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Utilizing a Culturally Relevant Ecology Curriculum to Help Students see Intersections between their Scientific and Cultural Identities

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by

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Introduction

Background

When a person walks into a secondary science classroom, they are met with a variety of sights: students reading out of textbooks, carefully following premade lab instructions, or listening to a lecture. These experiences are common for many students but do not reflect the best practices in science education. Students in this type of classroom are not active members in the construction of their own knowledge and, therefore, are not able to see the relevancy of the science curriculum as it can apply to their daily lives. As a result, teachers see lower levels of retention, and lack of interest from students (Howard, 2010). More so, this type of teacher-centered instruction perpetuates educational disparities (Byrd, 2016). Minnesota has one of the highest achievement gaps in the country, both across race and socioeconomic status (Grunewald & Nath, 2019). To address this divide, educators need to look critically at our instructional practices and ask critical questions of ourselves: Are we engaging all students? Do students see themselves reflected in our curriculum? Do students feel respected and valued within the classroom? The educational gaps seen within both the public and private K-12 educational system suggest that the answer to at least one of these questions is no. I recommend looking toward a more culturally relevant curriculum to increase student engagement and achievement in which students can see themselves reflected and can actively participate in the construction of knowledge. Here, I explore different historical and cultural perspectives on teaching ecology, before presenting a student-centered high school ecology curriculum focused on the intersection of student

identities and science. My objective is to use this curriculum to address the question: *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* For me, this question is personal. In this first chapter, I explore how I arrived at this question, which is the foundation for the review of the literature.

Context for Research

My interest in science is deeply rooted in my sense of connection to the natural world, and my personal history with it. Growing up, I spent my afternoons exploring the woods behind my parents' house. My first experiences with the scientific method involved walking through the woods and asking questions about bugs and plants. I could walk into the woods behind my house and explain the names of specific plants, how the land had changed through time, and where my dead fish were buried. These explorations made me curious about the world around me and gave me a sense of belonging in the larger world. My connection to the land was more than scientific; it was an intrinsic part of my sense of self. The more I explored, the more I began to cultivate a curiosity and connection to the world around me. I began to ask questions not only about the names of plants, but about the factors that affected their growth and change. I grew more curious about cyclical and seasonal changes in the landscape and wildlife around me.

My connection to and sense of belonging within the natural world has grown over time, and has driven much of my academic journey. In reflecting on how the natural world shaped my sense of identity, I began to wonder how it shaped others' identities. During my undergraduate studies, I explored how different populations related to the land through the lenses of race, gender, and socioeconomics. I learned that personal histories

have a significant influence on the types of questions we ask and how we relate to the natural world (Robbins, 2004; Savoy, 2015). In one example, I learned about the Great Dismal Swamp, in Virginia. I discovered how this one ecosystem could be viewed through completely different lenses by Indigienous People, fugitive slaves, and European colonists. For Indigneous peoples, the swamp was a rich ecosystem for hunting and gathering. Fugitive slaves used the swamp as a refuge from their captors, setting up camps and underground railroad stops. In contrast, European colonizers like William Byrd viewed the swamp as a, "miserable morass where nothing can inhabit," and thought it ought to be drained in an effort to make it reflective of transcendentalist paintings of the era (Struzik, 2021, p. 29). Reading about how other people relate to the natural world strengthened my own connection to natural spaces, and helped me better understand the role my identity played in making those connections. Beyond this, it helped me to understand how science has developed over time.

Science can be defined both as a body of knowledge and as a method of inquiry. As I read more about how individuals relate to the natural world and science as a whole, I became more interested in how science is used as a method of inquiry. Scientific inquiry is driven by curiosities and questionings. Our personal histories shape the types of questions we ask, as well as where we are willing to go to find answers (Robbins 2004). I am curious about wetlands - the plants, the biochemistry, their links to agriculture and climate change - because those are environments that I grew up around, but are also spaces in which I feel the safest. However, as a science teacher in an urban setting, I know that my students do not share my history or experiences with the outdoors. My students have expressed to me that this type of science does not feel relevant, they do not

feel connected to it. I believe part of this is due to a lack of exposure and historic disenfranchisement. Numerous studies show that people of color are far less likely than white individuals to participate in nature-based outdoor recreation, such as visiting a state or national park, hiking, canoeing, rock climbing, or biking (Gosalvez, 2020; Warren, 2006; Johnson, 2006). Researchers such as Gosalvez (2020) credit this to a combination of historic and current discrimnation and disenfranchisement. This disenfranchisement becomes abundantly clear when looking at news stories from the past two years. For example in May 2020, Christian Cooper, a Black man and avid bird watcher, had planned to spend his morning searching for Blackburnian warblers in Central Park. Instead, his morning ended abruptly with a call to the police by another resident who refused to leash her dog (Gosalvez, 2002). In the same year, Ahmaud Arbery, was chased down and shot by a white man in a car, while running in his own neighborhood (Gosalvez, 2002). These stories give credence to the false-perception that outdoor spaces and activities are not safe for or welcoming to people of color (Gosalvez, 2020). Many of my students share this belief, that the outdoors is only for white people and that it is not safe. Most of them have neither been to a state or national park nor gone beyond the basketball courts at their local parks. As a result, their relationships to natural spaces often feels distant and irrelevant. The questions they ask about ecosystems are driven by fear, misinformation, or me, their teacher rather than their own curiosities. I see a disconnect between my students and the fields of ecology and environmental science as a whole.

I first noticed this pattern when working with students as an outdoor educator. I worked as an environmental educator in a variety of settings both on the east coast and in the midwest for several years after finishing my undergraduate studies. My work largely

included bringing students into the woods to learn about wetland ecology, forest ecology, geology, and teambuilding. I primarily worked with students of color from New York City, most of whom had never been out of the city. These students often had fears around lack of lights, the sounds they heard, and the lack of pavement at the outdoor education center. In an extreme instance, I had a seventh grade student so fearful I had to carry her out of the woods. Doing this work led me to question how teachers in these settings could help students feel more comfortable. I noticed that for many students, the biggest factor in building confidence and comfort was time. When given more time in a particular space, students were able to ask questions and explore the space around them. They became more familiar with the landscape. As their familiarity with the space grew, my students were able to look past their initial fears and the types of questions they asked began to change. After a few days of exploration, they became less concerned with identifying everything in sight (in case it was poisonous) and more interested in relationships both in the natural world and among their peers. Critical to this shift was comfort and a sense of belonging. The longer students were in a forest, the more they began to claim it as their own, to point out landmarks with pride. As they felt more comfortable, their ability to look critically at the world increased.

I see similar trends in my work with 7-12th grade students in South Minneapolis, approximately 90% of whom identify as Black, Indigenous, and People of Color (BIPOC). Through observation, I've seen my students feel uncomfortable or disconnected from the natural spaces around them, even when those spaces are within walking distance. I see this most clearly when introducing the concept of ecology and ecosystems to them. When asked to give examples of a local ecosystem, many students

struggle with the understanding of the term *ecosystem*, and struggle to think of examples of Minnesota ecosystems. Instead they list coral reefs, the rainforest, or other ecosystems that they have never seen. When I ask about their experiences with nature they often list nature documentaries like “Planet Earth” or “Wild Kratts.” These shows have exposed my students to an amazing world of plants and animals but have also given them a sense of separation from those places. There is a divide between the natural world and the place where they live, which is not helped by the introduction of more scientific terms in the classroom. To address this I try to show them Minnesota’s local ecosystems. We look at images and videos of urban ecosystems, prairies, and forests and I bring them into natural spaces that are in their communities and around our school through field trips. When I tell my students that we will be going on a field trip outside I get mixed responses. Many are nervous about things like cell phone service, bugs, bears, or poisonous plants. Others excitedly tell me about how they are going to survive off the land. Regardless of their reaction, for almost all of them it’s the first time they’ve been on an unpaved trail or a city park without a basketball court despite the fact that many of these spaces are within walking distance from their homes. Once in these environments, students start to slowly gain comfort. The more comfortable a student is, the more I notice them engaging critically in scientific inquiry. This experience seems further encouraged when students notice something familiar - a plant, an animal, or even just the way a path curves. I’ve observed this trend in both my students in Minneapolis and New York. My students’ ability to ask deep scientific questions is strengthened by access and personal connection to natural spaces.

