001a) "cultural border crossings of students into school science" is an example where students like Renee can easily understand science if there is a similarity between their own culture and the culture of Western modern science. Other scholars such as Stephens (2000) and Davison and Miller (1998) also provide successful culturally responsive biology curricula examples, such as "Plants of the Tundra" and "ethnoscience lesson involving classifying Native plants" which also support Renee's liking for biology.

After her rather eventful high school science experiences, Renee started out as pre-med at a Midwestern university near her reservation, where she was faced with more obstacles. By that time frame, Renee had successfully passed many science courses, including organic chemistry. However, she had a bad experience with her advisor, who said to Renee that since she was from the reservation, she would not make it to medical school. Because of this negative stereotypical perception of Renee's Indigenous identity, her advisor did not approve of any more science content for Renee. So, Renee had to look for a new advisor, and this advisor happened to be an English advisor. So, her degree changed from pre-med to English, specializing in creative writing and concentrating on psychology. Despite having taken several science classes in pre-med, Renee ended up not going to med school.

In the meantime, Renee married a Sicilian White man and gave birth to her

daughter. However, she eventually divorced her husband. To make ends meet, Renee started working at a prison. When Renee's daughter became old enough to understand what she did, her daughter had a hard time dealing with the fact that her mother worked in a prison, and she asked Renee to do something else. While working at the prison, Renee noticed that a lot of the people there made some bad choices, and they did not have good decision-making skills. So, she wanted to take control of her career and life. She came to know of programs meant for Native Americans that would help her get a teaching certificate, and that was how she ended up becoming a teacher. A part of that grant was that she needed to do English as a Second Language (ESL) as her second endorsement. Hence, Renee became involved in the language and culture center to do her student teaching for the ESL part of her degree. Eventually, she got her initial teaching certification and her ESL graduate endorsement at a large midwestern university. Then, she went on to earn her Master of Education degree in Special Education and ESL. Renee's thirst for knowledge urged her to go to an upper midwestern state university to complete her Master of Science with two different majors: Cross-Curricular Instruction and Curriculum and Instruction, Leadership, and Art Integration. Then, she received her second master's degree in education at the same upper midwestern university majoring in Pre-K through 12 Administration.

Given her exemplary academic achievements and three master's degrees majoring in five different disciplines, Renee was destined to make her mark in teaching. Just around the time she finished her initial certification, two teachers from the alternative education program quit their jobs in EPPS and decided not to come back. The school then faced a situation where there were two openings in the alternative education program. So,

they hired Renee and another new teacher who just graduated to fill in the alternative education positions. Renee and her colleague had to be able to teach a certain number of topics or a certain number of classes for the kids to get the required credits to graduate from high school. Since Renee happened to have enough credits for science and language arts, she was able to get her house endorsement for both natural sciences and language arts in her school. She also taught the Umo^{ho} language, math, and science. Renee ended up teaching science because the school had a great need for science teachers since EPPS had gone through six middle school science teachers in a year. In the next year, the superintendent asked Renee to teach middle school science as well as alternative education (high school), so Renee started handling both positions. Before being given these positions, Renee worked as a paraprofessional at EPPS for elementary grades for two years before transitioning to a full-fledged classroom teacher and continuing to work at her school for 16 years. Renee told me that she has also taught Special Education for secondary grades (6th through 12th grades) before she was assigned to teach in the alternative education program.

Renee shared with me that at EPPS, the alternative education program is for high schoolers. She taught all of the high school natural sciences and middle school sciences. She also collaborated with Mid-America Transportation Center and Nebraska Indian Commission on Indian Affairs to get an after-school science program going at EPPS. This program was not just for high schoolers, it was for fourth grade on up. This went on for six years, and the school was running the program for the seventh year in 2022. Since Renee recently took charge of becoming the Director for Native American Education of the school this academic year, she has not had the time to be really hands-on with the

after-school science program currently. However, she continues to do many other things at her school, such as provide professional development programs to non-Native teachers and newly hired teachers and introduce them to the Umoⁿhoⁿ culture and language. She has also collaborated with a large midwestern university and with the Nebraska Commissioner on Indian Affairs for another after-school science program. In the summers, the program actually takes high schoolers (any student who has finished eighth grade through seniors) to the large midwestern university for classes from Sunday through Friday. They get to work at one of the university campuses, where they engage in science challenges and STEM challenges and then attend leadership workshops too. Currently, she also teaches the tribal government class with a social studies teacher, where she teaches the science component for high school students. Renee is also on the Science Education Partnership Advisory Board, which is a collaboration between EPPS and a midwestern medical university, where all the schools serving Native American students around the area develop science and math resources. She shared with me that she has been working with them for around 15 years, during which time, she served on the board of advisors. She has been newly elected to the Nebraska Indian Education Association Board of Directors too.

Despite Renee's school and college accomplishments, her Umoⁿhoⁿ female identity and intelligence are not always perceived well and respected by society at large. Renee told me that she grew up as a reservation Native American, and that is different from a Native American person who resides in cities and towns outside of reservations. Renee sadly said that she most often hears only the deficit viewpoints from the general population. However, out of sheer determination to succeed, and hard work, Renee went

on to complete high school and college and earn multiple degrees from renowned universities.

I'm from a reservation, like, I'm not just Native American, I'm reservation Native American, I grew up here. There is a difference between the way urban Indians are treated, I guess they call them urban Indians. It's an old term, but it's urban Native Americans and reservation Native Americans. You know, there's a difference between how they treat those different subsets of Native Americans in the general society...the common view or that I hear most often is that if we're on the reservation, and we stay on the reservation, you know, they assume that we're on drugs, they assume that we are alcoholics, they assume that we have kids when we were real young, that we didn't ever go to college, we never left the reservation. You know, they don't think that you can leave and get your education and come back, which I did.

(Interview transcript, October 25, 2022).

Even though Renee is highly accomplished and has a very successful career, she has had people doubt her pathway to higher education and hint that she has received free education because of her being a Native American woman. Aside from this, Renee also shared with me her experiences of being treated differently by people who doubt Renee's academic accomplishments and questioned her knowledge as compared to her Sicilian White ex-husband, who was far less educated than Renee. Renee's quote given below alludes to the negative stereotypical views that the general public has about Renee's intersecting identities of being a woman and a Native American, and this quote also throws light on how Renee is constantly having to prove herself to people around her,

how difficult it was for Renee in the beginning, and how she has changed her outlook regarding the microaggressions that she had had to endure.

My ex-husband was a Sicilian, so he was basically a European white man and he had very little college. But people would tend to talk to him and explain things to him in bigger terms, and then he would have to ask me what they meant. So, it's like the assumption was that just because he was a White male, he would understand better than I would [and] how things work. I see that with some of my [white] colleagues too how we can go to the same professional development...and they'll call on them a lot more. They'll even call on non-Native females before they'll call on a Native female to offer their opinions and stuff...It is something that I have had to overcome...since high school because I was the only Native female or the only Native in my graduating class. So, I guess it's just something that I've had to kind of navigate forever. And I guess...I kind of expect that I'm going to have to prove myself. And part of it's hard because we grew up to be humble, that's part of who we are. You don't brag about what you do and stuff. So it took me a long time to speak up and say I have all this education; I've accomplished all these things... I've accepted who I am. So, I guess [now] it doesn't really impact me much. It does impact how other people see me. I do know that. When I've interacted with some people, I've literally had to hand them one of my cards and be like, I have three master's degrees with five different majors. I understand that you're condescending to me, and I understand that you think I'm not smart enough to know what you're saying to me, but I do, and I need you to relate to me as though I am a full-grown adult person rather than somebody who

is ignorant.

(Interview transcript, October 25, 2022).

When I further probed Renee about what exactly people's perceptions of her were and what people think of Native people's life on the reservation, she shared her own academic experiences with me.

I had to hit the ACT score cutoff just like everybody else did. I had to take the PRAXIS exam just like everybody else did. And I scored very high on the PRAXIS exams, you know, I guess I'm just good at test taking or something, but people assume you don't have to do all those things because you're Native, so you get everything handed to you. I have a mortgage...I have college loans...I also have medical bills, but there's still that idealism out there, that everything is handed to us and then we get free everything, and we don't have to work for anything. So, it kind of belittles all of the hard work that we actually do on the reservation to try to make things better.

(Interview transcript, October 25, 2022).

Renee's experiences of being a Native American female teacher, the prevailing gender inequity, and the deficit mindset about Indigenous people have been studied extensively by theorists and researchers. Similar to Noel's (2002) statement that Native children are continually viewed with a deficit mindset and are being subjected to "intelligence testing," Renee had to continually prove herself as a student and teacher. From Crenshaw's (1991) intersectionality theory and TribalCrit (Brayboy, 2005) viewpoints, it is apparent that Renee has experienced the intersecting systems of oppression such as sexism and racism while she was belittled by society due to her

Native American identity and her gender. Renee's experiences also align with Solórzano, Ceja, and Yosso's (2000) view of critical theory in education, where societal and school structures continue to maintain racial, ethnic, and gender subordination. A few examples of racial and gender subordination that Renee gives are that her ex-husband (a European White male) and her non-Native White colleagues are perceived as "more intelligent" than her simply because she is Native American and a woman. Renee further adds that these societal perceptions still maintain the deficit viewpoint that people from the Native American Reservations cannot thrive without additional support and disregards the Native American people's achievements in their reservations. Renee's motivation to excel and high academic success urge people to take Chigeza's (2011) resource-rich view of Indigenous communities, instead of taking the deficit viewpoint that blames Indigenous students and explains their perceived failure in terms of low interest in academics, poor motivation, and perceived low ability levels of Native students.

Meeting of the Two Worlds of Science and Culture: Renee's Science Teaching Philosophies, Teacher Knowledge, and Practices

According to Renee's teaching philosophies, Renee is very much an advocate for teaching her students the best way that they can learn. Renee shared with me that learning and taking in that knowledge and trying to retain that knowledge has been an important part of her community's survival throughout many years. A part of her way of being a teacher is to remind them of things that they have within their tribe and the experiences they have had throughout their lives, such as the circle of life or the Four Hills of life. When I asked about her views on science education, she said she feels there are some systematic barriers where the importance placed on science right now across the country

is not as developed as she would like it to be. She feels that way because a lot of the schools are just strictly focusing on math and reading. Renee said that the legislation is such that students have to be proficient at reading by third grade. So, the schools are focusing more on reading and math. She also feels that science is not necessarily present in the elementary grade levels, and in most schools, students get only 20 minutes to do science every other day and then 20 minutes to do social studies the other days.

When Renee teaches science in middle school or high school, she has always integrated science into reading and math (the subjects that students get more time to engage in on a typical school day). Renee's pedagogical practices involve many different ways in which she incorporates science into core subject areas and other areas she feels she can fit the science content at the high school level while focusing on Indigenous (Umoⁿhoⁿ) cultural science. Renee elaborated on this by stating:

Now, it's kind of moved us to a place where [we] realize you can incorporate reading and you can incorporate art and everything else into science. It's not a stand alone little subject, you can cross over with the other subjects, and I guess it just became more important. I think it made me more inclined to help the students see science everywhere. It wasn't just set aside in a lab or set aside in the classroom. It's everywhere. Science is a parallel to [our cultural science], like, okay, I have this deer that we just butchered, and we did it in a certain way. Why did we air it out before we skinned it? Why did we remove parts of it first before we aired it out? Then [they] learn. Okay, well, these are the internal organs that potentially could rupture through, decay before you can butcher it, or might lead to a bad taste of the meat if it's sitting too long like that. So, I consider that all

science. Even though it's all science, it fits in so well with the things that they should be exposed to that I was exposed to, and my daughter was exposed to culturally. Hunting season is big...Since I experienced that in my own life, I can help them and then I have also [scientific] knowledge. Yeah, I can help them understand why that makes sense...Not only does it help them understand the science part of it, but it helps them understand the [cultural] side of it. So it's like a meeting of two worlds; science is like the meeting of two worlds for them.

(Interview transcript, December 8, 2022).

Renee's description of her teaching philosophies as the "meeting of the two worlds" aligns perfectly well with Aikenhead's (2001a) concept of "cultural border crossings of students into school science" and Jorgenson's (2020) findings of creating bridges between the two worldviews of Indigenous knowledge systems and Western modern science. Since 100% of Renee's students identify as Indigenous, she said that her method of teaching is to make it relevant to her students.

Another aspect of Renee's teaching philosophy relates to the historical trauma that her students and their ancestors have gone through and the challenges that they face in their everyday lives. Renee said:

I understand the hurt, a lot of noise inside of them, just historical trauma and all that, that they're trying to live with an imbalance in two different worlds. They face a lot of challenges, just in everyday life. Truancy...is a big issue. They move a lot, so mobility is really high. In general, the poverty rate is very high in our community. We have 100% free and reduced lunch here. We are in what's called a food desert. So, it's really hard to get access to fresh foods. The nearest grocery

store is about 30 miles from here so if you don't have a car which a lot of our families don't have a car or working car or gas, to go 30 miles...then that also contributes to your ability to get provisions for the household, so it all kind of snowballs into impacting them at school. I always have food and basic hygiene items available. My kids don't have to ask; they can come to eat it and use whatever they need to do. One of the kids was telling me this morning that nobody has snacks like I do. We do have a high rate of alcoholism and drug addiction here. We've even [had] more than one student [commit] suicide in the past couple of years here. And right before COVID hit, we had a big cluster, and so that obviously impacted the students and the staff and everybody in the whole community. The missing murdered Indigenous people: we've had several victims in our own community. If Indian Child Welfare Act gets overturned, [children] will have the risk of being sent off of the tribe and away from family and maybe never reunite...High poverty levels, high alcoholism, high drug use, domestic violence...all those are reasons for kids to be removed from their biological homes, but I don't know that necessarily means they need to be removed from the entire tribe. When we do sweat [lodge], we pour water on the rocks to make steam. The steam is cleansing and lifts up our prayers in our hearts. I mean, water is just a really big part of who we are. So, we talk about that both in this class and in the tribal government class. We talk about that, and they've participated in it. They [now] know those cultural ways [to heal].