These experiences have shown me that creating space for students to establish personal connections to nature is critical to engage them in the study of ecology. To do this, students need to feel that ecology is relevant to their lives, and see themselves reflected in outdoor spaces. However, in discussions with students, I've found that my students do not feel that ecology is relevant to their lives. My own experiences have shown that this extends beyond students to the larger field of ecology and environmental education. I have found these fields to be dominated by white, middle-class individuals such as myself. When working in outdoor education one of our greatest challenges was getting instructors from varied racial and economic backgrounds. My coworkers were predominantly white middle-class men and women with college degrees in environmental science. We all had a strong comfort level in the woods, and had grown up with experiences outside. This pattern holds true when we look at national data as well both within the sciences and the field of education. Within the sciences as a whole, women and people of color are underrepresented (Martinez & Christnacht, 2021). In education, 79% of public school teachers identify as white, and they serve a population of students that on average is about 47% students of color (National Center for Educational Studies, 2020; Schaeffer, 2021). Although we are seeing more individuals of color and women in science and education, this historical gap is still far from closed, especially in the fields of ecology and environmental science (Martinez & Christnacht, 2021). When working for the St. Paul Parks Department, I worked on programs that specifically aimed to address this inequity by bringing people who were typically underrepresented in natural spaces to various parks in the city. As the lead program manager for St. Paul's Park Ambassador program and an educator for Como Park Zoo and Conservatory's legacy programming - a

set of free programs aimed at increasing environmental literacy in youth - I experienced first hand the difficulties in running these programs and seeing positive outcomes. In my programs I often had trouble getting participants to sign up. For many, outdoor settings felt risky, either because of fear of the unknown or false narratives about who belonged in those spaces. The programs with which I worked are not unique in their efforts to bring more diversity into the outdoor spaces. In Minneapolis alone, programs such as Big City Mountaineers work adamantly to provide low-income, urban youth of color opportunities to go on canoeing and backpacking trips. Urban Boatbuilders do similar work. In their program, youth build a canoe before taking it on a trip down the Mississippi. The Tiny Field Project helps community members grow their own food by learning how to grow and care for boulevard gardens. Within the Minneapolis Park Board, the Teen Teamworks and Green Team projects pay youth to do maintenance, gardening, and educate the public in our local parks. I like to believe that these programs aid in helping bridge the gap between who feels comfortable and who feels uncomfortable in outdoor spaces. However, there is still a disconnect between the racial and socioeconomic makeup of employees leading this type of programming and the individuals they serve (Warren, 2006; Gosalvez, 2020, KoFan et al., 2016). Data from a 2022 survey by Zippia, found that approximately 64% of all ecology jobs are held by men, with 76.6% of all position holders identifying as white (Zippia, 2022). This gender and race gap is wider when looking at jobs that specifically involve working outdoors such as forest consultant, forester, field agronomist, and procurement forester. In each of the positions more than 90% of the positions are held by males (Zippia, 2022). These experiences, accompanied by census data, support the idea that white middle-class individuals feel more connected

and safe in outdoor spaces than people of color - and as a result represent the majority of those in the field of ecology (Martinez & Christnacht, 2021). In my role as an educator, I have a responsibility to understand this divide as well as help address it.

To better understand this divide, we must first consider the historical context. I suggest that one aspect of this divide is historical disenfranchisement from natural spaces, and a perceived lack of relevance of ecology related careers. My ideas around this first arose about ten years ago from a course I was able to take in college on nature, culture, and place. The course centered on writing our own narratives around a sense of place as well as reading those of others from a variety of experiences. Through reading the works of authors such as Robin Wall Kimmerrer, Lauret Savoy, and Tom Wessels, I was exposed to the idea that time period as well as socioeconomic and racial identities strongly influence relationships to land. Wessels exposed me to the idea that landscapes leave traces of their history. His work focused on reading the past of New England in tree scars, stone walls, and plant distribution (Wessels, 1997). Reading his work, and walking through the woods in Massachusetts with him, I began to understand the interconnectedness of human and ecological histories (Wessels, 1997). My understanding of this was strengthened by reading Kimmerer's experiences just a few hours away in Upstate New York. Kimmerer, an Indigenous woman, reads the land in a very different way from Wessels. Where Wessels saw the remains of early European farmers, Kimmerer saw a history of removal and displacement of Indigneous people and people of color (Kimmerer, 2013; Wessels, 1997). Both Kimmerer (2013) and Savoy (2015) discuss this history of removal, by looking at the idea that naming influences our relationship to land, and specifically the process of un-naming. They describe a history of rewriting the names

of land, and erasing the traces of Indigineous cultures and African American cultures. Specifically, they describe the process of erasing people of color from nature (Savoy 2015). In thinking about these works, and my own students' relationships to land, I conclude there must be a connection. The United States has a marked history of removing people of color from natural spaces, so it seems logical to me that this is part of why my students of color are underrepresented in the field of ecology (Savoy, 2015).

Considering this historical context is critical when thinking about how to best teach ecology to a diverse group of students. Specifically, we must be willing to speak about this history and present a vast array of experiences to our students. To do this, I suggest we look towards a more culturally relevant ecology curriculum that reflects both student voices, and a variety of voices that reflect student experiences. To be effective, I propose that an ecology curriculum must look not only at ecological literacy but also cultural literacy to highlight the intersection between science and culture. By focusing on this, I believe we will better represent students and as a result increase engagement and retention of science knowledge.

Summary

Within the sciences, people of color and women are underrepresented; this suggests that within the K-12 education system students are not engaging with science curriculum (Grunewald & Nath, 2019). My experiences have shown me that the current curriculum does not adequately represent student voices and perspectives. As a result, I believe that we are seeing a lack of engagement and intrinsic motivation from students. Within the field of ecology, I’ve noticed that students who feel uncomfortable or disconnected from natural spaces are less engaged with the material. Research and my

personal experience show this is the result of historical erasure of people of color from natural spaces (Savoy, 2015). My recommendation to address this is the creation of a culturally relevant ecology curriculum that is centered on building cultural relationships with land. In Chapter 2, I discuss the historical precedent for this type of curriculum as well as examine the effects of culturally relevant pedagogy on student performance. In Chapter 3, I provide an overview of a culturally relevant ecology pedagogy and the framework for its construction. Finally, in Chapter 4 I reflect on the effectiveness of this pedagogy, its potential strengths, weaknesses, and recommendations for future application.

CHAPTER 2

Literature Review

Introduction

Within the sciences we see an underrepresentation of people of color and women (Grunewald & Nath, 2019). In particular, we see young women and students of color begin to lose interest in pursuing science related fields beginning in middle and high school (Grunewald, n.d.). These realities suggest that K-12 students do not feel that their experiences with science are relevant to their lives. To address this issue, I look at the role of curriculum and specifically address the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* In this chapter I provide an overview of the literature that addresses this topic. First, I discuss what culturally relevant pedagogy is and the possible advantages of it for students. Next, I look at the existing ecology standards and curriculum recommendations in place for Minnesota students. Finally, I examine the missing pieces of this curriculum by looking at the natural and cultural history of Minnesota and look at how these histories could become part of a culturally relevant curriculum. In Chapter 3, I use the resources discussed in Chapter 2 to propose the creation of a high school ecology curriculum based in culturally relevant practices.

Culturally Relevant Pedagogy and its Effect on Student Learning

Culturally relevant education is a framework of teaching that centers students' cultural backgrounds, interests, and lived experiences in all aspects of learning. This type of pedagogy emphasizes student learning and achievement, affirmation of students' cultural competence, and facilitation of critical consciousness (Ladson-Billings, 1995).

Culturally relevant pedagogy specifically centers student identities as a core aspect of learning, and therefore is closely aligned with an ecological curriculum that centers students' perspectives (Jackson & Bryson, 2018). This section explores three aspects of culturally relevant pedagogy. First, this section defines culturally relevant pedagogy and how teachers can utilize it, second it explores the effect of this type of pedagogy on student academic performance, and finally it describes research on the effect of culturally relevant pedagogy on student efficacy and sense of self.

Framework for Culturally Relevant Pedagogy

Culturally relevant pedagogy first came into common use in the 1990s with the work of Gloria Ladson-Billings. Her 1995 article "Towards a Theory of Culturally Relevant Pedagogy" set a framework for what culturally relevant pedagogy is and why it ought to be an important aspect of modern education. Ladson-Billings' work built on previous efforts to center social justice and equity in education (1995). Where she differed from others was in her efforts to create a new framework rather than focus solely on reformation to teacher training programs (1995). In this article, Ladson-Billings looked at research she conducted with eight African American teachers. She found that through the use of a curriculum that centered student identity and focused on building cultural competency, student achievement grew (Ladson-Billings, 1995). This then became the cornerstone of her framework for a culturally relevant pedagogy. Ladson-Billings argued, "Culturally relevant pedagogy must provide a way for students to maintain their cultural integrity while succeeding academically" (1995, p. 476). To do this, teachers must encourage academic success and cultural competency as well as help students recognize, understand, and criticize social inequities (Ladson-Billings, 1995). In

this framework, teachers act as a bridge between students' home culture and school culture. This means that the role of the teacher must change in response to the individual students with whom they work and the cultural context that they bring to the classroom (Ladson-Billings, 1995). Ladson-Billing's work was further expanded by Geneva Gay, who defined culturally responsive teaching as "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (Gay, 2002). Gay emphasized that by situating academic experiences in lived experiences of students they are more likely to have higher engagement, interest, and academic achievement (Gay, 2002). Gay points out that to do this type of learning educators need to understand their students' histories on a deep level and be flexible in their teaching methods (Gay, 2002).