(Interview transcript, November 8, 2022).

Renee's long description of adverse childhood experiences that the Umoⁿhoⁿ

children face in their everyday lives is a stark reminder of the intergenerational trauma the community as a whole has been experiencing all these years after the forced subjugation by the U.S. Government in the past and also the foster care system that removes Indian children even to this day. Renee's practice of using water during cultural events in the sweat lodge acts as a potent way to help students cleanse, heal, and have some peace in their lives. Another comment from Renee about student mobility and truancy being high in her school is well supported by Hamann et al.'s (2022) study, where the authors state that student mobility is a significant feature of American Indian Education in Nebraska, and this feature is not anticipated by the state, the school districts, or local teacher education programs.

Renee's Diverse Pedagogical Approaches

"Make it Something They Care About First": Holistic Learning via Storytelling

When I asked more specifically about science teaching approaches, practices, and her own cultural beliefs about science teaching, Renee gave a detailed description of her pedagogical approach to "holistic learning" via storytelling.

[When] I grew up, we didn't really separate it like science, it was, as part of our way of life or way of being. It's just like our spirituality isn't separate from who we are either; everything is all one big, holistic picture. I guess systemically, traditionally, science is taught little piece, little piece, little piece. Our students learn better through whole-picture holistic learning...when you're doing a storytelling-type thing rather than just spitting out facts. If they remember the whole story, then they'll remember the little details. I think that the way that I teach helps them make connections to what they're seeing every day in the world and then it helps them to remember how things are related.

They'll look for the connections and the observations of how our people thought historically. I was talking about how hail was made and how that's the name, mási, our town was named after. I tell the whole story instead of just stating bullet points and facts and how it relates to our cultural history, instead of just isolating it to mean it's frozen pellets that come to the ground. I've always just told the story of the water drop [for explaining the water cycle] or told the story of the specific animal instead of, they have these many teeth, and they have this much fur or whatever. I use the story of Blackfish...That's the story of SeaWorld and how they mistreated the whales and how that changed their habitat and their behavioral pattern. [Students] got to see what a behavioral pattern was and how they survived and how they hunted...but they also had a story to go behind it. So, it was relevant to their experiences, you know, they could see why that mattered. I always had some kind of case study-type thing to back up whatever content they needed to learn...to make it important to them...what SeaWorld did, impacted the Pacific Northwest, with the oil pipelines, and the whole thing with Standing Rock that impacted...all the nations came together to defend that because that river comes right through here, everywhere south of there would have been impacted. So, I guess my pedagogy is just to make it something that they care about first, like through different tribal aspects of like in New Mexico, where they still don't have good running water and people are still rationing water because they have to haul it from hundreds of miles away. So, it's making them care about stuff. But it's not really a problem here on our reservation right now. It was in the past, so we have to remind them of the past.

(Interview transcript, November 8, 2022).

Renee's detailed description of her storytelling pedagogical approach relates well

with Sparks' (2000) and Gillies and Rafter's (2020) studies where Indigenous students have been found to master concepts in content-based subjects like science when oral techniques accompanied by visual and active cues are employed to promote active engagement and learning in Indigenous students. This explains why Renee's strategy of teaching science using the storytelling method is successful for her. Renee further added details about specific science subjects that her people were proficient in by stating that:

We do have some physical sciences in our culture...[students] finished building an earth lodge and that takes a lot of knowledge of angles and weight. So, this classroom that we're in is kind of modeled off of the earth lodge. You know, how we have a circle building...and support beams, and the roof comes up to a center hole. And that takes a lot of planning. Yeah, planning and knowledge of how that roof can be strong enough to hold if somebody were to step on it, but yet still have a hole in the middle. Once they start digging into their culture and their history and stuff, I teach them about that, then they just start to see, oh, this is why that custom, this is why that makes sense.

(Interview transcript, December 8, 2022).

Renee's examples of Indigenous systems of knowledge, such as the story of the Blackfish (biology) and building of the earth lodge (physics) are similar to a study by Burgess (1999) that validates Renee's statements. Burgess (1999), like Renee, has stated that Indigenous people have studied and know a great deal about the flora and fauna, and they have their own classification systems and versions of meteorology, physics, chemistry, earth science, astronomy, botany, pharmacology, psychology (knowing one's inner world), and the sacred.

Cultural Relevance vs. Standards-Based Science Teaching

Given the specialized nature of the science and culture courses that Renee teaches in high school, Renee does face the dilemma of cultural relevance vs. standards-based teaching for her students. However, Renee shared with me that she makes lessons relevant and engaging to her students by using hands-on strategies, art-based science and math, bringing elders into her classroom, and translanguaging and language preservation/revitalization.

To me, my method of teaching is to make it relevant to the students and 100% of the students I work with are Native American. So, the easiest way for me to teach science is through the cultural lens. While I was working with science, have always been very encouraging to do hands-on stuff, which is what I feel is needed anyway. I would buy my own supplies and stuff. [The school] allows me to do these things in my classroom to teach it as I see fit, and they have faith that I'm doing what I need to do...they really encourage engaging lessons, which usually include something for the kids to do hands-on or to participate in, not lecture-based. Most of our students don't learn lecture-based, they just don't. Yeah, I get bored at lectures, you know, so I don't think they'd want to sit through them.

(Interview transcript, November 8, 2022).

Renee's culturally relevant and hands-on approach to teaching science is very similar to studies conducted by Cleary and Peacock (1998), Castagno and Brayboy (2008), Sparks (2000), Haynes-Writer and Valdez (2021), where the researchers have concluded that concrete ways to connect learning to students' lives are employing a more holistic approach and integrating experiential learning, service learning, hands-on

learning, and field trips. Renee's strategies align well with Sparks' (2000) finding that students from Native American cultures learn new skills by observing them and then doing them.

Development of Critical Consciousness and Civic Engagement in Indigenous Students

Renee employs project-based, hands-on, experiential learning engaging students in field trips and case studies where she connects environmental awareness and civic engagement to students' lives, such as the water quality project and helping students create a bulletin board about the "Missing Murdered Indigenous Women" for the "Parent Night" event at school so that there is increased awareness about these ongoing issues with their reservation. Renee said that these projects have made a huge difference in her students' understanding of science, as she herself did not have any such opportunities when she was in school.

We're doing the water quality curriculum...the point of the curriculum is to build civic engagement around water quality. Historically, we've had some pretty poor water quality here on the reservation, and just more recently in history, we've gotten an upgrade to our infrastructure. So, had we done this project 10 years ago, we probably would have found bacteria in our water because we are on boil order all the time...I think it was 2007 or 2008, we [school] literally were closed from Thanksgiving through Christmas break because our water was so full of bacteria that basically the E. coli was too dangerous. So, we didn't have any running water that we could use. So, we ended up having to close the school for that entire time and get this petition from the government for emergency purposes because we just didn't have the ability to provide fresh water.

So [now], when the kids were testing for bacteria and stuff, they were very interested in that. They tested [the water] for nitrates, nitrites, lead, oxygen, and a whole spectrum of tests; there's like 18 things on the test strips. And they also used bacteria bottles, they tested for bacteria, and they tested for a little tube with a pill in it. They tested for dissolved oxygen. We tested for all that, and they looked at the results, and they talked to each other about the results. They told some of the other teachers, which, I guess, in and of itself is civic engagement by telling other people. They brought in other people to see what they were doing and to see the results...then they learned about other areas and water problems there. That's about it for the water quality project.

Then, we learned about our history here...the government, whom would we have to talk to for us to make changes to this, if we were going to go on a government level [like] the Game Warden, we have our Wild Fish and Wildlife Office and we have our environmental safety people and, and so just all of that, for the water [quality project]. They even wanted to test other stuff. So, they tested like Dr. Pepper, and they tested all these other different liquids. And, the thing is, had we not had them go collect the water and bring it back and care about the water, or give them a reason to care about what we're doing, I think that they wouldn't have cared about the chemical reaction going on. They would have just not seen the relevance of it. Since this [water] came from our own Creek. [It] has contaminants, so when we tested that water, they got to see the bacteria and stuff and it's been deemed unsafe to use on the garden, and so they got to experience that firsthand and test those waters. We just walked down and got this, and now

we're using these chemicals to see what's in there. Then that made the difference. When I was in school, we never did that kind of field study. You know, it was all in the classroom, little vials that the teacher had ordered or whatever and it was predictable, so the teacher knew what color it was supposed to be.

(Interview transcripts October 25th, November 8th, and December 8th, 2022).

Renee shared with me some photos that she took of students conducting a water quality project, which are given below:



Image 7.1. *Water Quality Project*



Image 7.1. *Water Quality Testing*

Renee's water quality project is a great example of experiential learning and collaborative science education that is already highlighted by researchers such as Djonko-Moore et al. (2018) and Sharkey et al. (2016). The researchers, like Renee, have concluded that students' science knowledge and engagement can be enhanced through cultural relevance and eco-justice-related topics, such as the environmental impacts of chemicals used in industries and small businesses around the school. Like Renee's water quality projects, these projects by Djonko-Moore et al. (2018) and Sharkey et al. (2016)

not only addressed the national science standards but also addressed the overall unit objective of applying relevant knowledge of chemistry to everyday situations and students' knowledge about eco-justice. Renee's strategy of experiential inquiry also complements Buxton's (2010) study in which the Social Problem Solving through Science (SPSS) projects helped middle school-aged youths to study the local environmental challenges that had implications for human health and well-being. Other studies that are very similar to Renee's culturally relevant inquiry-based, place-based science teaching are Sutherland and Swayze's (2012) study that concludes that Indigenous science education needs to focus more on real-world issues based on students' lives and communities, providing opportunities for personally meaningful, experiential, inquiry-based and place-based learning that is fundamental to scientific and environmental literacy. To understand Renee's rationale for choosing place-based experiential strategies, Zocher and Hougham's (2020) study provides a great explanation. Zocher and Hougham's (2020) study integrates place-based experiential education to offer a way to engage American Indian students and other culturally and linguistically diverse students in responding to the intersectionality of culture, power, and the local environment using innovative pedagogical practices. Renee's pedagogical practices and Zocher and Hougham's (2020) study critique the U.S. environmental education curriculum in that it has not entirely focused on understanding the biophysical environment of the local rural or tribal populations (such as land and water issues), and little attention has been paid to discussions about the environmental problems created by the dominant Western cultural norms, such as dumping of industrial wastes into rivers or lakes and other environmentally destructive effects of human activity. Just like Renee,

who described the instance of heavy bacterial contamination in the water source (in the creek that flows through the reservation), the dumping of industrial wastes into rivers and lakes near the Indian reservations described by Zocher and Hougham (2020) is extremely problematic and could be considered as environmental racism because they were intentionally aided by U.S. government leaders who belong to the dominant White race.

Other related civic engagement projects that Renee did with her students were the “Missing Murdered Indigenous Women (MMIW)⁴⁷” bulletin board and “Walk for the lost children⁴⁸”. Renee shared the details about the projects as follows:

[In] my culture class, we've done a lot with the missing murdered Indigenous women. They've done a bulletin board for parents' night so that it could spread awareness, which is considered important for civic engagement. They did the missing murdered Indigenous women project and...they took what they learned, and they made a bulletin board display during “Parent Night” and it's still up, so it's like spreading awareness. They came up with some statistics and stuff and some artwork that they did and made a bulletin board out there in the hallway where, you know, everybody walks by there can see it. So, that's a form of civic engagement that they did, and it included culture. And now we're working on some civic engagement for the lost children that were lost to the foster system, “the walk for the lost children.” So that's the next piece of civic engagement that

⁴⁷ According to *MMIW* (n.d.), Indigenous women and girls are being taken from their families and tribes in an alarming way. As of 2016, the National Crime Information Center has reported 5,712 cases of missing American Indian and Alaska Native women and girls. Strikingly, the U.S. Department of Justice’s missing persons’ database has only reported 116 cases. The majority of these murders are committed by non-Native people on Native-owned land. The lack of communication combined with jurisdictional issues between state, local, federal, and tribal law enforcement, make it nearly impossible to begin the investigative process.

⁴⁸ The lost children whom Renee is referring to are children taken away from their parents/tribes by the foster care system in many U.S. states.

my students and Bevan⁴⁹'s students are going to be involved in. It's a multi-class collaboration to go do that. And then Jeremy⁵⁰'s students are also going to be invited to join us too. So, that's a really hard, impactful one because the students literally march for five miles [when]it's cold.

(Interview transcript, November 8, 2022).

The water quality project, the MMIW project, and the Walk for the Lost Children projects teach Renee's students not only about the scientific elements of studying water and the impacts of water/environmental pollution but also educate students about environmental racism. In this way, Renee's students learn how and why marginalized populations such as their own are more likely to end up with poisonous/toxic substances in their environment. Then this is connected to larger issues of crime and injustice in Indigenous communities such as MMIW. So, according to Renee, her Indigenous community suffers from the effects of water pollution, and they also suffer from the lack of policing and other resources that are always provided to dominant populations but are denied or provided to a lesser degree for the Indigenous populations, such as Renee's tribal community. This is evidenced by many Indigenous women who went missing or were killed in Renee's reservation, but unfortunately, the authorities did little about it. The authorities never listened to the communities about either the MMIW or the missing children, so Renee had to take up these projects with her students so that awareness can be built around these real and disturbing issues. These grave happenings in Indigenous communities support the notion that people belonging to the dominant race do not care about the natural environment that the marginalized populations live in. Some more

⁴⁹ Pseudonym.

⁵⁰ Pseudonym.

evidence from the literature is provided by Torso et al.'s (2021) study where the Coeur d'Alene Tribe in northern Idaho has been profoundly affected by environmental hazards due to toxic metal contamination from historical mining practices. Renee shared the photo of the MMIW bulletin board that her students created:



Image 7.3. *Missing, Murdered Indigenous Women Project Bulletin Board*

Arts-Based STEM Teaching

Renee is also a strong advocate for incorporating the arts in STEM teaching. She herself has participated in various art-integration programs and uses the art supplies in her science and math classrooms.

I participated [in] the "Mastering the Arts" program" and "Integrating the Arts." They both supplied some of the art supplies for whatever I want to use it for...just basic supplies that they supplied to everybody like special kinds of paper, markers, paint, color pencils, black paper...Art-wise, they pretty much gave me

the training to use it, even the Cricut⁵¹ machine they provided, and I've used that with the students to make some geometrical shapes and stuff, a mug press, so some of my kids have been able to design their own mug.

(Interview transcript, November 8, 2022).

Since many of Renee's students are multiracial and multilingual, arts-based pedagogical approaches would suit well for them, as Berriz, Wager, and Poey (2018) have found that arts inspire emergent bilinguals to use their imaginations to link their lived experiences to solving academic problems, and this broadens the possibilities for culturally and linguistically diverse students. Just like Renee's science class, science education literature provides evidence for STEAM-based projects, such as that of Liao's (2016) study, which gives examples of arts-integrated STEM projects in which students designed and engineered a 3-D display of a story by drawing on mathematical knowledge along with scientific knowledge.

Involving Native Elders from the Community in Classrooms

When I observed Renee's classroom on three different days, I found that she had at least two Elders from the community in her classroom to help her integrate the Umo^{ho} culture and language into Renee's lessons. Renee said:

I do have elders that work in my classroom with me. Like, I hire elders, as part of my program, and they sit in the class with me in two of the high school classes, and I have one that comes around with me to two of the elementary classes. They will add their opinion if they think more needs to be said, or if something needs to be said differently, they will let me know.

⁵¹ A Cricut is an electronic cutting machine that can cut all sorts of designs from materials like paper, vinyl, card stock, and iron-on transfers.

(Interview transcript, October 25, 2022).

Renee's strategy of involving Elders in the community is very similar to what Chigeza (2011) said about tapping into the community's cultural wealth, which is an array of cultural knowledge, skills, abilities, and contacts possessed by Native communities. Sparks (2000) and Bang and Medin (2010) have also talked about the value of using Native experts and Elders as instructors and resources in the classroom so that loss of Native American traditions and language could be prevented. Renee has Elders teach with her in her classrooms because she values the wisdom of the Elders, and this method also provides positive role models for her Native students. Also, these Elders are some of the last fluent speakers of the Umoⁿhoⁿ language, and so they fill in gaps in Umoⁿhoⁿ knowledge that Renee lacks, and they are helping to revitalize the language. This is exactly what Sparks (2000) found in his study. Renee centers on multiple Indigenous ways of knowing by letting the Elders incorporate music, ceremonies, storytelling, dance, songs, and other vehicles to instruct students just like Sparks' (2000) and Bang and Medin's (2010) findings.

Use of Multimedia and Technology for Instruction

Renee used case studies in the water project and encouraged them to include photographs and voice recordings in their project work or while integrating the Umoⁿhoⁿ language into science. She explained case studies as looking at situations that are happening in real life in different locations. She gave an example of case studies that her students used for their project, such as that of Flint, Michigan, which is a real-life situation that is going on that does relate to science. Renee added:

I encourage the kids to take pictures...so they can have [them] with them.

Sometimes, I have them turn on their voice recorder...when I'm teaching them new phrases or new content and they're not with me and they want to remember how to say something or remember even a word for something, then they can have access to that on their phone. I have 50 minutes a day with them. And so, then whatever I want them to work on during that period, I have them open it, [and] do the recording themselves. If they want to practice other words and stuff and play Umoⁿhoⁿ language games on the App, they can do that, you know, because most of them have a phone and stuff. I don't have Chromebooks in this room yet, which is another thing that I'm working [on] for the future so that we can have Chromebooks for them to make their own videos or even iPads.

(Interview transcript, December 8, 2022).

Renee's strategies of including multimodal elements of arts and technology into her pedagogy are similar to what Krajcik and Sutherland (2010) stated that various features of literacy are embedded in inquiry science, such as connecting multiple representations (e.g., art and multimodal elements) and providing opportunities for students to use technology to improve their understanding of science. Renee's multimodal, inquiry-based learning strategy also supports McGinnis's (2007), finding that students' social worlds are multilingual and multimodal; hence, inquiry-based projects are successful in promoting student success in science.

Translanguaging in Renee's Classroom: Preserving and Revitalizing the Umoⁿhoⁿ Language

As the recently appointed Director of Native American Education, Renee's schedule is packed, as she goes from class to class teaching the Umoⁿhoⁿ language and

culture in an attempt to preserve and revitalize their language. Renee's high school class starts off going over the Umoⁿhoⁿ terms using flashcards for colors, seasons, animals, common food items, verb tenses, and other common words that students would come across in their daily lives. Students repeat the Umoⁿhoⁿ terms after Renee. Renee has dotted-line Umoⁿhoⁿ worksheets for students to practice reading and writing their Native language. The students also watch YouTube videos on the Umoⁿhoⁿ culture and powwow celebrations. Renee uses visual aids, photos, digital copies, and artifacts such as models while explaining the Umoⁿhoⁿ terms. Renee shared with me that the Umoⁿhoⁿ language is very descriptive and that her tribe came up with terms based on their observations. All of Renee's lessons aligned well with the seasons so that the students could relate to their daily life happenings. Renee also uses the Umoⁿhoⁿ language App as a useful teaching tool for different grade levels; this App is embedded in the Chromebooks used by students.

Renee fluidly moved between English and Umoⁿhoⁿ languages and encouraged her students to do the same. As mentioned earlier, she was ably supported by the Elders in her classroom if she gets stuck explaining phrases in the Umoⁿhoⁿ language, for example, Renee did not know the term for breakfast cereal, and the Elder in the classroom clarified her doubt and voiced the right term to her and the students. Renee gave a few examples of Umoⁿhoⁿ words that are coined smartly, logically, and meaningfully by her ancestors.

I teach the kids that, you know, our people were smart, we came up with words based on how things function or you know, describing things, like, our word for coffee is moⁿkoⁿsabe, which means black medicine because we understood that

there was kind of a healing property to caffeine on a certain level, you know, it could help with a headache or could help you be more alert. Our mother's sister is also our mom and actually, our word for them is Nohóⁿzhíⁿga which means "little mom." Our number for six is "shápe." And our number for 12 is "shápenóⁿba." Our number for two is "noⁿba." So, our word for 12 shápenóⁿba literally means two sixes. So, they observed somehow, that either you add six and six, or you multiply six by two, and you get 12. So that's, I guess, one example. Another observation science-type thing is our word for rain is názhíⁿ. Our word for "to command" somebody to stand up is názhíⁿ-a. And then our word for hair is názhiha. And it's all vertical. Názhíⁿ comes down vertical. And then názhíⁿ-a is to stand up. And then názhiha hangs down vertical. So it's all related in a scientific way, as far as why they call them that or why they were named so close to each other.

(Interview transcript, October 25, 2022).

I was quite surprised to hear Renee say the Umoⁿhoⁿ word for the mother's sister that meant "little mom." In Tamil language too, we respectfully call the mother's younger sister as சித்தி (Chithi), which also means "little mom." This similarity between a Umoⁿhoⁿ and Tamil word highlights the ingenuity of Indigenous people across the world and their ability to coin words/phrases meaningfully and logically in their Native languages.

When I asked Renee how she incorporates the Umoⁿhoⁿ language specifically into science teaching, she shared with me that:

When I was teaching middle school science, I would use some language but not as

much as I use here [high school culture class]. Like I'm more language-heavy obviously here because that's my core subject. I just had phrases and stories [then] and sometimes I had some of the other culture aides come in and talk to the kids about stuff and so, when I was teaching science, I taught in a way with a story. I think about 20 years ago when we started working on this program here, the Umoⁿhoⁿ Language and Culture Center...it wasn't always able to reach everybody. And now we're kind of reaching out a little more with the elementary, you know, we got it so that we can make the elementary rotation, and then I have more high school classes, and I'm co-teaching [language] with core subjects.

(Interview transcript, November 8, 2022).

Since I visited Renee's classroom around Halloween⁵² and during wintertime, culturally relevant storytelling and learning of terms related to the holiday season were in progress in her classroom. Some examples of the Halloween-themed Umoⁿhoⁿ words and phrases that Renee used in class are Zhú etázhi and Wanóⁿxe⁵³ (see the photos below).

⁵² Halloween is not a cultural holiday for the Umoⁿhoⁿ people since Europeans brought the festival here among the Umoⁿhoⁿ people. So, all the Umoⁿhoⁿ words related to Halloween are coined based on observations. For example, Zhú etázhi is the word for Frankenstein, which literally means “not his body” in the Umoⁿhoⁿ language.

⁵³ Wanóⁿxe means Ghost.

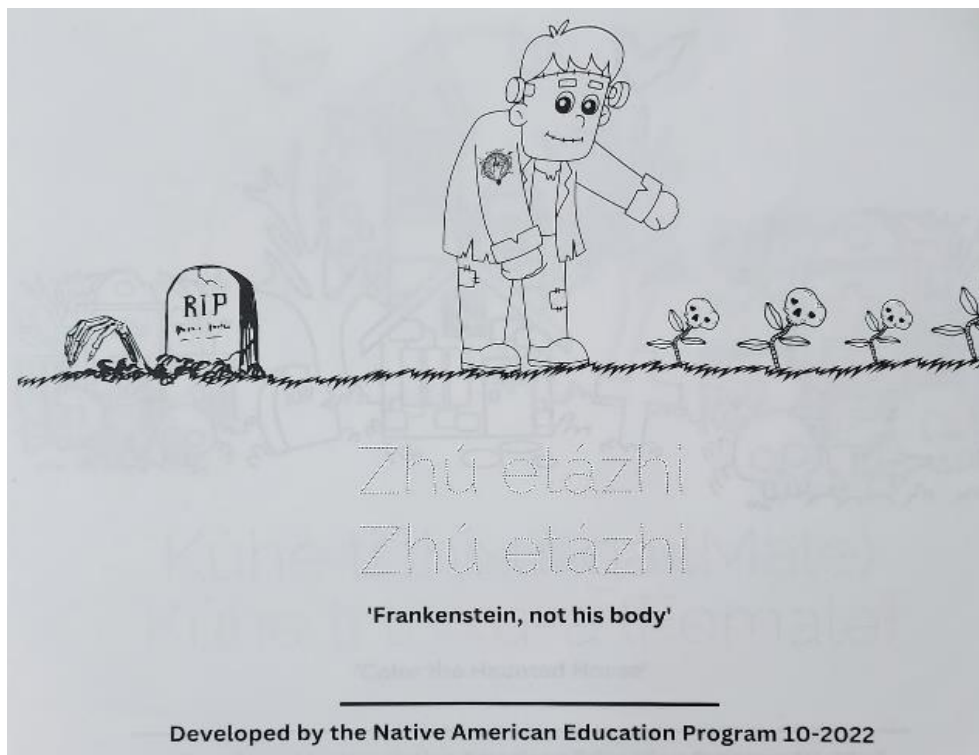


Image 7.4. Language Revitalization: Umoⁿhoⁿ word for Frankenstein

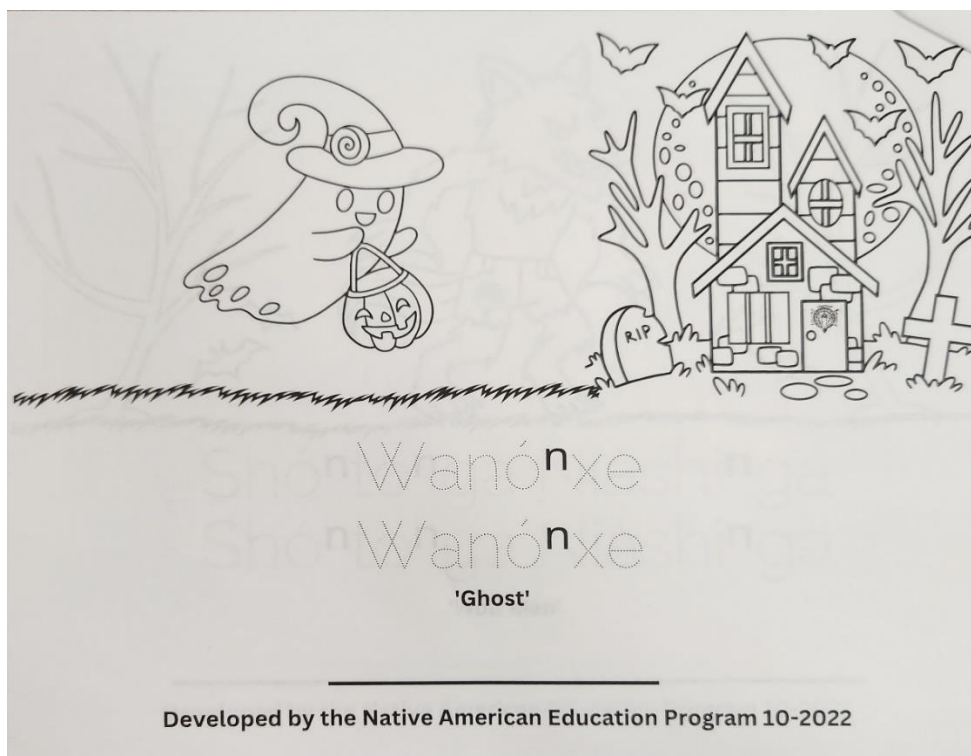


Image 7.5. Language Revitalization: Umoⁿhoⁿ word for Ghost

Renee added that she is passionate about preserving and revitalizing the Umoⁿhoⁿ

language because it is facing extinction, and she uses translanguaging in her classroom to help students in her school learn their Native language to help preserve and revitalize it.