Both Ladson-Billings (1995) and Gay (2002) emphasized the importance of teachers becoming experts on their students, in order to build an inclusive curriculum. Jackson and Bryson (2018) argued that to build this understanding teachers must understand the specific communities that they serve. They suggested that pre-service and active teachers use community mapping as a mechanism to engage and understand the places they work (Jackson & Bryson, 2018). Community mapping allows teachers the opportunity to identify and make connections with the experiences of one another (Jackson & Bryson, 2018). They described community mapping as a way of telling a neighborhood's story. In community mapping teachers, either independently, in groups, or with their students, work to gather information about the community they serve. Participants collect data about the community housing, businesses, healthcare, green spaces, and play areas. To do this, they speak with community members and local school

personnel (Jackson & Bryson, 2018). This type of mapping allows teachers to better understand the experiences of their students, but can also be a powerful tool in helping students learn more about their communities and the strengths they as community members bring to the classroom. In this way, community mapping has both potential benefits for teachers and students, and better allows teachers to act as the bridge described by Ladson-Billings (1995).

Jackson (2005) argued that the key to understanding student culture lies inside the classroom, rather than just out in the community. She argued that relationship building with students, and a fearless expectation that all students will learn, is critical to culturally relevant teaching (Jackson, 2005). Jackson argued that learning happens when students have understanding, motivation, competence and confidence (Jackson, 2005). Incorporating a student's cultural experiences, through the use of culturally relevant curriculum, is critical to each of these components. Jackson looked specifically at African American students. To best serve these students, she argued that teachers need to use the interconnectedness of language and cognition as a frame for instruction. To do this, she recommended two instructional practices: mediated learning and literacy enrichment (Jackson, 2005). Jackson argued that these two practices allow teachers to build relationships with students and build student confidence and competency. In mediated learning, students develop discussion skills through an interactive process. The goal is for students to describe a personal motivation for learning, meaning that they can explain why they are learning and how it relates to their individual lives. To do this, the teacher must engage students in activities that build confidence, before allowing them to critically analyze and identify personal connections (Jackson, 2005). Jackson argued that

this tool is most effective when teachers use appropriate cultural themes. For African American students, she described nine themes that elicit student experiences and cultures. These included: spirituality, resilience, humanism, communalism, orality and verbal expressiveness, realness, personal style and uniqueness, emotional vitality, and musicality (Jackson, 2005). By combining these themes with academic content, students' are more likely to engage with the material and be motivated to expand on their learning (Jackson, 2005). Beyond mediated learning, Jackson also recommended teachers use *literacy enrichment*. She argued that underachievement in African American students is most clearly seen in literacy skills such as inferential thinking and vocabulary development (Jackson, 2005). To empower students, literacy needs to be the focus. Mediated learning allows for students to develop both inferential thinking and communication skills. Literacy enrichment builds on this by creating literacy skills that foster social interaction for language development and guide application. Jackson pointed out that literacy for African American students is deepened when teachers build on the practices and expertise of their everyday lives. She looked to research that builds on the definition of literacy as more than a mental phenomenon but as a social, cultural, historical, and political practice. Tools such as thinking maps can help students see these connections, and build on literacy practices as more than just active reading (Jackson, 2005). Regardless of the specific practice used, Jackson (2005), Jackson and Bryson (2018), and Gay (2002) all argue that utilizing cuturally relevant pedagogy is an art that requires teachers to adapt to their specific students. To do this effectively, teachers must first know their students, and be open to having their own assumptions questioned, both inside and outside of the classroom.

The emphasis on understanding individual student needs means that culturally relevant pedagogy is more than just a series of tools, and that the specific tools a teacher uses will be dependent on the cultures of their students. To better understand and serve their students, teachers seeking to practice culturally relevant curriculum need to understand both the complexity and strength of their students' cultures. Tyrone Howard (2010) addressed this idea in his book *Why Race and Culture Matter in Schools*. He emphasized that culturally relevant pedagogy is more than just a way of teaching and cannot be broken down into a series of small steps. Instead it is the embodiment of a professional, political, cultural, ethical, and ideological disposition (Howard, 2010). Key to this is understanding that culture is complex, and includes many aspects of student life, all of which have value (Gay, 2002). Culturally relevant teaching requires teachers to understand that their students' home-cultures vary, and teachers must choose instructional practices that are appropriate for those cultures. For example, Jackson provides tools for working with African American students in an urban setting; however these cultural norms may not be appropriate for students with different home cultures (Jackson, 2005). Regardless of their student body, teachers who practice culturally relevant pedagogy have a firm belief that all their students' identities are assets in their learning abilities (Dodo Seriki, 2018). Dodo Seriki (2018) discussed the value of this, and also emphasized that culturally relevant pedagogy is dispositional in nature, rather than a series of discrete steps. This means that to be effective, teachers seeking to practice culturally relevant pedagogy must go beyond just knowing about the communities they serve and consciously or unconsciously reject deficit orientation and instead view students through an asset-based lens (Dodo Seriki, 2018). When done correctly, Dodo

Seriki suggests that the framework of culturally relevant pedagogy is a key way to engage all students in science education (2018).

The use of a culturally responsive pedagogy framework within science education is of particular interest as it offers the potential to address pervasive issues of marginalization of ethnically diverse students (Garvin-Hudson & Jackson, 2018). Garvin-Hudson and Jackson presented an example of culturally relevant pedagogy in a summer science program (2018). They argued that with an increase in ethnically, linguistically, and culturally diverse students, science classrooms need to be transformed. They argued that science has an inherent tension between western/eurocentric views and indigienous knowledge. They stress that within science education, addressing this tension is of particular importance as we often view the subject as objective and value/culture-free (Garvin-Hudson & Jackson, 2018). The solution to this, they argue, is to utilize a culturally relevant approach. To be culturally relevant, Garvin-Hudson and Jackson utilized an approach that centers student identities by utilizing Ladson-Billings' lens (2018). They argued that this means the creation of a curriculum that seeks to actively empower students intellectually, socially, emotionally, and politically by intentionally bringing conversations of sociopolitical consciousness, cultural competence, and academic success into it (Garvin-Hudson & Jackson, 2018). Culturally relevant curriculum utilizes students' cultures as a mechanism for learning and positions students' knowledge and lived experiences as valuable for developing new knowledge. By teaching students through this lens, they argued that the innate tension in science between western and non-western ideologies can be addressed (Garvin-Hudson & Jackson, 2018).

Effect of Culturally Relevant Pedagogy on Student Academic Achievement

Culturally relevant pedagogy centers students' cultural identities and lived experiences as assets in education and focuses on increasing students' cultural competence (Ladson-Billings, 1995). In doing this, practitioners argue that students are better equipped to achieve academically, regardless of the subject matter (Gay, 2002). Howard reviews several of these studies in his discussion of culturally responsive pedagogy (2010). Specifically, he shows that in both English and mathematics classrooms teachers who instituted culturally relevant teaching practices saw higher levels of proficiency. Howard (2010) provided an example from the Ing School of California. He cited data obtained by the California Department of Education from the Ing School that showed an increase in their Annual Performance Index (API) after the school implemented culturally relevant practices. Specifically, the Ing School saw a change in API scores from 432 in 1999 to 578 in 2006 after the implementation of culturally relevant practices (Howard, 2010). Within the field of science, Morales-Doyle (2017) saw similar results after instituting culturally relevant practices in a high school chemistry classroom. Their data showed academic achievement that exceeded expectations of a typical high school chemistry course (Morales-Doyle, 2017). Morales-Doyle showed that key to seeing this growth was the teacher's understanding of both what culturally relevant pedagogy is and commitment to the practice (2017). Howard (2010), Morales-Doyle (2017), and work by Underwood and Mensah (2018) all showed that teachers' perceptions and preconceptions of culturally relevant pedagogy played a key role in the effectiveness of this type of pedagogy. Underwood and Mensah (2018) found that this was true both with science teachers and science teacher educators.

When teacher educators had misperceptions about culturally responsive pedagogy, they were not effective in utilizing it, and their teacher candidates found it less effective in their own classrooms (Underwood and Mensah, 2018). Despite these challenges, the overwhelming evidence is that the utilization of culturally relevant pedagogy leads to greater academic achievement in students; however, this is not the only benefit seen in the literature.

Effect of Culturally Relevant Pedagogy on Student Efficacy and Sense of Self

Culturally relevant pedagogy has been shown to increase student academic achievement in core curriculum areas as discussed above; it has also been linked to an increase in student efficacy and sense of identity. Essential to culturally relevant pedagogy is the development of a critical consciousness and commitment to social justice. This critical consciousness can then help students to better understand their own role in the world and gain agency (Howard, 2010). Through developing this consciousness, students are better able to critique cultural norms and address social inequities both within their school and community (Ladson-Billings, 1995).

This sense of empowerment is described both by teachers and students. Students interviewed by Garvin-Hudson and Jackson about their experiences with a culturally relevant science curriculum showed an increased interest in science (2018). Students also reported feeling empowered and inspired to go into fields of science, specifically mentioning the effect of speakers of color on their understanding of the field (Garvin-Hudson & Jackson, 2018). Byrd conducted a similar study with students in grades 6-12 to see how culturally relevant teaching affected student learning and ethnic-racial identity development. She found that in a survey of 315 students, those who

experienced culturally relevant teaching showed significantly higher academic outcomes and ethnic-racial identity development (Byrd, 2016, p. 5). Within the context of a chemistry classroom, Morales-Doyle found that students demonstrated complex thinking about both science and social justice as well as a renewed commitment to their communities and cultural origin after participating in a culturally responsive teaching (2017). Beyond this, students also demonstrated confidence as credible youth science experts (Morales-Doyle, 2017). Talpade and Talpade (2018) quantified increases in student academic confidence and racial identity development through the use of the Sankofa Scale - a scale specifically constructed to measure student perceptions (p. 4) . They utilized surveys to confirm both the validity of the scale and to affirm that utilizing culturally relevant pedagogy increases student sense of identity and academic confidence (Talpade and Talpade, 2018). These studies show that beyond increases in academic achievement, culturally responsive teaching can increase student sense of self and agency within their communities.

Culturally Responsive Pedagogy Section Summary

Culturally responsive teaching is rooted in the centering of student identity and culture in the classroom (Gay, 2002). Teachers who engage in this type of teaching utilize a variety of tools to understand their students as individuals and as members of a larger community, and use this information to customize their instruction (Jackson & Bryson, 2018; Gay, 2002; Jackson, 2005). As discussed above, this framework has been shown to increase student academic achievement and critical consciousness (Ladson-Billings, 1995; Talpade & Talpade, 2018; Morales-Doyle, 2017; Garvin-Jackson & Hudson, 2018). Teacher perception of culturally responsive teaching is essential to its success

(Underwood and Mensay, 2018). Specifically, teachers need to understand this framework as an embodiment of a professional, political, cultural, ethical, and ideological disposition rather than a set of prescribed steps (Howard, 2010). Beyond this, teachers who practice culturally responsive teachers should be critically conscious of power dynamics in education and the role within that system (Gay, 2002). When not viewed through this lens, pedagogy based in culturally responsive teaching can prove more harmful than beneficial to students (Howard, 2010; Underwood and Mensah, 2018). When culturally responsive teaching is used as a set of prescribed steps or tasks to accomplish there is a risk of isolating students by being reductionist (Howard, 2010). Instead, teachers must commit themselves to the ideological framework of culturally responsive teaching and focus on the assets each student brings into the classroom (Dodo Seriki, 2018). By utilizing this framework, students within the sciences have been shown to be more engaged academically and culturally (Garvin-Hudson & Jackson, 2018). I propose it is reasonable, then, to apply the framework to an ecology curriculum.

In the next section, I look at current Minnesota ecology standards and how they are implemented in the classroom. Finally, I examine natural and cultural history that could be instrumental to the creation of a culturally responsive ecology curriculum rooted in the Minnesota science standards in an effort to answer the research question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"*

Ecology Academic Standards and Best Practices in Ecology Pedagogy

Culturally responsive pedagogy centers student identities and is focused on helping students develop critical consciousness. As a result, it presents an excellent

framework for addressing the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* Beyond utilizing a culturally responsive framework, science curriculum must also meet the standards of Minnesota approved by the Minnesota Legislature for students studying life sciences. Minnesota requires students to gain a basic understanding of ecological concepts through several standards. Minnesota state standards 9L.2.2.1.1, 9.L.2.2.1.2, 9L.3.2.1.3, 9L.4.1.1.1, and 9L.4.1.1.1 all describe the ecological concepts of which students should have mastery (Minnesota Department of Education, 2019). These concepts include an understanding of how energy is moved and transferred through an ecosystem, the role of carrying capacity in population growth, an understanding of how ecosystems can change through the introduction of new species, and the social, economic, and ecological risks and benefits of changing ecosystems. Beyond this, Minnesota standard 9L.4.2.2.1 specifically requires students to be able to obtain and communicate contributions from diverse cultures to our understanding of interactions among humans and living systems (Minnesota Department of Education, 2019). In order to master these standards, students must have a firm understanding of the different components of an ecological system, the factors that can change the functions of that system, and the history that has enabled us to understand and study various ecosystems.

This section provides an overview of the ecology standards Minnesota students must meet as well as pedagogy recommendations from educators. The second part of this section compares two different approaches to teaching ecology. The first, what Paul Robbins (2004) defines as apolitical, views the researcher/scientist as completely objective. I refer to this as classical ecology, as it represents historic trends in ecology

pedagogy and is how it is more frequently referenced in the literature. The second perspective centers student identity and background as an integral part of the creation of science. Robbins (2004), refers to this as political ecology. These two approaches center humans' relationships to nature in vastly different ways and represent the western/non-western dichotomy seen in current science education debates. Therefore, examining both approaches is critical to understand how ecology has been taught historically and what knowledge is missing from that curriculum.

Classical Ecology Pedagogy Practices

Minnesota's ecology standards provide a foundation for students to gain an understanding of how to create models of energy movement and transfer through ecosystems, the role of carrying capacity in population growth, the role of new species in an ecosystem, and the social, economic, and ecological risks and benefits of changing ecosystems (Minnesota Department of Education, 2009, 2019). How students gain mastery of these concepts is up to the individual teacher, school, and/or school district. Discussion on best practices for teaching students to master ecological concepts varies greatly, with a great deal of emphasis on the use of authentic data and experimentation to create inquiry-based curricula (Yael, 2017; Bowman & Govett, 2010). These approaches utilize what Paul Robbins calls an "apolitical" approach to teaching ecology (Robbins, 2004). Robbins uses this term to define science in which the researcher is viewed as objective and separate from the questions and investigations they are conducting (Robbins, 2004). Apolitical ecology, more often referred to as classical ecology, is rooted in the idea that western science is objective, and conducted by a disengaged observer. This is in contrast to political ecology, the term Robbins uses to describe science which

centers the researcher and their identity in the type of science they produce (Robbins, 2004). I further explore these differences later in this chapter. First, I provide an overview of classical ecology curricula as well as their effectiveness in the classroom.

Inquiry-based curricula are central to many discussions on best-practices for ecology teaching. This type of learning focuses on creating authentic science experiences for students. Inquiry-based programs use a variety of tools, including the introduction of published scientific data, the collection of data by students, and whole group discussions (McNeil, Pimentel, and Strauss, 2011). This type of learning is currently used as a cornerstone of many schools for which STEM (Science, Technology, Engineering, and Mathematics) is a focus (Erodogan & Stuessy, 2015). STEM-focused schools have shown higher rates of scientific success for students, and as a result, many of the practices in these schools have been utilized for implementation in non-specialized schools (Erdogan & Stuessy, 2015). Specifically, inquiry-based learning has been highlighted as a key component in shifting student learning away from memorization and towards true concept mastery (Bowman & Govett, 2015).

The use of published data and student-collected data is perhaps one of the biggest components of inquiry-based learning. Bowman and Govett emphasize this in looking at the Next Generation Science Standards (2015). They stress that in order to better help students master the skills of science they must be allowed to engage in authentic science inquiry, where they are collecting, analyzing, and critiquing data (Bowman & Govett, 2015). Yael (2017) found that curricula that used published scientific data about human impact and ecological function had a positive influence on both teachers' perceptions of the curriculum's success and student interest in the topic. How students collect or analyze

data varies depending on the classroom, instructor expertise, and access to collection tools or collected data. As a result, the quality of student learning also varies (Bowman & Govett, 2015).

In addition to the use of published data, whole-class discussion is another commonly used tool in inquiry-based ecology programs. In whole-class discussion models, students are asked to respond to probing questions. These discussions can be teacher- or student-facilitated and have varying structures depending on the classroom teacher (Pimentel & McNeil, 2013). Pimentel and McNeil examined the effectiveness of this tool and found that framing, in other words how the material was presented, was critical to the success of these discussions (2013). They looked at transcripts of whole-class discussions in ecology classrooms and found that student involvement was typically limited to simple phrases or short sentences. Their research showed that teachers rarely asked probing questions, which reinforced a classroom-wide belief that the teacher was the expert as opposed to students (Pimentel & McNeil, 2013).

In both these practices, whole-class discussion and student data-collection, educators attempt to implement an inquiry-based approach. This means that students are engaging actively with the material in order to discover patterns. In their discussions of this curriculum, Bowman and Govett (2015) and Yael (2017) both emphasized the importance of objectivity. This is stressed in many science curricula, where the individual is viewed as separate from the investigation. These types of curriculum intentionally separate the personal histories and identities of participants, meaning that they view the student, teacher, and past researchers as completely objective. However, McNeil, Pimentel, and Strauss point out that teachers' beliefs play a significant role in the

effectiveness of these classical curriculums (2011). In looking at surveys of student learning through an ecology unit, McNeil, Pimentel, and Strauss found significant variation between teachers in terms of their practices based on their teaching beliefs (2011). They found that teachers who had higher percentages of time focused on group work, student dialogue and idea sharing, had higher levels of student achievement. Their results suggest that to be most effective, ecology curricula need to include opportunities for students to argue and have a voice within the classroom, they need to be politicized (McNeill, Pimentel, and Strauss, 2011). This research suggests that incorporating student experience and voice into an inquiry-based curriculum may be critical for student success.