Renee said:

We're literally facing extinction for our language, and so we definitely encourage it [translanguaging]. Amongst the Indigenous communities, there is a drive to save the language, revitalize the language.

(Interview transcripts, October 28, 2022, and November 8, 2022).

Renee also said that her community has very few Native language speakers, and she gave reasons for this problem.

A large part of our language loss is due to trauma inflicted on us from boarding schools, assimilation practices, laws, and an interrupted mid-generation. So, some people never got to be fluent in any language because they weren't yet fluent in Umoⁿhoⁿ and then they were forced to learn English and they never became fluent in English. So, when you have somebody who never got to have a natural, fluent language, then obviously the language they pass down is going to be damaged as well.

(Interview transcript, November 8, 2022).

Renee's translanguaging practices and her efforts to preserve and revitalize her language are very similar to what was found by several researchers who worked with Native American populations. Renee engages in the dynamic process of meaning-making by using the students' full linguistic repertoire, which was theorized as the pluriliteracy approach by García and Flores (2013). Renee's culturally and linguistically relevant practices are alike Alaska Native Knowledge Network's (1998) culturally responsive

schooling, which has a firm grounding in the heritage language and culture Indigenous to a particular tribe and is a fundamental prerequisite for the development of culturally healthy students and communities associated with that place. Similarly, Renee's practices in her science classroom support findings from science education studies, such as Demmert and Towner (2003), Stephens (2000), Demmert (2001), Demmert (2011), and Pease (2004) that state that Indigenous students become enthusiastic and engage more with science content if they are given opportunities to do science activities that promote usage of their native languages in Indigenous language immersion programs. Although EPPS has not yet arrived at the stage where dual-language programs and Umo^hoⁿ immersion programs could be implemented, the school is headed in the right direction. Renee shared with me that she is very grateful to have a school superintendent, who is mindful of their culture and Umo^hoⁿ language, as she is very supportive of incorporating culture and language throughout the school, for example, in the design of their classrooms and in the artwork in the hallways. Some photos that illustrate the culture and the Umo^hoⁿ language in school hallways are provided below:



Image 7.6. *Hallway Poster #1*



Image 7.7. *Hallway Poster #2*

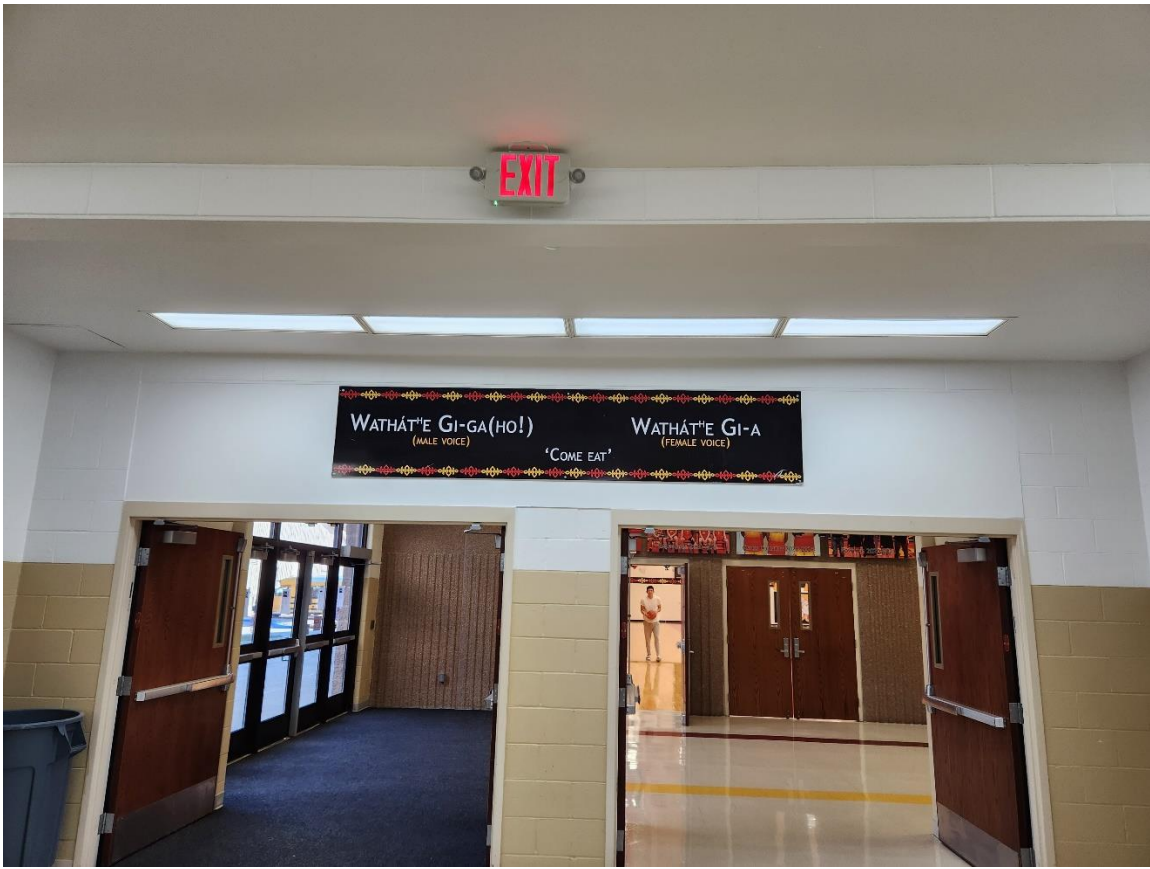


Image 7.8. *Hallway Poster #3*

Renee's Views on Health Issues of Indigenous People and the Importance of Food Sovereignty

Renee is inspired by how the Pawnee tribe has managed to bring back their thought-to-be extinct Indigenous blue corn species and ended up successfully cultivating them. She is so impressed by them selling blue corn mash and blue corn flour that she and other Native American teachers wrote a curriculum about the story in which the Pawnee tribe was successful in securing their food sovereignty. Renee also shared the same details as Amy did about the ways in which natural food sources were intentionally taken away from Indigenous tribes by the U.S. government, which had the ulterior motive of forcefully subjugating the Native American People. I asked Renee about how she is

incorporating this knowledge in her own science classroom and how this connects to the current-day health issues of her community members. Being a science teacher, Renee expertly explained the science behind the health issues of her community members and her school's efforts to help its students.

One of my units is how being put on a reservation impacted the food sovereignty of the [tribal] nations...An example right there is that it caused their [Pawnee] corn to go extinct, and that was one of the main things they lived off of. It's not just them, you know, we didn't have... our health has really declined because of being on reservations because we weren't able to... we mostly ate vegetables and buffalo [before], you know, and deer and whatnot. And once [the U.S. government] put us in one spot, we [couldn't] follow the buffalo herd, we [couldn't] get our food sources...which also talks to historical trauma. The foods that we were given by the [U.S.] government, and they called them commodities were not foods that were indigenous to us, and our bodies did not know how to process them. We didn't have anything like sugar. You know, everything was plant-based for us. [With] the introduction of sugar, our bodies didn't know how to metabolize that sugar. We didn't have "drinking alcohol." So, our livers didn't know how to process it; our livers still can't process it. That's why we have so much alcoholism because it affects us so fast, and it damages our liver, so alcohol wasn't indigenous to us, and it affected our health. Processed foods, canned goods, we didn't [do] canned stuff like that [with too much] sodium... So that is a big, huge thing. We were no longer able to have the foods that we had natural to us before being put in reservations, and it impacted our bodies in a negative way.

We're still dependent on these foods; commodities still do exist for those that are financially unstable. Everything's processed and packaged and not necessarily the healthiest for a growing brain [of students]. We do a lot of diabetes education because we have some students that are diabetic, as well as some staff. And quite honestly, they say, if you're Native American, there's a 50-50 chance you're gonna get it just from being Native American. So, no matter what you do, your genes are dictating that; you are more than likely to get it. We have a full-time nurse because we have so much need for medical, you know, students that take medicine throughout the day. And like I said, we have several diabetics that have to go check their sugar and take shots, and maybe eat something. So, we have a full-time nurse on staff [at the school].

(Interview transcript, November 8, 2022).

As was explained in Chapter 5, Renee's account is exactly the same as what Flood (2014) and Phippen (2016) have written about the systematic government-sponsored slaughter of the American Bison to ensure the subjugation of Native American people.

Renee even uses stories and documentary movies to explain the importance of achieving food security and sovereignty to her students.

We're taking kids to go see a movie called "Women of the White Buffalo", [in] which there [are] nine women, and they all have amazing stories of hardships, and overcoming [those] hardships.

(Interview transcript, November 8, 2022).

Renee's use of audiovisual resources as a pedagogical tool to explain challenging

topics evidences her teaching expertise and experience and also her deep commitment to including and engaging all of her students. The benefits of such visual representations have been well documented in the literature, such as Cleary and Peacock (1998), Gilliland (1995), Castagno and Brayboy (2008), and Gillies and Rafter (2020).

Renee's Perspectives on Healing from Intergenerational Trauma, Tribal Justice, Indigenous Sovereignty, and Reclamation of Native Land

Renee shared with me that the Umo^ohoⁿ tribe, like the other Native American tribes in the country, has historically been subjected to dehumanizing practices by the U.S. government, such as deculturalization that stripped away their identity, religion, and language, while their children were taken away to boarding schools. This practice is still continuing in another form where their children are being taken away by the foster care system, as was mentioned earlier in this chapter. Renee elaborated on healing from intergenerational trauma that occurs from participating in walks for missing children and Indigenous women by facilitating her students' engagement in civic engagement projects and activities.

A lot of that trauma comes from children being taken from us. Our way of doing things [walks, bulletin boards, etc.] is to remember those people and to make a sacrifice for them, and to pray that things get better and to spread awareness to people who don't know, that's our part of healing. The whole thing is spiritual, the whole thing is healing. We never have a big gathering without a holy man there to bless us and pray for the event and for the people there. And we always pray for those who passed on before us. And we always pray for the homes of the people who are participating, and we always pray for those who want to be there but

couldn't. So, there's a lot of spirituality involved in everything that we do when it's a large group.

(Interview transcript, November 8, 2022).

Like Renee, researchers such as Brown et al. (2016) and Skewes and Blume (2019) also talk about the pervasive influence of racism and the historical trauma resulting from colonization on American society and culture, such as the effects on the health and well-being of American Indian people, and the cultural disconnection, stereotypes and harassment, acculturative stress, and mainstream culture clash that Native American youth experience in today's world, all of which were described by Renee in multiple instances.

Renee said to me that she supports wholeheartedly Native American sovereignty and tribal justice.

I am a huge, huge, huge, huge supporter of Indigenous sovereignty, we are our own nation. All these other countries managed to have different nations on the same continent. You know, that's what we were. We are our own nation, we are our own people, our own way of life. So, as far as tribal sovereignty, I totally [and] 100% support that. I'm right there in the battle [of] trying to get equality. It's not even justice at this point. We're not trying to fight for justice at this point. We're just trying to fight for equality. Okay, justice is still down the line. You got to be equal before you can get justice. We're not, I mean, look at the MMIW just got a database, I think last year, the year before, and let's be honest, that database is not accurate. So, in order for us to be seeking justice, first, we need to call it. You have to understand that tribes, tribal people, and Indigenous people

didn't own the land, the land was a living thing too. Our ideal of ownership wasn't...they [the U.S. government] exploited that because we didn't view anybody as owning, you know? How can you own life? That land takes care of you, that land helps you survive, that land provides for you, the same way as the sky. They all provide for you and protect you and how do you own that? So, I guess that's where I stand on "land back." It's like, you know, what never should have happened to begin with. Well, just like a lot of stuff never should have happened, to begin with.

(Interview transcript, November 8, 2022).

Renee echoes what scholars such as Lee and McCarty (2017) and Mullen (2021) have already spoken about in the literature about tribal sovereignty, tribal justice, and calls for returning Native people's land to its original stewards. Similar to Renee's passionate support for tribal justice, there is a growing scholarship on environmental racism directed at Native American people, and self-determination and self-governance for Indigenous people over land, natural resources, and education.

Renee's Suggestions for Science Teachers Outside of Reservations

To help teachers working with Indigenous students in urban and non-reservation school settings, Renee offered some useful suggestions to meet the needs of Native students. Renee said:

First things first, they have to be mindful, like they have to be mindful of their students, they have to know their students. It's just like any other kind of differentiation. Our students learn better through whole-picture holistic learning. And so, they have to have elements in their teaching that help you see the whole

picture and then break it down into...instead of like, starting with a small piece and just adding on it and expecting them to make those connections. Start with the whole picture, and then go back and build it so that they can know what they're trying to build. Case studies are [also] a perfect way for a lot of our students. We need to make science a special [subject], so they could at least get 25 minutes a day every day.

(Interview transcript, November 8, 2022).

As discussed earlier in this chapter, Renee's first suggestion are well supported by Barnhardt and Kawagley (2005) and Burgess (1999), who detail the advantages of using holistic approaches to teaching Indigenous students. Renee's other suggestions indicate that science teachers could use case studies such as the water situation in Flint, Michigan, and in New Mexico, where tribal communities still do not have good running water and people are still rationing water.