Centering Student Identity in Ecology Pedagogy

In contrast to classical ecology practices, Robbins (2004) proposes using what he calls "political ecology," an approach to science that centers the individual and their cultural background (Robbins, 2004). Robbins argued that all science is inherently influenced by our cultural and socioeconomic backgrounds (2004). He pointed out that everything from the type of questions we ask to our access to scientific tools is influenced by culture, economics, and race (Robbins, 2004). Political ecologists - a field in which Robbins is prominent - look at how cultural, historical, economic, and political backgrounds influence the field of ecology and the natural sciences as a whole. They specifically centered the individual and their relations to the world, and argued that no science can be truly objective. Thus, to fully understand patterns in the natural world, we need to understand our own positionality as researchers and scientists and how this influences what we see (Robbins, 2004). This type of work is of interest when

considering a culturally relevant ecology curriculum for students as it leans into the idea that researchers have positionality and therefore offers space for student voice and culture within the sciences.

Teaching ecology through a lens that centers student identity, rather than viewing it as separate, requires teachers to rethink what they already know about the subject. Robbins pointed out that our backgrounds influence how we define different ecology terms and concepts (2004). Classical lenses position humans as separate from nature, when considering ecology. As a result, the way classical ecologists approach issues of restoration and conservation differ greatly from those who utilize a political ecology lens. Robbins specifically discussed the role of classical ecology in perpetuating ideas of ecoscarcity and land degradation, which have a disproportionately negative impact on global policies directed at developing countries (Robbins, 2004). Carolyn Merchant continues this discussion in her book *Radical Ecology* where she pointed out that relation to land differs greatly across culture, and as a result affects our approach to science (2005). She discussed how utilizing a classical lens has resulted in numerous instances of land disenfranchisement and a disregard for indigineous scientific knowledge (Merchant, 2005). Curriculas that utilize Robbins' political ecology lens center discussions around these issues in the classroom, and specifically ask the learner and educator to critically evaluate their own positionality in thinking about ecological issues.

In terms of high school curricula, understanding ecology through this politicized lens is of particular importance, not only for students but also for teachers in examining their own practices. Research by McNeill, Pimentel, and Strauss (2011) as well as Pimentel and McNeil (2013) suggested that teacher beliefs and perceptions play a

significant role in student learning and enactment of curriculum. This is consistent with research by Howard (2010), who found that teachers' perceptions of their students' abilities and assets or deficits heavily influenced student success. These studies show that, as teachers, our positionality already influences our understanding of both science content and our students. Howard continues this line of thought by pointing out that if teachers' perceptions influence their curriculum and approach towards teaching then so too do students' positionalities influence their ability to learn (Howard, 2010). By engaging in direct conversations around those positionalities, students can then better understand the ecology content and see themselves reflected in the material (McNeill, Pimentel, and Strauss, 2013).

This politicized lens closely aligns with a culturally relevant framework. Howard (2010) pointed out that culturally relevant pedagogy is innately political and perhaps a better term is political pedagogy, as it more clearly describes the centering of student experience and history in the curriculum. A political ecology lens specifically centers the human experience on our understanding of ecology and shows science to have subjectivity in it (Robbins, 2004). As a result, it offers a unique opportunity for students to engage in complex dialogue and argumentation, which McNeill, Pimentel, and Strauss (2011) found to be key in student academic achievement.

Ecology Standards and Pedagogy Section Summary

Minnesota requires students to gain an understanding of basic ecological concepts during their high school life science classes. These standards focus on concepts of energy movement and transfer through ecosystems, the role of carrying capacity in population growth, the role of new species in an ecosystem, and the social, economic, and ecological

risks and benefits of changing ecosystems (Minnesota Department of Education, 2009, 2019). However, how students gain mastery of this content is largely up to the individual teacher and school district. In this section, I looked at two main approaches to teaching ecology: classical and political. Classical lenses largely remove humans from nature, viewing us a species as separate from the rest of the world (Robbins, 2004). In contrast, political ecology lenses center humans in ecosystems. Beyond this, political ecologists look at the role that an individuals' socioeconomic, political, and cultural backgrounds plays in the types of questions they ask and the scientific answers they find (Robbins, 2004). These two lenses present a dichotomy within both the field of ecology and the teaching of ecology. Both can be effective and ineffective approaches to teaching students depending upon the belief systems of the teachers and the level of voice given to students in the classroom (McNeil, Pimentel, and Strauss, 2013). However, the political ecology lens does offer more potential for students to see their cultural selves reflected in the classroom. This lens is more consistent with the framework for culturally responsive curricula, as it centers the student experience (Robbins, 2004; Howard, 2010). In the next section, I further explore how this political lens can be utilized within a culturally relevant ecology curriculum. Specifically, I look at how varying cultural and historical perspectives on land use have been used to extend the conversation about ecological concepts.

Cultural/Historical Perspectives on Land Use and Ecological Sciences

Current approaches to teaching ecology often center on a classical lens, where humans are viewed as separate from nature. These narratives utilize a western scientific lens to teach students ecology and leave cultural and historical land use practices out of

the curriculum. To create a culturally relevant curriculum these cultural and historical lenses must be a central theme throughout ecology units. Using a political ecology lens is one possible approach to doing this. In teaching ecology through a political ecology lens, the cultural, political, and socioeconomic background of researchers and students is centered in the teaching of ecology (Robbins, 2004). Beyond this, political ecology lenses also look at the history of a place through a variety of perspectives (Robbins, 2004; Merchant, 2005). To do this within the context of a Minnesota life science classroom, we need to first understand the diverse cultural and historical landscapes of Minnesota and of ecology. This section provides an overview of the ecological and cultural history of Minnesota. The second half of this section provides examples of how this historical and cultural knowledge can be applied to an ecology curriculum.

Perspectives on Minnesota Natural and Cultural Histories

Minnesota's ecological history can be pieced together through a variety of sources. Ecologists primarily rely on quantitative data sources such as tree rings, soil cores, plant and animal surveys, and geological surveys. Additionally, qualitative data sources, such as historical documents like diaries, military records, geological and ecological surveys, oral traditions, and storytelling, also play a major role in our understanding of what Minnesota has looked like throughout time (Bussey, Davenport, Emery, and Carroll, 2015). Classical ecology curricula tend to focus only on quantitative data sources - tree rings, plant surveys, soil cores, and other ecological methods. However, when one uses a political lens, the types of questions asked change and additional data is included, allowing for a fuller understanding of humans' relationship with land and how it has changed over time (Nassauer, 1995).

In order to fully understand the ecological history of a place, Nassauer (1995) argues that we must include both the cultural and ecological histories. Nassauer, a landscape architect and ecological researcher, argues that culture and landscape are inherently linked. Human perception, cognition, and values affect the landscape and are affected by the landscape (Nassaur, 1995). Therefore, cultural perspective is key to understanding how land has and will change over time.

When considering Minnesota's ecological history, culture is key in understanding changes in ecosystems including loss of wetlands, changes in biodiversity, and current ecology management tactics. In looking only at quantitative data, ecologists can see a shift in Minnesotan landscapes beginning with European settlement. Specifically, there is a large shift in percent of land that is covered in forests, wetlands, and prairies - with wetland losses ranging up to losses of 35,6500 hectare per year during the time of early European settlement (Johnston, 1991). In looking just at the numbers, these losses can appear puzzling. However, in considering a historical perspective it becomes clear that these losses are associated with a shift in the dominant cultural landscape and values. Prior to European settlement, Dakota culture was dominant in Minnesota. Dakota relationship to land differs greatly from that of early European settlers. Waziyatawin, a Dakota writer, teacher, and executive director of the Dakota nonprofit Makoce Ikicupi has explored these differences through several books and their time working at Cornell University. One of the primary differences, as described by Waziyatawin, is the idea of relationship to land. Waziyatawin recounts Dakota origin stories which focus on reciprocity between land and people, in which the two affect each other in both positive and negative ways (Waziyatawin, 2008). In these stories, we see different types of land

practices that center humans in the landscape. With the colonization of Minnesota, this narrative is largely lost as the Dakota people were displaced, and Dakota histories were rewritten (Waziyatawin, 2008). Instead, European cultural values became dominant. These narratives frame nature as something to be conquered or used, and nature as separate from humans (Radkau, 2008). In looking at these cultural narratives in addition to ecological data, we are better able to understand Minnesota's ecological history as well as how different approaches to studying ecosystems emerge.

The role of culture in studying ecology is perhaps most clearly seen when looking at the restoration of ecosystems. Data on wetland and forest loss along with data showing increased human impact on ecosystems has been used to help garner support for ecosystem restoration and reclamation projects (Hobbs & Norton, 1996). Restoration projects typically focus on creating stable ecosystems that are consistent with their historical appearance (Hobbs & Norton, 1996). These efforts have been used across Minnesota, and have been used to restore wetlands, forests, and prairies. However, in many of these projects the emphasis is specifically on preservation. Restored sites are then preserved, meaning that human use is limited or eliminated completely. In this type of restoration, humans are viewed as separate from nature and the source of harm rather than a reciprocal entity (Kimmerer, 2013).