Chapter Summary

In this chapter (Chapter 7), I have presented Renee's stories which are her racialized and gendered lived experiences that have shaped her teaching philosophies, pedagogical decisions, and culturally and linguistically responsive pedagogical practices to teach science to Indigenous students and meet their unique needs. Some of the themes that surfaced in Renee's story include diverse culturally and linguistically responsive pedagogical strategies for science classrooms, her teaching philosophies and spirituality grounded on lived experiences, and her views on tribal sovereignty and food security for people in her tribal nation. In the next concluding chapter (Chapter 8), I will conduct a cross-case analysis of the overall themes from all of my participants' stories and discuss

the connections (and unique elements) between them while providing the researcher's (my own) perspectives on my interactions with my participants. I will conclude by stating the study's strengths and limitations, implications of my study to research and teaching, and suggestions for future research.

CHAPTER 8

TEACHING SCIENCE THE UMO^oHO^o WAY: BRINGING IT ALL TOGETHER

Synthesis and Discussion

After having described in detail my participants' lived experiences of teaching science and meeting the needs of the Umo^oho^o students, I now synthesize and discuss the findings from the stories of all three participants in a cross-case analysis focusing on the common themes between all three participants, overlapping themes among two participants, some unique themes and issues that came up during my participants' individual interviews, and my relationship and shared understandings/experiences with my participants.

As Clandinin and Connelly (2000) have stated, "relationship is key to what it is that narrative inquirers do" (p. 189), my relationships with my participants played a key role in this collaborative narrative research. The discussions in Chapters 5, 6, and 7 were more fluid and story-like and connected with my own researcher interpretations and the relationships I have built with all three participants (Clandinin & Connelly, 2000). I have negotiated the entry and exit with my participants in the way of ongoing negotiations of the narratives between the participants and myself, the union of their narratives or experiences shaping this inquiry (Clandinin & Connelly, 2000). Hence, the discussion section is also written in the same vein.

To visually represent the unique and common themes that came up during the interviews, I designed a three-circle Venn diagram and a table (Figure 8.1 and Table 8.1).

Figure 8.1: Venn Diagram of Unique and Overlapping Themes from Participants' Lived Experiences

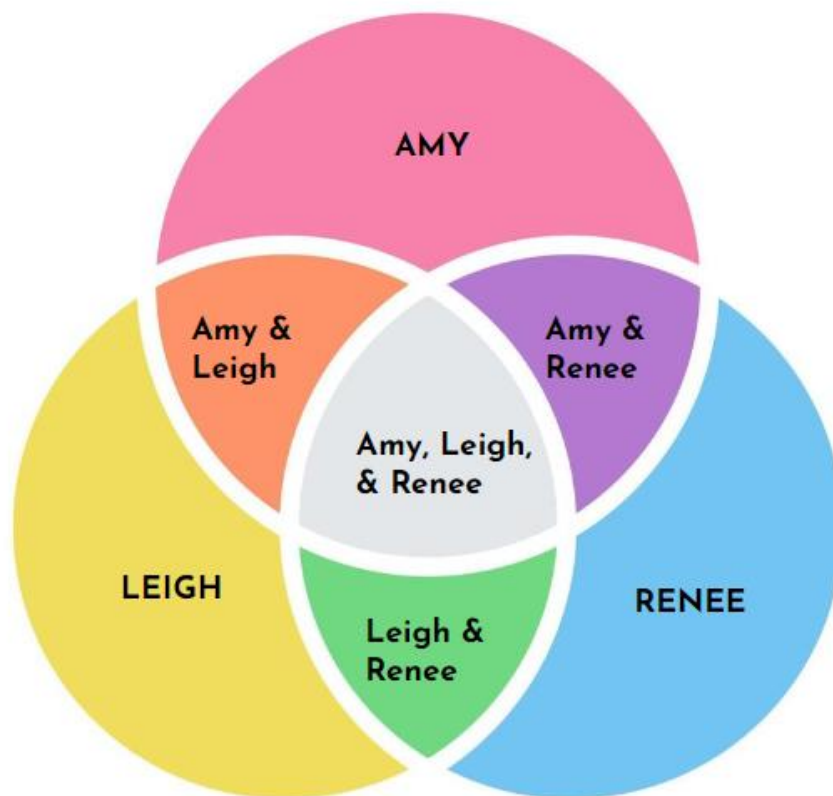


Table 8.1: Unique and Overlapping Themes from Participants' Lived Experiences⁵⁴

Participants	Unique and Overlapping Themes
<p>Amy, Leigh, & Renee</p>	<ul style="list-style-type: none"> • Holistic learning. • Indigenous spirituality. • Learning from nature and elders. • Storytelling as a pedagogical tool. • Natural elements as sentient beings. • Critical thinking in science. • Strategies for helping students heal from intergenerational trauma. • Food sovereignty. • Tribal justice and Indigenous sovereignty.

⁵⁴ Same color codes as in the Venn diagram

<p>Amy</p>	<ul style="list-style-type: none"> • Family members' experiences of deculturalization and religious suppression • Prayer song and sage ceremony • Sacred hoop of life: the Indigenous way of life • Four Winds: Culturally responsive Science terms for Four Directions • Familial bonding with students
<p>Leigh</p>	<ul style="list-style-type: none"> • Master naturalist and gardener • Respect for all living beings: Plants, spiders, birds, etc. • Use of weather folklore in science projects: Calculation of snow days in winter; Halo around the sun brings rain. • White ally: Insider and Outsider perspectives. • Sisterhood and Deep Concern for Indigenous people: Umoⁿhoⁿ, Winnebago, Ho-Chunk, and Wampanoag. • NGSS better than Nebraska State Science Standards.
<p>Renee</p>	<ul style="list-style-type: none"> • Being a reservation Native American. • Umonhon identity and spirituality. • Personal experiences of being discriminated against for her Native American Woman Identity. • Seven directions: Culturally relevant science knowledge. • Four Hills of Life: infancy, adolescence, adulthood, and old age; Culturally relevant science knowledge. • Personal lived experience of the unfair U.S. Government's foster care system. • Water quality project: Hands-on teaching about Environmental Racism. • Raising Awareness among Indigenous students: MMIW Bulletin board & Walk for Lost Children. • Study of biology closer to Umoⁿhoⁿ traditional science knowledge.
<p>Amy & Leigh</p>	<ul style="list-style-type: none"> • Áshita thewathe: Outdoor science classroom. • Ewithe Woⁿgithe: All people are relatives. • Science is everywhere. • Medicine garden. • Greenhouse farming. • Spring season: Planting Gardens. • Tadé sagi: culturally relevant science. • Habitat loss project.

	<ul style="list-style-type: none"> • Tree age project.
Amy & Renee	<ul style="list-style-type: none"> • Umo^hoⁿ language preservation & revitalization. • Indigenous food sources were brutally taken away. • Seasonal science lesson planning. • Being a Matriarch. • Focus on the development of Indigenous cultural and linguistic identity. • Health issues among Native Americans: Diabetes, obesity, mental illness, suicidal tendency, alcoholism, and drug addiction. • Civic engagement
Leigh & Renee	<ul style="list-style-type: none"> • Cultural relevance more important than science standards. • Use of multimodal instructional technology and art in science teaching: Puppets, videos, songs, dance, and skits. • Teaching focuses on the big picture. • Socio-emotional learning.

Common Themes Between All Three Participants

According to my model, nine themes were common among all three participants with some overlaps between two participants and a few unique themes drawn from each participant's stories. Firstly, I will discuss the nine common themes that were considered most important by my participants while teaching science and meeting the needs of the Umo^hoⁿ students, such as (a) employing holistic learning; (b) focusing on Indigenous spirituality, culture, and language; (c) learning from nature and from elders; (d) using storytelling as a pedagogical tool; (e) considering natural elements like the sky, earth, wind, animals, insects, and birds as sentient beings and that all humans are related to each other; (f) encouraging critical thinking in science by connecting with real-world issues; (g) learning about the effects of intergenerational trauma on students; (h) the urgent need for food sovereignty; and (i) ensuring tribal justice and Indigenous sovereignty. I will

also intersperse the overlapping themes between two participants and the unique themes identified for each participant.

Holistic Learning. As already stated in Chapters 5, 6, and 7, all three participants valued holistic learning or the big-picture learning the most while teaching science to Indigenous students. Renee, Leigh, and Amy vouch that their students learn better by starting the scientific concepts on a macro level and then breaking them into smaller, easily digestible pieces. This holistic method of teaching is more culturally responsive to the Indigenous student population, as many scholars have pointed out (Aikenhead, 2006; Barnhardt & Kawagley, 2005; Haynes-Writer & Valdez, 2021; Cleary & Peacock, 1998; Castagno & Brayboy, 2008; Sparks, 2000). As all my participants have stated, holistic teaching practices make their Indigenous students connect science to their culture and language, and the practices also make students feel proud of their Indigenous identity.

Indigenous Spirituality. Renee, Leigh, and Amy also stressed the importance of spirituality in teaching Native students. Amy's practice of prayer song and sage ceremony, Leigh's beliefs of natural elements as spirits that guide science teaching, and Renee's insistence on traditional prayers led by the Elders before any civic engagement event are examples of how spirituality is incorporated in culturally responsive science teaching.

Learning from Nature and Elders. While analyzing my participants' lives using Clandinin and Connelly's three-dimensional narrative inquiry framework of temporality, sociality, and place, it becomes apparent that all three of them learned science by learning from nature and from their elders, including their parents and grandparents. The chronological description of stories in Chapters 5, 6, and 7 evidence that elders have

played a major part in educating Amy, Renee, and Leigh because they learned to forage, hunt, fish, use scarce natural resources, learned about wild plants and berries and also learned about weather folklore.

Storytelling as a Pedagogical Tool. As my participants have reiterated, it is from their elders' stories that they learned their traditional Indigenous knowledge about natural sciences, such as biology, physics, and earth sciences. Some examples are Renee's practice of teaching her students the story of a water drop and hail (mási in Umoⁿhoⁿ) while explaining the water cycle and connecting the scientific process of taking out of the internal organs and airing the meat aligns with the Umoⁿhoⁿ traditional customs. Amy also shared stories, such as the Umoⁿhoⁿ creation stories that led to her design the medicine garden in the shape of the 8-pointed morning star, and Leigh sharing the story of how students called out the wind by reciting tadé sagi multiple times in a science outdoor lesson, and how they relate to Tigóⁿho (Grandpa) Cottonwood tree. All of these examples from my participants align with what the researchers, such as Sparks (2000) have explained about the significance of storytelling as a pedagogical tool for teaching Indigenous students. The pedagogies of storytelling and involving Elders in the Umoⁿhoⁿ community center the traditional Indigenous knowledge rather than Western modern science; hence analyzing these pedagogical practices using the lens of critical race theory in science educational research, Renee, Amy, and Leigh's stories and teaching practices resonate with Parsons et al.'s (2011) findings that including participants' voices and stories counter the racial inequities that are prevalent in science education by resisting the domination of Eurocentric pedagogies in science education. Hence, the prominence of my participants' counter-stories in this dissertation help in decolonizing Eurocentric

science education, albeit in a small way.

Natural Elements as Sentient Beings. Another culturally sustaining pedagogical practice that all three participants employ is to consider natural elements like the sky, earth, wind, animals, insects, and birds as sentient beings and that all humans are related to each other. Some examples include Leigh's use of puppets to explain the characteristics of nocturnal animals and the practice of respecting plants before harvesting their produce; Amy's reverence of the Grandpa Cottonwood Tree; and Renee's spirituality and connections with Wakoⁿda (Creator) and natural elements while teaching science to her students.

Creator Wakoⁿda. As Indigenous people, Renee and Amy highly respect their Creator Wakoⁿda and strongly believe in the spirituality associated with the creation story and the lives of the Umoⁿhoⁿ people. La Flesche (1992) describes Wakoⁿda in *The Omaha Tribe*⁵⁵ as follows:

An invisible and continuous life was believed to permeate all things, seen and unseen. This life manifests itself in two ways: First, by causing to move: All motion, all actions of mind or body are because of this invisible life; Second, by causing permanency of structure and form, as in the rock, the physical features of the landscape, mountains, plains, streams, rivers, lakes, the animals and man. This invisible life was also conceived as being similar to the willpower of which man is conscious within himself—a power by which things are brought to pass.

Through this mysterious life and power, all things are related to one another and

⁵⁵ *The Omaha Tribe* is the first major, comprehensive ethnographic book written about a Native American tribe, coauthored by European fieldworker Alice C. Fletcher and a member of the Umoⁿhoⁿ tribe Francis La Flesche. Fletcher lived among the Umoⁿhoⁿ tribe and was respectfully called Ma-she-ha-the by the Umoⁿhoⁿ people. She developed a strong relationship with La Flesche adopting him as her son, and they lived together for many years (Fletcher & Flesche, 1992).

to man, the seen to the unseen, the dead to the living, a fragment of anything to its entirety. This invisible life and power was called Wakoⁿda (p. 6).

The description of La Flesche (1992) about “all things are related to one another and to man...” aligns with what Amy and Renee shared with me about the interrelatedness of all people or Ewithe woⁿgithe and the Indigenous ways of learning from nature. Renee also said that her people learn everything from nature and base their learning on different seasons of the year, Four Hills (stages) of life, and the seven directions. This is very similar to what Amy shared with me about the medicine wheel or “Táde Duba,” “Four Winds,” or “Four Directions,” which correlate with the four seasons of the year.

We Are All Connected. Amy’s deep bonding with her students aligned with the Umoⁿhoⁿ saying, Ewithe woⁿgithe, which means that we are all connected to each other. I was especially surprised to hear the phrase Ewithe woⁿgithe, because this Umoⁿhoⁿ phrase is strikingly similar to a verse from my Native language Tamil poem, “யாதும் ஊரே யாவரும் கேளிர்.” This verse which reads as “yaadhum oore yaavarum kelir” is from a 2600-year-old Tamil poem, *Puranānūru*, written by Kaniyan Poongunranar, also known as Poongundranar, an influential Tamil philosopher from the Sangam age who lived around the 6th century BCE. This verse means, “all the places on Earth are our town, and all the people are our relatives.” This most progressive ancient Tamil poetry calls for unity and equality for all. Poongundranar rejected the division of humans into various categories and emphasized our universality, stating that all humans are relatives. This similarity between the traditional Indigenous sayings of two different languages from entirely different parts of the world emphasizes the fact that all

Indigenous cultures around the world fundamentally believe in the interconnectedness of people. This also explains how I was able to develop and maintain strong researcher-participant relationships with my participants, as I believe that I am related to them as an Indigenous woman from another part of the world, a true ally to the Umo^oho^o people, and a fellow science teacher. Additionally, as discussed in Chapter 5, the use of camphor and incense in my religious (Hindu) practices is similar to the use of sage in Indigenous communities, which also makes me believe that we are all connected.

Encouraging Critical Thinking in Indigenous Students. The next common theme that emerged was encouraging critical thinking in Indigenous students by connecting science teachings with real-world issues and conditions. Examples of this theme are Amy's and Leigh's habitat loss project and weather folklore project, and Renee's civic engagement projects, such as the water quality project; the missing, murdered Indigenous women bulletin board project; and the Walk for Lost Children. Grave issues such as environmental racism against the Indigenous populations and unfair foster care systems followed by the U.S. Government were able to be understood by unpacking this theme.

The problems of environmental racism and dumping of industrial wastes around the Indigenous areas of settlement and reservations are already discussed in Chapter 7, where connections between Renee's water quality project and Zocher and Hougham's (2020) study were explored. However, another pressing problem that the Umo^oho^o community faces is the taking away of their children by the U.S. Government's foster care system, as was described in Chapter 7. Educating Indigenous students about real-world issues pertaining to their own tribal communities will bring awareness to

Indigenous students and empower them to become strong and well-informed members of their community so that they can contribute toward Indigenous self-determination and sovereignty. Hence, Renee's, Amy's, and Leigh's use of civic engagement projects at their school is all the more important for growing strong leaders from their community.

Healing from Intergenerational Trauma. There were several examples that Amy and Renee shared with me about the effects of intergenerational trauma on their students, and the necessity for socioemotional learning and healing for their traumatized Indigenous students. Leigh and Renee focus on socio-emotional learning aspects by providing life-skill set lessons and by stocking basic necessities such as food and hygiene products for their students.

Food Sustainability, Tribal Sovereignty, and Justice. The next two common themes of the importance of attaining self-sustenance and food sovereignty, and the significance of tribal justice and Indigenous sovereignty are related to the theme of connecting science to real-world issues. Additionally, I relate my participants' efforts in developing critical consciousness in science education to Calabrese Barton and Upadhyay's (2010) social justice pedagogy in science education, which commits to all students, regardless of race, culture, ability, language, and gender, having access to learning opportunities in science that foster personal and social transformation. The importance of becoming self-reliant with Indigenous food sources was well described by Amy, Leigh, and Renee in the earlier chapters, and they have demonstrated how they help their students learn a life skill and cultivate the Indigenous "three sisters" (corn, beans, and squash), other vegetables, and fruits. Like Renee, Amy, and Leigh, researchers such as Brown et al. (2016) and Skewes and Blume (2019) also talk about the pervasive

influence of racism and the historical trauma resulting from colonization on American society and culture, such as the effects on the health and well-being of American Indian people, and the cultural disconnection, stereotypes and harassment, acculturative stress, and mainstream culture clash that Native American youth experience in today's world, all of which were described by my participants in multiple instances. Additionally, the brutal massacre of Indigenous food sources, such as the American bison also was explained in detail in Chapter 5, where Amy's quest for food self-sustenance and sovereignty is well justified and supported by Flood's (2014) and Phippen's (2016) work.

While analyzing these inhumane, oppressive, and biased practices against Indigenous people, Brayboy's (2005) TribalCrit seems to be a better theoretical lens to describe the lived experiences of tribal peoples such as Renee and Amy, and it provides the explanatory power to understand the inequities and injustice the Indigenous populations are continually subjected to. Since TribalCrit focuses on the pervasiveness of both racism and colonization in society, it helps us analyze the U.S. government's financial motives and the foster care system. Using critical race theory (CRT) and TribalCrit lenses, it becomes apparent that these motives align with the CRT tenets of "interest convergence" and two of the TribalCrit's tenets of "U.S. policies toward Indigenous peoples are rooted in imperialism, White supremacy, and a desire for material gain" and "governmental policies and educational policies toward Indigenous peoples are intimately linked around the problematic goal of assimilation." Amy's and Renee's lives are replete with stories that speak to how Native people have been subjugated and assimilated into the "mainstream American culture" for the purpose of the U.S. government's material gain and for reinforcing White supremacy.

Other than aligning with theory, the underlying motives and related practices of governmental organizations and service institutions have been explored by scholars in the educational research literature. In the literature pertaining to teacher education programs in the United States, Castagno (2012) and Anthony-Stevens et al. (2020) found that federally funded Indigenous teacher preparation programs housed at mainstream, predominantly White universities can be colonial, and the work of teacher educators is difficult given the context of imperialism, White supremacy, and assimilation that still structures educational institutions (Castagno, 2012) and another important point to note is that predominately White institutions (PWI) of higher education have struggled to create space in higher education for intentional support of Indigenous self-determination, sovereignty, and tribal nation building through their Indigenous teacher preparation programs (Anthony-Stevens et al., 2020).

Cultural Relevance vs. Standardization. Some of the themes that overlapped between Renee's and Leigh's life stories were that cultural relevance is more important than science standards. In fact, Leigh and Renee stated that they would prefer to use the Next Generation Science Standards instead of the Nebraska State Science Standards because the Nebraska one doesn't have biology for second grade, and there is too much emphasis on math and reading, relegating science to a "less-important subject" status. Considering the underrepresentation of Indigenous students in STEM careers, where only 3% of the STEM workers identify themselves as Native Americans, Native Hawaiians, and Pacific Islanders (Fry, Kennedy, & Funk, 2021) and the relatively low position of the United States in international standardized science and math assessments (*PISA 2018 Worldwide Ranking*, 2020), Leigh's and Renee's insightful comments make perfect

sense. Renee's and Leigh's comments on the need for cultural relevance also align with Aikenhead and Michell's (2011) findings that international tests are being developed using state and national science standards based on Western modern science and do not include Native American knowledge and languages.

Arts-Based Approaches to Teaching Science. Renee and Leigh also use multimodal elements in their science teaching, such as videos and arts-based approaches such as students using puppets and designing their own mugs using creative art. Renee, Amy, and Leigh have continually centered on multiple Indigenous ways of knowing by letting the Elders incorporate music, ceremonies, storytelling, dance, songs, and other vehicles, such as using puppets to instruct students just like what Sparks (2000) and Bang and Medin (2010) found in their studies.

Language Preservation and Revitalization. The overlapping themes between Amy and Renee were that they both are very concerned about the Umoⁿhoⁿ language preservation and revitalization. Renee being the Director for Native American Education has worked with all classroom teachers in incorporating the Umoⁿhoⁿ culture and language in everyday lessons. Some examples of incorporating the Umoⁿhoⁿ words in science classrooms are “*Táde Duba*,” or “Four Winds, *moⁿkóⁿsabe* (coffee), weather-related terms such as *mi* (sunshine), *mási* (hail), etc. Although EPPS is not yet at the language immersion stage due to very few speakers of the Umoⁿhoⁿ language remaining in their community, both Amy and Renee are working hard in incorporating the Umoⁿhoⁿ language terms in their everyday lessons so that students get the opportunity to learn and refine their knowledge about their own Indigenous language. This theme is very related to another overlapping theme between Renee and Amy that their culturally and

linguistically responsive science teaching focuses on the development of cultural and linguistic identity in their students. Amy's and Renee's use of Umo^oho^o weather terminology in their classes also emphasize the importance placed on the Umo^oho^o language preservation and revitalization, just as many other scholars, such as McCarty (2008), Hermes (2005), and Lomawaima and McCarty (2006) have stated.

Being a Matriarch. Both Renee and Amy are respected matriarchs in their community, and so they stand up for the issues faced by their tribe, such as the need for food sovereignty and bringing back Indigenous food sources. They both talked about the health issues that children and elders in their community have due to consuming processed "Western" foods and drugs, such as diabetes, obesity, alcoholism, and drug addiction, and having had the opportunity to stand up for these issues and help their community.

Nature-Based Outdoor Science Classroom. The themes that were common between Amy and Leigh came up could be due to the fact that they are co-teachers teaching science in the same classroom for elementary and middle school students. These were the development of cultural science curriculum called *Ashita Thewathe* (outdoor science classroom) and the upkeep and maintenance of outdoor classrooms such as the medicine garden, greenhouse, planting gardens, and the Little House of Learning. Both Leigh and Amy believe in the concept of "science is everywhere" and are always enthusiastic to implement nature-based science in their classroom, such as the tree-age project and habitat loss project.

Unique Themes Drawn from Participants' Stories

There were several unique themes that were drawn from my participants' stories.

Amy's stories highlighted Amy's family's bitter experiences of deculturalization, religious suppression, and genocide faced at the hands of the U.S. Government; the promise she made to her father that motivated her to become a teacher; her deep familial bonding with her students; and her unique pedagogical practice of using an Umo^{ho} prayer song and sage ceremony at the beginning of every class. Leigh's stories highlighted themes, such as her being a master naturalist and gardener; her respect for all living beings like plants and animals; her use of the weather folklore in a science inquiry project; her stating that there is a lack of animism in Western science; her using puppets to teach science; her doctorate degree in education; and her deep concern for and sisterhood with Indigenous communities she has encountered in her life, such as the Wampanoags, the Umo^{ho} peoples, the Winnebago peoples, and the Ho-Chunks. So, an important theme that came up in Leigh's stories is that she is a true White ally to Indigenous people, having both the outsider and insider perspectives on Indigenous education. The unique themes that surfaced from Renee's stories were that she was a reservation Native American, who is highly qualified and well-accomplished; her liking for biology due to similarities between biology and the Umo^{ho} cultural science; her strong Umo^{ho} identity and spirituality; her personal experiences of facing racial and gender inequities due to her Native American woman identity; her own mother forcibly taken away by the U.S. Government's foster care system; and her hands-on teaching and raising critical consciousness in her students by incorporating the water quality project, the MMIW project, and the Walk for the Lost Children.

The nature-based science curriculum and the culturally and linguistically sustaining pedagogical strategies used by my participants not only meet the needs of the

Umo^hoⁿ students, but they are also in perfect sync with the Indigenous science curricula and strategies for many other Indigenous populations in the U.S. and Canada that are detailed in my literature review, such as Culture-Based Education (Demmert, 2011; Reyhner et al., 2010; Gilbert, 2011), Culturally Responsive Science Curriculum (Stephens, 2000), Science-Technology-Society Curriculum (Aikenhead, 1997), Rekindling Traditions Curriculum (Aikenhead, 2001b), and Ethnoscience (Brayboy & Castagno, 2008; Snively & Corsiglia, 2001; Davison & Miller, 1998). Many Indigenous schools have supported the creation and development of curricular cultural standards, such as the ones that Renee, Amy, and Leigh are implementing in EPPS. Some examples are Alaska Native Knowledge Network (1998), Kamehameha Early Education Program (KEEP) for Native Hawaiian students, Rock Point and Rough Rock community schools on the Navajo reservations, and Tuluksak School for Yu'pik tribe in Alaska (Castagno & Brayboy, 2008; Demmert, 2001).

Strengths and Limitations of the Study

There would always be strengths and limitations to any research study. Aside from the strengths that are already discussed in the implications for teaching and research section, additional strengths are listed below:

- a) Rich insights were gained from Indigenous science teachers' lived experiences, which is an underrepresented topic in the extant literature.
- b) As the majority of the Indigenous student population has been historically the oppressed class, belongs to the low socioeconomic class, and does not have many opportunities to excel in STEM careers, this study could inform the academic community and policymakers about the ways to improve the

academic outcomes of Indigenous students and their interest in pursuing STEM careers.

- c) Interview data are a great strength for this study, as they uphold and forefront the voices of my participants.
- d) Artifacts, such as photos triangulate my data sources.
- e) Another strength is that I have spent adequate time in the field to establish trustworthiness and get all the relevant information needed for a qualitative research method such as narrative inquiry, which relies heavily on prolonged and consistent engagement, persistent observation, thick description, triangulation, dependability audits, and member checks (Lincoln & Guba, 1985, as cited in Loh, 2013).

There are also some limitations to this study; the first one is the sample size of three participants. Since this dissertation study had a definite and short timeline, I was immersed in the field for a period of three months. If I had had the opportunity to collect the data for probably one year or more, it would have allowed me to gather richer and more detailed data and also develop deeper researcher-participant relationships. The life stories of individuals have multiple layers and nuances, and context is very important, so another general limitation of narrative research, including mine, is knowing how much information is needed to re-story someone's life story. The final limitation that I have identified is that my participants were recruited from a neighboring city in the Midwestern state where I teach, and they shared their experiences focusing on school/community variables and resources pertaining to the American Midwest. So, some findings might not be generalizable to the teaching community in different parts of the

U.S. or other countries in the world.

Implications of the Study for Teaching Practice

The implications for teaching practice identified from my study are as follows:

- (a) Nature-based education and civic engagement projects as highlighted in this study could lead to more active engagement in science for Indigenous students, thereby reinstating pride in their Indigenous identity and motivating them to advocate for the rights and sovereignty of their tribal nations.
- (b) If experiential, project-based, hands-on learning is adopted by Indigenous schools, science teachers, administrators, researchers, and educational policymakers would be able to meet the academic needs of Indigenous learners, which could eventually aid in promoting overall educational equity in the country.
- (c) Since culturally and linguistically responsive science teaching has been shown to help in improving academic success in science for Indigenous students, more Indigenous students could take up STEM careers, which would ensure upward social mobility of Indigenous tribal communities.
- (d) The culturally and linguistically relevant pedagogical strategies and the socio-emotional learning methods mentioned in the study could help Indigenous learners heal from intergenerational trauma and help them cope better with challenges in their adult lives.
- (e) This study could encourage future researchers to probe more into the knowledge gaps identified, such as decolonizing science education

frameworks; critical race-based, culture-based, and language-based epistemologies; and culturally and linguistically sustaining practices in science education.