In contrast to this type of restoration, new shifts in restoration have focused on creating cross-cultural collaboration. Bussey, Davenport, and Carroll are restoration ecologists whose 2016 work centered on creating coalitions between tribal and nontribal peoples to create forest management plans that allow for both restoration and use of land . Their work centers on how knowledge is generated and utilized in a collectively managed

northern Minnesota forest. They utilize both traditional and western scientific ecological knowledge to look at best practices for forest management. They found that by combining these knowledge sets they were able to better understand multiple ways of knowing and by formalizing informal knowledge restoration practices were more likely to be culturally appropriate for multiple groups (Bussey, Davenport, Emery, and Carroll, 2016). Beyond this, by using different types of cultural knowledge the forests they worked in were able to support and be supported by people. In this type of restoration work, humans and the environment are interdependent, rather than separate (Bussey, Davenport, Emery, and Carroll, 2016).

These two approaches to restoration of ecosystems demonstrate the significance of culture in how we interpret and interact with a landscape. They also reinforce the idea that science is innately political, and that the type of questions we ask and research we do is influenced by our cultural histories (Robbins, 2008). In considering a culturally relevant ecology curriculum, these perspectives offer the potential to bring more students into the conversation about what science is and how it can be done.

Utilizing Cultural and Historical Knowledge in an Ecology Curriculum

In looking at ecology through a lens that centers individual identity, conversation can shift to include multiple perspectives and sets of experiences (Robbins, 2008). In terms of ecology, this can have dramatic effects on how we approach ecosystem questions, as seen above with the example of ecosystem restoration and management (Bussey, Davenport, Emery, and Carroll, 2016). In a high school science classroom, using cultural and historical knowledge in an ecology curriculum is then a potentially powerful

tool to create a culturally relevant curriculum and to allow students to better see intersections between science and their lives (Price and McNeill, 2013).

Robin Wall Kimmerer (2013) and Lauret Savoy (2015) both explore the role of cultural history in their science research and teaching, and discuss how bringing their own histories into the classroom the type of work they do has been transformed. For Kimmerer, this work centers on bringing indigineous knowledge into the classroom. A botanist, and citizen of the Potawatomi Nation, Kimmerer's work focuses on the intersections between western science and indigienous knowledge (Kimmerer, 2013). She looks at how her relationship to land is influenced by her upbringing and cultural history, and examines the places in her life where this has been in conflict with western science. Kimmerer's experience was one of leaving behind her questions rooted in the idea of plants as people in an effort to conform to western scientific ideologies before circling back to a place where she could explore questions in which the person-hood of plants was once again dominant (2013). She describes this journey as one of forgetting her indigienous practices and cultural beliefs before rediscovering how to use that knowledge within the context of western science (Kimmerer, 2013). Kimmerer's work offers a guide for how to use cultural knowledge to strengthen scientific understanding of the world. For her students, this type of thinking has led to transformational conversations about restoration and conservation. She remarks on how in her years of teaching she's seen her students' thinking begin to shift away from one in which humans are separate and problematic for the natural world into one in which there is a mutualistic relationship (Kimmerer, 2013). Kimmerer's work shows science and culture to be symbiotic rather

than in conflict, and as such offers interesting perspectives when considering a culturally relevant ecology curriculum.

Savoy's experience is different from that of Kimmerer. As an African American woman, Savoy's journey is one of uncovering a history of displacement. Where Kimmerer has a strong sense of connection to land, Savoy struggles to find her own family history in an American landscape that has continuously tried to erase it (Savoy, 2015). In her work, she travels across the United States to find traces of her family history. Instead she finds echoes, and reminders of color lines still prominent across most of the United States (Savoy, 2015). Throughout this journey, Savoy emphasizes how a sense of place is critical to identity development. For her, finding that connection to land has been disrupted by the racial landscape around her. That lack of belonging to landscapes is at odds with her own ecological and geological understanding of the world (Savoy, 2015). Savoy discusses the power of reclaiming and uncovering these lost stories and histories of landscapes. She discusses how for both herself and her students, understanding the cultural history of a place changes her interaction and approach to studying it scientifically (Savoy, 2015).

These two perspectives illustrate how culture influences the way that we relate to land, develop a land ethic, and are able to engage in dialogue around ecological issues. By including these types of experiences in the conversation, students are better able to see themselves and center themselves in the content. Price and McNeil (2013) call this a "lived science curriculum," meaning a curriculum in which the lives, communities, and experiences of students are centered. They looked at the effect of using this type of curriculum and found that students were able to see intersections between their lives and

science as well as retain ecological concepts when presented in this manner (Price & McNeill, 2013). Students who participated in a climate change curriculum that was rooted in community history similarly saw an increase in critical science agency; that is, an ability to take action and advocate for their beliefs (McNeill & Houle, 2012). This research, as well as the experiences of Savoy and Kimmerer, suggest that in utilizing an ecology or natural science curriculum that is rooted in the lived experiences of students we can expect higher engagement and a greater understanding of the intersections between science and self.

Cultural/Historical Perspectives on Land Use and Ecological Sciences Section Summary

Culture and history play a significant role in our understanding of landscape and land use. Cultural values change the types of conversations we have about ecosystems and their values (Nassauer, 1995). In Minnesota, cultural narratives have had a significant role in the conservation and restoration of various ecosystems as well as our understanding of those ecosystem functions (Bussey, Davenport, Emery, and Carroll, 2016). By including various cultural and historical perspectives in the curriculum we are better able to understand how an ecosystem works and its relation to us as individuals (Kimmerer, 2013). For students, including these different perspectives can be a critical component of creating a "lived science curriculum" (Price & McNeil, 2013). Science curriculums that incorporate cultural and historical knowledge have been shown to increase students' critical science agency, interest, and understanding of ecological concepts (McNeil & Houle, 2012).

Summary

Inequities within science education have led to an underrepresentation of people of color and women in STEM fields (Grunewald & Nath, 2019). There is a decline in the representation of individuals of color and women in science related fields beginning in middle and high school (Grunewald, n.d.). To address this issue, I look at the role of curriculum and specifically address the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"*

In this chapter I provided an overview of the literature on this topic. First, I discussed how culturally relevant pedagogy is a framework that centers student culture and experience in the classroom. I looked at research that supported the idea that this framework increases student academic achievement as well as student efficacy and sense of self. Next, I looked at the ecology content that students in Minnesota are being asked to master. I gave an overview of two different approaches to teaching ecology: classical and political ecology, and discussed the benefits of both curriculum frameworks. I found that political ecology frameworks are more closely aligned with culturally relevant curriculums, as they explore how culture and history affect science. Finally, I looked at the content that a political ecology curriculum would include by examining different cultural and historical perspectives on Minnesota land use. I looked at how two different educators used their own cultural identity to create a culturally relevant science content, and finally looked at how this could affect student learning. I found that students who saw themselves reflected in the curriculum had higher academic achievement and were better able to engage critically with the material. I also found that engaging in

conversations around culture and history of land led to a more complex understanding of ecological systems.

In Chapter 3, I describe how I will utilize these frameworks in the creation of a culturally relevant ecology curriculum for high school biology students. Finally, in Chapter 4, I reflect on the curriculum itself: its potential strengths, weaknesses, and future applications.

CHAPTER 3

Project Overview

Introduction

This capstone aims to address the question; *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* In Chapter 2, I looked at the existing literature to better understand culturally relevant pedagogy and current ecology curriculum. In reviewing the literature, I found that using culturally relevant pedagogy has been shown to increase student learning. Further, by incorporating elements of the field of political ecology there is strong potential for students to see themselves and their experiences reflected in the curriculum. Political ecology, as defined by Robbins (2004), centers the researcher's identity in science, and therefore views science as subjective rather than completely objective. In an effort to better understand how this plays out in a high school classroom, I created an ecology unit curriculum for biology students rooted in the framework of culturally relevant pedagogy. In this section I provide an overview of the project, background on the setting for its implementation, the timeline utilized for creation and implementation, and a plan for evaluation of its effectiveness.

Project Description

I intended to create a culturally relevant ecology unit for a high school biology classroom. Current ecology curricula focus on creating opportunities for students to engage in authentic science opportunities and discovery-based curriculum (Bowmen & Govette, 2015; Erdogan & Stuessey, 2015; Pimentel, Silva, and McNeil, 2013). Discovery-based curricula centers on students generating and analyzing their own data, and then using this data to develop scientific conclusions (Pimental, Sliva, and McNeil,

2013). Additionally, discovery-based curricula view the student/scientists as objective, therefore viewing the science and scientist as separate entities (Robbins, 2004). This type of curriculum allows students to be actively engaged with material and see applications to other aspects of their lives; however, it often is limited in whose perspectives and experiences are represented. Curriculas that center on authentic data collection often misrepresent bias in science and the role that individual identities play in the creation of scientific knowledge, as they are rooted in a system where the scientist acts as an objective observer (Robbins, 2004). This creates a gap between students' understanding of science and their understanding of self. To address this gap, I created a two week long curriculum that centers student identity in the process of science. The curriculum was created utilizing culturally relevant pedagogy practices, and backwards design process.