- (f) Culturally and linguistically responsive strategies, such as storytelling for holistic learning; nature-based outdoor science teaching; use of arts and multimodal approaches like puppets, videos, songs, and dance; experiential, project-based, hands-on projects; civic engagement projects; and involving Elders in the community can be used by science teachers to help integrate the rich cultural heritage of different tribes and ethnicities into educational programs and advocate for the inclusion of culturally responsive educational curricula in the local contexts.
- (g) Culturally relevant educational curricula such as Culture-Based Education (Demmert, 2011; Reyhner et al., 2011; Gilbert, 2011), Culturally Responsive Science Curriculum (Stephens, 2000), Science-Technology-Society Curriculum (Aikenhead, 1997), Rekindling Traditions Curriculum (Aikenhead, 2001b), and Ethnoscience (Brayboy & Castagno, 2008; Snively & Corsiglia, 2001; Davison & Miller, 1998) can function as a bridge between the local knowledge base and the acquisition of knowledge that comprises “global education,” which includes STEM education.
- (h) Teachers of Indigenous students in non-reservation schools can take away from this study that being mindful and taking time to know their students is important. In addition, focusing on holistic learning, using outdoor resources and places for teaching science, and getting help from Elders in

the community could be ways in which they could make their teaching more culturally relevant.

- (i) This study could also provide a powerful model for White science teachers (like Leigh) to do this important work by caring for and allying with the Indigenous communities.
- (j) This narrative inquiry contributes to the sharing of unique stories from different tribes/clans and could inspire other communities to share their own unique experiences.
- (k) The humanizing stories featured here could help Indigenous science teachers and scholars that read this feel solidarity with others.
- (l) Extended benefits of the study are that the voices of Indigenous science teachers would be heard by research scholars, stakeholders, school administrators, teacher educators, and educational policymakers so that the needs of Native American students and science teachers could be better met.
- (m) Other possible benefits to society may include a better understanding of the struggles, barriers, challenges, and joys experienced by Indigenous science teachers while using unique culturally and linguistically relevant pedagogical practices to meet the specific needs of the students from their own community/Native American reservations.

Potential Suggestions for Future Research

Science educational research featuring Indigenous and minoritized student and teacher populations is fraught with tensions, contradictions, and conundrums because of

the requirement of specific contexts and the complexities these contexts present for science educational researchers (McKinley & Gan, 2014).

Some possibilities for future research include:

- a) Further exploration of critical race-based, culture-based, language-based, and asset-based pedagogies and epistemologies in science education.
- b) More research that examines decolonizing science education frameworks that are found in this study.
- c) Exploring culture and language revitalization in relation to science education, and the confluence between Indigenous culture, language, and science.
- d) Future research could identify the unique culturally and linguistically responsive collaborative and experiential teaching practices of science teachers within the local Native American communities.
- e) Longitudinal study research designs could help in determining Indigenous science teachers' capability and confidence to use culturally and linguistically responsive/sustaining practices by documenting their students' science achievement during consecutive school years or for finding the aspects influencing their students to take STEM courses in middle and high school.
- f) Future studies in this area could consider the interactions between science teachers and Indigenous students through researcher observations and narrative inquiries. Similarly, future research could also work on the perceptions, self-efficacy, and confidence of Indigenous science teachers

while using culturally and linguistically responsive/sustaining practices.

- g) Classroom observations could add another dimension to the data and serve to provide a more comprehensive view of the way Indigenous science teachers operate within their classrooms and their use of culturally and linguistically responsive/sustaining practices. Studies could be conducted about diverse students' perceptions too. This could also pave new ways to look into the benefits of scaffolding; the use of inquiry methods; and the use of culturally and linguistically responsive teaching practices, such as using Native students' funds of knowledge to teach science.
- h) Future research could also look into interactions between Indigenous science teachers and their co-workers, Indigenous Elders, parents, school administration, educational policymakers, and the wider community. This could lead to better support systems for Indigenous science teachers in the way of science-content-based, culture-based professional development programs to prevent "teacher burnout," in the present-day, high-pressure "high-stakes-testing-based" educational scenario. This could ultimately lead to better teacher retention in critical school environments, such as Native American reservations, and rural and urban schools.
- i) Future researchers should include more Indigenous scholars (and cite them too) who have described the culturally and linguistically sustaining practices of in-service and preservice Indigenous science teachers, thereby upholding the voices of minoritized people and resisting the prevailing hegemonic and epistemological racism in K-12 schooling, teacher

education, and educational research.

- j) Future research could focus on support systems and professional development programs that help Indigenous science teachers and teacher educators to better leverage students' funds of knowledge, develop their intercultural competence, and provide ways how to redesign science lessons to make them culturally and linguistically syntonic.
- k) Future research could focus on hegemonic educational systems that set Indigenous science teachers up to disengage from science teaching and their notions of traditional paradigms in science, such as objectivity and positivism/post-positivism, which are prevalent in STEM.
- l) Future research could explore how science teachers navigate their own ways of knowing and the cultural and contextualized approaches to knowledge construction within the constraints of STEM learning and their own intersectional identities.

Although many suggestions for future research are listed above, educational researchers must be vigilant to not essentialize and generalize pedagogical strategies that are described for Umo^hoⁿ students to all Indigenous students or communities, as multiple epistemologies and worldviews exist and are valid. Pedagogical practices useful for one Indigenous student community cannot be imposed on another Indigenous student/community because they belong to a different Native American tribe that could have different cultural and linguistic contexts and also because each Indigenous student's lived experiences are unique, diverse, and complex.

Conclusion

As a researcher who aims to highlight the assets and achievements of the Indigenous teachers and schools I have focused on the commendable and innovative curricula and pedagogical practices that are being practiced at EPPS to celebrate their progress and accomplishment through my narratives. In my dissertation, I have highlighted my participants' teaching philosophies and science teaching practices that have engaged their students in science, language, and culture as well as those practices that helped in creating a positive and nurturing classroom environment for Umo^oho^o students. Amy, Leigh, and Renee's pedagogical practices provide compelling evidence and support several researchers' documentation that there are apparent benefits in creating cultural standards in Indigenous schools; valuing Indigenous knowledge as assets; using students' funds of knowledge; integrating hands-on and project-based learning; involving local community and elders in classrooms; utilizing language immersion, preservation, and revitalization strategies; and employing culture-based, experiential, and place-based science education for Indigenous students.

Clandinin and Connelly (1994) state that "it is in the research relationships among participants and researchers, and among researchers and audiences, through research texts that we see the possibility for individual and social change" (p. 425). Exploring the lived experiences of Indigenous science teachers informs future research and helps in improving the science learning outcomes for Indigenous students, thereby incorporating social justice and equity in science education. When narrative inquiries such as mine are published, the embedded stories could have a huge impact on teachers, researchers, and educational policymakers, which could open up new and promising pathways for

Indigenous students.

Amy, Leigh, and Renee's culturally and linguistically sustaining teaching practices leave us hoping for a better tomorrow for the Umoⁿhoⁿ people. I conclude my dissertation with Renee's words:

We're reaching more of the kids, more of the students...there seems to be a shift.

So hopefully, it continues...

(Interview transcript, November 8, 2022).

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Appendix A
Earth People Public School Research Approval Cover Letter

June 10, 2022

The Superintendent
Earth People Public Schools
Nebraska

Dear _____:

Good morning! I am a doctoral candidate from the Department of Teaching, Learning, and Teacher Education at the University of Nebraska-Lincoln pursuing my Ph. D. Program in Educational Studies. I am interested in conducting a narrative inquiry study of exploring the culturally and linguistically relevant pedagogies used by Indigenous science teachers within the Earth People Public School.

Purpose

The purpose of this study is to explore the lived experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogies to meet the needs of Indigenous students. A narrative inquiry will allow these individual educators to share their stories and experiences and provide guidance on how to help educators meet the needs of the Native American student population, and the study will highlight their voices as Native American teachers.

Procedures

Participants would include two science teachers (elementary/middle school and high school) from the Earth People Public School. Qualitative data will be collected from these two science teachers via individual 2 semi-structured interviews and 3 classroom observations. Recruitment of participants will begin in the last two weeks of October 2022. Qualitative data collection will begin in the last week of October 2022 and be completed by the last week of December 2022. Two science teachers will be recruited via snowball sampling and criterion sampling from known contacts and networks who volunteer and are willing to participate in the study. No personal or identifying student information will be collected. Each interview and observation will last approximately 60-90 minutes. Classroom observations will take place during the school day, and interviews will take place after students have been dismissed for the day. Participants will also be provided an opportunity to fill out an exit survey to provide the information they deem important after observations and interviews have been completed.

I have attached copies of the data collection instruments, such as the informed consent form, verbal and email scripts to recruit participants, and the interview questions for the study in this email. I will need a written letter from you on your school district stationery that approves of my research in your school so that I can attach that to my IRB application; hence I will be grateful if you could please provide me with an official

letter of approval. I will look forward to hearing from you soon. Thank you very much for your time and consideration of my request in advance. If you need any other information from me, please feel free to contact me at uganesan2@huskers.unl.edu and/or 402-405-2652.

Sincerely,

Uma Ganesan

Appendix B

Verbal Script for Recruitment of Indigenous science teachers

OPENING:

Hi. My name is Uma Ganesan from the University of Nebraska-Lincoln. I am conducting a research study on the experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogies to meet the needs of Native American students. Participation would involve you allowing me to interview you twice for 60 to 90 minutes, visit your classroom for three days, and share your experiences from the interviews and visits in my dissertation. There are no known risks involved and participation is voluntary.

Would you be interested in participating? If so, what time and location would work best for you for the interview?

CLOSING:

Do you have any questions you would like answered now?

You may contact the researcher Uma Ganesan via email at uganesan2@huskers.unl.edu or by telephone (402-472-2231). If you prefer to speak with someone else, call the UNL Research Compliance Services Office at 402-472- 6965.

Appendix C

Email Script for Recruitment of Indigenous science teachers

Dear _____,

We are Uma Ganesan and Dr. Theresa Catalano from the University of Nebraska-Lincoln. We are conducting a research study on the experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant

pedagogies to meet the needs of Native American students. You are being contacted because you are an Indigenous science teacher (an adult above 19 years of age) using culturally and linguistically relevant pedagogical practices to teach Native American students at your school and the local Native American community. As such, we would like to invite you to be part of our study. Participation would involve you allowing us to interview you 2 times and visit your classroom for 3 days, collect your lesson plans and samples of your students' completed and de-identified worksheets, and tell the story of your lived experiences in my dissertation. Your real name will not be used in the study, and any photos taken during visits will be de-identified (will not contain your face or your students). We will member-check with you for verifying the authenticity of our interpretation of your story. You may complete an optional participant feedback survey from the University of Nebraska-Lincoln, which will ask about your research experience. This 14-question, multiple-choice survey will be anonymous and should be completed after your participation in this research, and this survey could take around 5 minutes to complete it. If you are interested in participating, please read and sign the attached consent form and email it back to uganesan2@huskers.unl.edu and tcatalano2@unl.edu. If you have any questions regarding your rights as a research participant or need to report any concerns about the research, call the UNL Research Compliance Services Office at 402-472-6965.

Appendix D Informed Consent Form

IRB #: 20220922222EX

Study Title: Exploration of the lived experiences of Indigenous science teachers: A narrative inquiry.

Authorized Study Personnel:

Principal Investigator: Uma Ganesan, M.S. Office: (402) 472-2231

Secondary Investigator: Theresa Catalano, Ph.D. Office: (402) 472-2231

Key Information:

This study aims to investigate the experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogies to meet the needs of Indigenous students. If you agree to participate in this study, you will be interviewed 2 times in your school or via Zoom or in a quiet location of your choosing about your science learning and teaching experiences and the culturally and linguistically relevant pedagogical practices that you use at your school. You will be asked 15-20 questions during the interviews, which will be recorded with an audio recorder phone application or video-recorded on Zoom. There are no risks associated with this study. You will be provided a copy of this consent form.

Invitation:

You are invited to take part in this research study. The information in this form is meant to help you decide whether or not to participate. If you have any questions, please ask.

Why are you being asked to be in this study?

You are being asked to be in this study because you are an Indigenous science teacher using culturally and linguistically relevant pedagogical practices to teach Native American students at your school and the Native American community.

What is the reason for doing this research study?

We would like to learn more about your stories and your racialized/gendered lived experiences that could provide us guidance on how science educators could meet the needs of Native American students. We would also like to highlight your voices as Native American science teachers in research publications.

What will be done during this research study?

You will be interviewed twice and asked 15-20 questions related to science learning and teaching, your culturally and linguistically relevant pedagogical practices, and your racialized and gendered experiences in your own schooling and teaching. The interviews will take 60-90 minutes to complete. The researcher will also make three visits to your classroom and take observation notes and photographs that will be de-identified (your face or your students' faces will not appear in the photos) for purposes of the study. The researcher will collect your lesson plans, syllabi, and samples of your students' worksheets. Member-checking will be done with you by the researcher for verifying the authenticity of their interpretation. You may complete an optional participant feedback survey from the University of Nebraska-Lincoln, which will ask about your research experience. This 14-question, multiple-choice survey will be anonymous and should be completed after your participation in this research, and this survey would take around 5 minutes to complete it.

How will my interview responses be used?

This study will involve the collection of private information (name, dates, etc.). Your information could be used or distributed to another researcher for future research studies without an additional informed consent from you. Identifiers (name, dates, etc.) will be removed prior to being distributed. Your interview responses will be published in academic journals and/or presented at teaching/research conferences designed to inform teachers about your experiences.

What are the possible risks of being in this research study?

There are no known risks to you from being in this research study.

What are the possible benefits to you?

The benefits of being in this study include your voice as a science teacher being heard by research scholars, stakeholders, and educational policymakers so that the needs of Native American students and science teachers could be met. I will invite you to become a

coauthor in my future journal publications or conference presentations (after my dissertation study).

What are the possible benefits to other people?

Possible benefits to society may include a better understanding of the struggles, barriers, challenges, and joys experienced by Indigenous science teachers while using culturally and linguistically relevant pedagogical practices to meet the needs of the Native American student population.

What will being in this research study cost you?

There is no cost to you to be in this research study.

Will you be compensated for being in this research study?

As a token of appreciation for your time and support of our research, you will receive an Amazon gift card worth \$50.

How will information about you be protected?

Reasonable steps will be taken to protect your privacy and the confidentiality of your study data.

The data will be stored electronically through a secure server and will only be seen by the research team during the study and for 3 years after the study is complete. The only persons who will have access to your research records are the study personnel, the Institutional Review Board (IRB), and any other person, agency, or sponsor as required by law. The information from this study may be published in scientific journals or presented at scientific meetings but the data will be reported as a group or summarized data (de-identified) and your identity will be kept strictly confidential.

What are your rights as a research subject?

You may ask any questions concerning this research and have those questions answered before agreeing to participate in or during the study. For study-related questions, please contact the investigator(s) listed at the beginning of this form.

For questions concerning your rights or complaints about the research contact the Institutional Review Board (IRB):

- Phone: 1(402)472-6965
- Email: irb@unl.edu

What will happen if you decide not to be in this research study or decide to stop participating once you start?

You can decide not to be in this research study, or you can stop being in this research study (“withdraw”) at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the investigator or with the University of Nebraska-Lincoln. You will not lose any benefits to which you are entitled.

Documentation of informed consent

You are voluntarily making a decision whether or not to be in this research study. Signing this form means that (1) you have read and understood this consent form, (2) you have had the consent form explained to you, (3) you have had your questions answered, and (4) you have decided to be in the research study. You will be given a copy of this consent form to keep.

Participant Feedback Survey

The University of Nebraska-Lincoln wants to know about your research experience. This 14-question, multiple-choice survey is anonymous. This survey should be completed after your participation in this research. Please complete this optional online survey at: <http://bit.ly/UNLresearchfeedback>.

Participant Name:

(Name of Participant: Please print)

Participant Signature:

Signature of Research Participant

Date

Appendix E IRB Approval Letter



Official Approval Letter for IRB project #22222 - New Project Form

September 30, 2022

Uma Ganesan
Teaching, Learning and Teacher Education
HENZ 118 UNL NE 685880355

Theresa Catalano
Teaching, Learning and Teacher Education
CPEH 262 UNL NE 685880233

IRB Number: 20220922222EX
Project ID: 22222
Project Title: Exploration of the lived experiences of Indigenous science teachers: A narrative inquiry

Dear Uma:

This letter is to officially notify you of the certification of exemption of your project for the Protection of Human Subjects. Your proposal is in compliance with this institution's Federal Wide Assurance 00002258 and the DHHS Regulations for the Protection of Human Subjects at 45 CFR 46 2018 Requirements and has been classified as exempt. Exempt categories are listed within HRPP Policy #4.001: Exempt Research available at: <http://research.unl.edu/researchcompliance/policies-procedures/>.

- o Date of Final Exemption: 9/30/2022
- o Certification of Exemption Valid-Until: 9/30/2027
- o Review conducted using exempt category 2(ii) at 45 CFR 46.104
- o Funding (Grant congruency, OSP Project/Form ID and Funding Sponsor Award Number, if applicable): N/A

You are authorized to implement this study as of the Date of Final Approval: 9/30/2022

We wish to remind you that the principal investigator is responsible for reporting to this Board any of the following events within 48 hours of the event:

- * Any serious event (including on-site and off-site adverse events, injuries, side effects, deaths, or other problems) which in the opinion of the local investigator was unanticipated, involved risk to subjects or others, and was possibly related to the research procedures;
- * Any serious accidental or unintentional change to the IRB-approved protocol that involves risk or has the potential to recur;
- * Any protocol violation or protocol deviation
- * An incarceration of a research participant in a protocol that was not approved to include prisoners
- * Any knowledge of adverse audits or enforcement actions required by Sponsors
- * Any publication in the literature, safety monitoring report, interim result or other finding that indicates an unexpected change to the risk/benefit ratio of the research;
- * Any breach in confidentiality or compromise in data privacy related to the subject or others; or
- * Any complaint of a subject that indicates an unanticipated risk or that cannot be resolved by the research staff.

This project should be conducted in full accordance with all applicable sections of the IRB Guidelines and you should notify the IRB immediately of any proposed changes that may affect the exempt status of your research project. You should report any unanticipated problems involving risks to the participants or others to the Board.

If you have any questions, please contact the IRB office at 402-472-6965.

Sincerely,

for the IRB



Appendix F
Permission Email to Conduct Research at EPPS

From: _____
To: Uma Ganesan
Subject: Re: Request to conduct my research in your school
Date: Thursday, August 25, 2022, 2:27:50 PM
 Non-NU Email

Uma,
 I give you permission to conduct your outlined research in our school district.

Superintendent
 Sent from my iPhone

On Aug 25, 2022, at 11:37 AM, Uma Ganesan <uganesan2@huskers.unl.edu>
 wrote:

Dear _____,

Good morning! I hope your school year has started out well! Thank you very much, again, for sending me the permission letter to conduct my research study at your school!

As I informed you earlier that UNL's IRB might contact me again regarding my IRB application, I received an email from them today. They have advised me to get an email approval from you for my proposed research at your school. I will be very grateful if you could just reply back to this email stating that I have permission to conduct the below-mentioned research study at your school.

I have briefly outlined the project details below (in italics), which are identical to the contents of the data collection instruments that I emailed you earlier:

Study Title: *Exploration of the lived experiences of Indigenous science teachers: A narrative inquiry.*

Authorized Study Personnel:

Principal Investigator: *Uma Ganesan, M.S. Office: (402) 472-2231. Mobile: 402-405-2652.*

Secondary Investigator: *Theresa Catalano, Ph.D. Office: (402) 472-2231*

Purpose:

The purpose of this study is to explore the lived experiences of Indigenous science teachers in elementary, middle, and high school settings to see how their racialized and gendered lived experiences shape their use of culturally and linguistically relevant pedagogies to meet the needs of Indigenous students. A narrative inquiry will allow

these individual educators to share their stories and experiences and provide guidance on how to help educators meet the needs of the Native American student population, and the study will highlight their voices as Native American teachers.

Brief Data Collection Procedures:

Participants would include two science teachers (elementary/middle school and high school) from the Earth People Public School. Qualitative data will be collected from these two science teachers via individual 2 semi-structured interviews and 3 classroom observations. Recruitment of participants will begin at the last two weeks of October 2022. Qualitative data collection will begin in the last two weeks of October 2022

and be completed by the last week of December 2022. Two science teachers will be recruited via snowball sampling and criterion sampling from known contacts and networks who volunteer and are willing to participate in the study. No personal or identifying student information will be collected. Each interview and observation will last approximately 60-90 minutes. Classroom observations will take place during the school day, and interviews will take place after students have been dismissed for the day. Participants will also be provided an opportunity to fill out an exit survey to provide the information they deem important after observations and interviews have been completed.

Thank you, again! I will look forward to receiving your email soon! Have a great day!

Best regards,

Uma Ganesan

Appendix G
Permission Letter to Conduct Research at EPPS

August 18, 2022

Uma Maheshwari Ganesan
Doctoral Candidate
Department of Teaching, Learning & Teacher Education (TLTE)
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Re: Permission to conduct research

██████████ Public School grants Uma Ganesan permission to conduct research in our school district.

Superintendent
EarthPeople Public School
Nebraska

Appendix H

Interview Protocols

Pre-Visit Interview

1. Tell me how you became a science teacher.
2. Could you please tell me about your family/clan/tribal background and your childhood?
3. How do you think your experiences growing up influence you as a teacher and as a science teacher in particular?
4. Do you think that your race/tribal affiliation matter to teach in your school?
5. Please tell me about your role at EPPS. When did you join EPPS? How long have you worked here?
6. How has your Native American identity influenced your life experiences and your science teaching at your school?
7. Please tell me about your own K-12 science classroom experiences that influenced your science/STEM learning.
8. How did Native American culture, traditions, and interactions with elders in your community shape your science knowledge and pedagogical practices?
9. Do you believe your science learning/teaching journey has been impacted by your race and gender? If so, in what ways?
10. How do the demographics of your classroom affect your beliefs about teaching science to Indigenous students?
11. What does “teaching science using culturally and linguistically relevant practices” mean to you?
12. Is language important when teaching science? How do you feel about integrating science content and Earth Peoples’ language instruction and language revitalization? Do you do translanguaging in your classroom?
13. What are the common pedagogical practices that you use in your science classroom? Can you give me a few examples?
14. Could you please elaborate on the Indigenous Day slides: Nature-based education, greenhouse, art/puppets – little house of learning, medicine garden, planting gardens.
15. How do you use your/your students’ funds of knowledge to teach science to your students? Please provide an example of how you have done this.
16. How actively do students participate in your classroom?
17. How do you feel about their engagement in science after you introduced culturally and linguistically relevant pedagogical practices? Was there a difference before and after the introduction of your strategies?
18. How do you cope with and balance cultural relevance and a standards-based teaching environment in science classrooms?
19. Please discuss the programs, events, and activities you have organized in your own science classrooms or school-wide events in the past semesters.
20. How have your interactions with your colleagues influenced your science teaching?

21. Were support systems (such as supportive school administration – funds and supplies - and policies, etc.) available to you in order to teach science using culturally and linguistically relevant practices? If so, what are they?
22. Were professional development opportunities available to you in order to teach science using culturally and linguistically relevant practices? If so, what are they?
23. How do you navigate the cultural and racial approaches to knowledge construction within the constraints of standards-based STEM learning? What challenges do you face while doing these?
24. How do you cope with the trauma of historical deculturalization/trauma in your community? How do you use those experiences in teaching science to your students?
25. Have you heard of the term decolonization? If so, what are your opinions about tribal justice, Indigenous sovereignty, and the reclamation of Native land?

Post-Visit Interview

1. What factors do you think influence Native American students' science identity development? How can science teachers serve them better?
2. Thinking about the big picture and current times, what do you feel are the systemic and structural barriers to teaching science to Native American students during and after the COVID-19 pandemic?
3. Is there anything you want me to know about you as a science teacher or your own background/experiences in your community or about your students?
4. After spending this time with me and doing these interviews, what part of your story do you really want me to tell? What do you want to know from me?
5. If there was one thing that you could tell people about teaching Native American students science, what would that be?
6. What suggestions/advice would you give Native American teachers and students who do not live in reservations to succeed in science and pursue STEM careers?
7. What activities, programs, or events do you plan to organize for your students to engage them in the future?
8. What are your greatest accomplishments in your science classroom while using culturally and linguistically relevant practices as an Indigenous science teacher?
9. What are your greatest struggles/challenges in your science classroom while using culturally and linguistically relevant practices as an Indigenous science teacher?
10. If you could think of a metaphor to describe science teaching, what would it be? (For example, science learning is like a flower, you can smell it first but then when it opens you can really see its beauty).
11. Could you please tell me what kinds of support you might need from your school, colleagues, and the local community to promote holistic and meaningful science teaching at your school in the future?
12. Do you think your pedagogical practices meet the emotional needs of your student community? If so, how do they help in the healing of historical wounds experienced by your community members?
13. Do you have any other information to add?

Appendix I
Member-Checking Email to Participants

Dear [Name]:

I hope you are doing well! Your kind cooperation in our meetings, interviews, and classroom observations has helped me complete the “story” of your racialized and gendered lived experiences of teaching science to Native American students of your school. There are some conclusions and findings that I have drawn regarding your experiences, and I would love to have your feedback about these. May I come and meet with you on [Date of follow-up] at [Time] for a maximum of 30 minutes to request you to review and verify my findings (story)? Please feel free to contact me if you have any questions.

Thank you!

Uma Ganesan

Appendix J
Thank You to Participants

Dear [Name]:

Thank you so much for sharing your experiences during the past weeks. During the course of the next two weeks, I will analyze the story of your racialized and gendered lived experiences of using culturally and linguistically relevant practices in your science classroom. May I follow up with you at a later date for your feedback on any findings that will emerge from your story? This is to make sure that I am co-constructing the stories of your experiences accurately.

Thank you!

Uma Ganesan

Appendix K
Transcriptionist Confidentiality Statement

I _____ (name of transcriptionist) agree to hold all information contained on audio recorded tapes/and in interviews received from [Uma Ganesan/Theresa Catalano], primary/secondary investigators for [Exploration of the lived experiences of Indigenous science teachers: A narrative inquiry] in confidence with regard to the individual and institutions involved in the research study. I understand that to violate this agreement would constitute a serious and unethical infringement on the informant's right to privacy.

I also certify that I have completed the CITI Limited Research Worker training in Human Research Protections.

Signature of Transcriptionist

Date

Signature of Principal Investigator

Date

Appendix L
Data Sharing Plan

Individual-level data could be shared but would be de-identified. Data will be made available to colleagues via OneDrive in a de-identified folder. Since this project has a small sample size, data will have no identifiers to the participant's name or school's name, and no master list will be shared with colleagues with whom the data is shared.