The creation of this curriculum was rooted in two educational frameworks: culturally relevant pedagogy and backwards design. As discussed in Chapter 2, culturally relevant pedagogy centers students' cultural backgrounds, interests, and lived experiences in their learning (Ladson-Billings, 1995). In this framework, teachers center their students' identities and lived experiences as assets in the classroom and as a mainframe of the curriculum (Dodo Seriki, 2018). Culturally relevant pedagogy centers students' experiences in the classroom, and utilizes culturally appropriate teaching strategies (Gay,2002). To do this, teachers first gain an understanding of the student body they serve, and then choose appropriate strategies (Jackson, 2005). This unit aimed to embody that practice by drawing on students' experiences inside and outside of the classroom with ecology in order to build a collective set of knowledge. Specifically, I looked at students' individual experiences as well as experiences from authors of a variety of

backgrounds in order to make sense of the ecological concepts at play around us. To create a curriculum that does this, I utilized a backwards design framework (Wiggins & McTighe, 2011). In backwards design, teachers start by considering the specific outcomes they want from a lesson, and then work backwards to determine the best possible activities to help students achieve that outcome (Wiggins & McTighe, 2011). For this project, my goal was for students to see intersections between their cultural and scientific identities. All of my objectives for the unit were rooted in this concept, and in measurable outcomes of it.

During this unit, these educational frameworks were utilized to address ecology standards mandated by the state of Minnesota. Specifically, this unit addressed Minnesota Science Standards 9L.2.2.1.1, 9.L.2.2.1.2, 9L.3.2.1.3, 9L.4.1.1.1, and 9L.4.1.1.1. These standards describe the ecological concepts students should have mastery of. Concepts that were addressed included an understanding of how energy is moved and transferred through an ecosystem, the role of succession and disturbance in changing ecosystems, and the social, economic, and ecological risks and benefits of changing ecosystems. Standard 9L.4.2.2.1 also requires students to be able to describe contributions from diverse cultures to our understanding of interactions among humans and living systems (Minnesota Department of Education, 2019). The unit objectives were rooted in addressing these standards, with a particular emphasis on the ability of students to describe contributions to science from diverse cultures (including their own cultures). To do this, students read and heard from a variety of perspectives, including the works of Robin Wall Kimmerer (2013) and Lauret Savoy (2015) - both of whom study the intersections of science and culture. Kimmerer, describes the intersectionality of culture

and science through her own lens as an Indigenous woman (2013). In contrast, Savoy presents historical and cultural context for African American scientists in the United States (2015). Students read these perspectives as well as others, before looking at the role that their own identities play in the creation of science. This type of research is in alignment with a political ecology lens, as described by Paul Robbins (2004). Through this lens, humans are centered as connected to - rather than separate from- the natural world. Robbins'(2004) position centers cultural identity as critical in the creation and generation of scientific questions and analysis of scientific data. In the context of this curriculum, this lens allowed discussion about the role of culture in the act of doing science (Robbins, 2004). By teaching ecology through this lens, my hope was that students would gain an understanding of both the Minnesota State Science Standards and develop a deeper understanding of intersections between science and culture.

To allow students to fully engage in conversations about identity and science, students participated in a variety of activities beyond the primary readings discussed above. Students conducted ecological field work, utilized reference materials such as textbooks and field guides, and engaged in reflective writing. Each lesson that students participated in had a series of activities that utilized a combination of whole group, small group, and individual activities. Lessons began with whole group discussion of ecological topics, then small group exploration of a local ecosystem or literature about an ecosystem, and ended with individual reflection. Through these activities, students were given opportunities to explore ecosystems near our school, their homes, and outside of the city in which they live through a combination of direct observation, photographs, and readings. Students concluded the unit by creating a final project in which they looked at a

local ecological issue through a variety of scientific lenses and their own cultural lens. Students then presented their findings in a miniature poster presentation session.

In summary, the final curriculum created for this project was a two week long unit. The unit utilized a culturally relevant framework, and was created using backwards design. The curriculum addressed Minnesota Science Standards 9L.2.2.1.1, 9.L.2.2.1.2, 9L.3.2.1.3, 9L.4.1.1.1, and 9L.4.2.2.1. In addition to these standards, the curriculum incorporated political ecology perspectives, and a variety of voices from western and non-western scientists. Students had opportunities to reflect on their own role in science, and the effect of their personal experiences on their approach to doing science. By incorporating a variety of voices, as well as focusing on this specific set of state standards I hoped to address my initial question: "*How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"*

Project Setting and Audience

This project was intended to take the place of an existing two-week ecology unit for high school biology students. Specifically, this curriculum was intended to be implemented in an urban charter school of Minneapolis. The school serves approximately 220 students in grades 7-12. About 91% of students are students of color, and 92% are eligible for free or reduced lunch. This unit was designed for students in a general biology class at the school. General biology classes range in size from 15 to 25 students. Most students take biology during tenth grade and are 15-16 years old. Students are required to take a full year of biology to graduate. About one third of students participate in a Junior Reserve Officer Training Corps (JROTC) program. For a majority of students

this class is their first experience with biology and ecology content. Classes meet every other day for 100 minutes. The curriculum was designed in order to accommodate this type of scheduling.

Project Timeline

This curriculum was created and implemented in five stages beginning in the summer of 2021 and continuing into the 2022-2023 school year. Stage One of the project involved reviewing existing ecology curriculum and Minnesota State Standards, this stage was begun during the summer of 2021, and finalized throughout the 2012-2022 school years along with Stage Two. During Stage Two, resources were collected and best practices in ecology and political ecology education were examined. This work happened in conjunction with Stage One. During Stage Three, the unit curriculum was designed and reviewed. Stage Three began with the creation of clear objectives for the two-week unit. After the creation of objectives, pre- and post-tests were made along with formal and informal assessments for the whole unit. Finally, daily activities were planned based on the objectives and assessments. Curriculum design, and activity construction happened during the summer of 2022. Finally, the curriculum was implemented in the fall of 2022, before being reviewed and revised by looking at pre and post test data.

Project Assessment

The goal of the project was to help students see intersections between science and their individual identities. To measure the effectiveness of this two-week unit in progressing that goal, pre- and post-test assessments of students were used. These tests asked students a series of free-response questions both about specific ecology concepts as well as reflective questions that asked about intersections that students see between their

scientific and cultural identities. The assessment used free-response questions so that students could reflect on their cultural identities and how that affected their relationship to science. After the unit, I compared individual students' pre- and post-test data. I specifically looked for two things: 1) progress towards mastery of the science standards 2) understanding of intersections between cultural and scientific identities. I believed that in utilizing this type of assessment I would be able to see not only if students are mastering the science concepts but if there is a significant shift in their relationship towards science. After viewing student responses I modified the curriculum in order to better reflect student needs. In the future, I anticipate a need to further revise the assessments after further implementation of the curriculum.

Summary

In an effort to answer the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* I created a two week long ecology unit for high school biology students. In this chapter, I provided an overview of my intended project: its length, participants, and timeline for implementation. This curriculum was intended for high school biology students in a Minneapolis public charter school. To create the curriculum, I used a culturally relevant framework as described by Gloria Ladson-Billings (1995) and backwards design as described by Wiggins and McTighe (2011). My content drew upon the field of political ecology and addressed Minnesota state science standards 9L.2.2.1.1, 9.L.2.2.1.2, 9L.3.2.1.3, 9L.4.1.1.1, and 9L.4.1.1.1. The project was implemented in 5 stages: 1) review and examination of existing ecology curriculum 2) collection of resources on best practices for teaching ecology 3) curriculum development 4)

curriculum implementation and 5) curriculum evaluation and revision. In Chapter 4, I look at stage 5 of this process and reflect upon the effectiveness of this curriculum. I describe the strengths, weaknesses, and future applications of this unit plan.

CHAPTER 4

Conclusion

Introduction

In beginning this project, my hope was to answer the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* To answer this, I began by looking at the literature around culturally relevant curricula and ecology curricula. My research showed me the importance of bringing students' home cultures into the classroom and in rooting their understanding of the natural world in their own identities. I used my learnings from the literature to begin constructing an ecology unit for high school students that was rooted in helping them develop a deeper connection to their local ecosystems. In this chapter, I discuss my major learnings from this project, the literature that guided the creation of this curriculum, the implications and limitations of this project, and the future potential of this project.

Major Learnings

The ecology unit created for this project was written for use by high school teachers in urban settings. The goal was to create a launching point for teachers to bring more student voice and experience into conversations about ecosystems. The more I researched and created this unit the more convinced I became of the importance of this type of work, and the need for curricula to be heavily adapted for the individual needs of students. Creating this curriculum, I had an opportunity to engage critically in lesson creation in a new way. With this unit, I was able to pause and consider the outcomes I wanted my students to achieve. By taking the time to switch how I approach curriculum

development, I was able to learn how to better create authentic assessments, engage students in culturally relevant experiences, and critically evaluate my own lesson plans.

When beginning this curriculum, my intention was to increase my understanding of how to make authentic assessments that allowed students different pathways for engaging in the material. One of my hopes was to provide students with different pathways of demonstrating content mastery. I was also hoping to build assessments which allowed students to bring their cultural knowledge into the classroom. By looking at authors like Geneva Gay (2002) and Scherer and Guttersrud (2018), I was able to edit and revise my assessments to better allow for student voice. I was best able to do this by creating lessons that offered multiple ways and opportunities for students to show understanding. For example, in my first lesson students had the opportunity to brainstorm what an ecosystem is before exploring one in small groups. Students then had an opportunity to use new terminology to go back and revise their initial ideas about what an ecosystem is. Having this initial and revised explanation both in words and diagrams allowed me to better understand where students were gaining knowledge, and where they were struggling with new concepts. Learning to build in flexibility to my assessments has been an area of growth for me. I have appreciated the time and opportunity to try different types of assessment and see what feels relevant and authentic for students. In creating these assemenets I also learned that this flexibility will continue to be critical for me. I will need to adapt assessments depending on the specific students that I serve. This level of customization has felt critical to embracing a more culturally relevant approach.

Beyond assessment, I was hoping to create opportunities for students to investigate their local ecology. In building a curriculum that was rooted in inquiry and

discussion I think I was able to do this. Beginning with the first lesson, students have repeated opportunities to go out and investigate their local ecosystems. Creating this type of lesson presented challenges around how to have conversations with students about what urban ecosystems are. I found myself continuously going back and revisiting the types of questions I asked students. I scaffolded outdoor experiences in order to ensure that they were meaningful and relevant to students. During this curriculum, students read different perspectives on ecosystems and so were able to explore how their lens differs from that of their peers and other scientists. Determining how to have conversations with students about these different perspectives has been challenging. Through conversations with my peers and fellow educators I have learned that there is not one right way to do this, and that depending on my student body the approach I take will have to adapt. This need for flexibility and adaptability has been a common thread for me throughout this capstone experience, and has become most clear for me when considering the process of revision.

Overall what I have most enjoyed and learned from this experience is the process of revision, and the power of knowing that curriculum should be a living thing. Often in academic settings there is a focus on completion; in the field of education there is a better understanding that the way we learn and the things we learn are constantly evolving. While intellectually I have always had an understanding that the way I teach is constantly changing and adapting to meet the needs of my students. However, in writing this curriculum I had an opportunity to put that into action. Revising my paper and my curriculum offered me the opportunity to see how changing a single question could have a powerful impact on the type of responses I received from students and my peers. Doing

these revisions empowered me to push myself to try new styles of questioning and to offer more flexibility and room for change within each of my lessons.

The ability to slow down the pace of creation and revision allowed me the opportunity to more critically evaluate the types of questions, readings, and activities that my students engage with. This level of critical reflection has been one of the most powerful aspects of this experience. Through discussions with peers, edits from my instructors and my content reviewer, as well as student feedback I was able to begin the process of revision of this curriculum. I found that in reviewing my curriculum with both my objectives and a culturally relevant lens in mind I was able to ask myself critical questions about the content I was creating. I found myself asking, is this activity aligned with my daily objectives? How does this activity allow students to connect their personal experiences with science content? Are these texts written by individuals who represent the experiences of my students? Am I providing adequate scaffolding for student learning? When I reviewed my content with these questions in mind, I was able to see my own habits and lens of science more clearly. For example, in editing lessons on food webs and food pyramids, I realized that I had completely ignored urban ecosystems. By making a simple shift between discussing swamp ecosystems and city ecosystems, I was able to create a lesson that was more relevant for my students and that allowed them to better see the relevance of ecology in their daily lives. The power of intentional revision has been a major learning for me. In creating explicit questions to guide my revisions, I have begun to understand how I can better adapt my teachings to the students I serve.
In creating this curriculum I was able to critically engage with the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between*

their scientific and cultural identities?" I found that in creating this type of curriculum I was able to better understand the role that my own cultural identity plays both in science and in my teaching of the subject. Throughout this project I have gained a stronger understanding of how to create effective assessments, evaluate the effectiveness of my curriculum, and engage students in culturally relevant science. These major learnings were heavily influenced by a few key pieces of literature, which I discuss in the next section.

Key Literature

Throughout this process, I found myself returning to the work of authors who connected their own scientific research to their unique cultural lenses. Robin Wall Kimmerer, Lauret Savoy and the essays found in the collection *All We Can Save,* continuously helped me to recenter the curriculum on student experience (Kimmerer, 2013; Savoy, 2015; Johnson & Wilkinson, 2021). Kimmerer, in her work *Braiding Sweetgrass* (2013), showed the intersections between ecological research and indigineous science. I found that in looking back through Kimmerer's book, and her ideas about incorporating indigineous knowledge into the classroom, I was able to create a few lessons that looked specifically at the role of culture in science. Specifically, in lessons four, six, and eight I was able to build a curriculum where students compared indigneous and western scientific approaches to the same ecological issues. Looking at Kimmer's work allowed me more perspective and pushed me to question my own preconceptions (Kimmerer, 2021). Savoy's work similarly acted as a guide for me in building this curriculum (2015). In her book, *Trace*, Savoy presents a model for how students can find their own connections between their personal histories and their scientific understandings

of the world (2015). Finally, in looking at Johnson and Wilkinson's anthology *All We Can Save* I was able to find narratives from individuals who reflected my individual students (2021). I utilized this anthology in thinking about possible additional readings and extension activities (Johnson & Wilkinson, 2021). I think all three of these readings are critically for teachers seeking to find ways to incorporate student narratives into ecology units.

Beyond these authors, I found that I kept returning to authors who were experts in culturally relevant pedagogy. Specifically, I found myself rereading work by Ladson-Billings (1995), Gay (2002), and Jackson (2005). All three of these authors emphasize the importance of incorporating student culture and voice into the classroom through a variety of different methods. Jackson discussed the importance of using students' knowledge and cultural norms to drive conversation (2005). To provide an opportunity for this, I worked to incorporate as much small group and whole group discussion into the unit as possible. Students are continuously given an opportunity to collaborate with their peers, as well as to share their own perspectives on topics. Many of the questions and assignments that students do are open-ended, meaning there is not one correct solution, but rather an emphasis on explaining their thinking and supporting claims with evidence. My hope in doing this was to allow for students to really drive the direction of the unit, and to allow the instructor to adapt and modify based on the students in the room. In addition to trying to incorporate student voice into the lessons, I also wanted to ensure that my assessments were rooted in a culturally relevant perspective. To do this, I looked to the work of Scherer and Guttersrud (2018). Scherer and Guttersrud (2018), emphasized that in teaching students science adaptability is critical – both from

the students and the instructor. They focus on the idea that student identity and belief systems influence how they adapt to new information, and as a result using assessments that measure this flexibility gives educators an opportunity to more accurately assess student growth (Scherer & Guttersrud, 2018).

Reexamining the works of these authors helped to reinforce to me the importance of incorporating varied perspectives on science into curriculum, and providing pathways for students to bring their full selves into the classroom. In the next section, I discuss the implications and limitations of the curriculum I created before looking at some possible future work.

Implications and Limitations

Through the creation of this project, I was able to learn a great deal about the importance of incorporating student voice and culture into curriculum, as well as the importance of discussing the role that our identities play in science. My hope is that this curriculum can act as a resource for teachers seeking to do just that. In reflecting on the ecology curriculum I created, I realized there are several implications as well as limitations to this work. In this section, I discuss those possible implications and limitations.

In creating this curriculum, I was able to make a resource for myself to use in future years. This curriculum provides an outline for teachers hoping to incorporate more student voice and identity into science. Learning science in classrooms, I was often taught to try and maintain objectivity. However, my experiences both as a student and an educator have shown me that true objectivity in science is neither possible nor helpful (Robbins, 2004; Savoy, 2015). When scientists root their science in their passions and

interests, our understanding of the world is strengthened (Struzik, 2021). I believe that this is the primary strength of the curriculum I created for this project, it provides students and teachers opportunities to bring their own voice into the creation of science. I think that in implementing this type of approach to science throughout the school year, there is an opportunity for students to engage more deeply in the sciences. Additionally, by providing students opportunities to be co-creators of knowledge they are more likely to see the relevance of science in their lives (Bowman & Govett, 2015; Dodo Seriki, 2018; Garvin-Hudson & Jackson, 2018).

While this curriculum offers a starting point for educators hoping to incorporate student identity into science curriculum it is limited in its scope. This curriculum was created primarily for implementation in urban classroom settings. An assumption was made that teachers and students would have access to an outdoor space such as a local park, neighborhood, or play-ground area. Without access to an outdoor space of some sort, this curriculum would need to be changed fairly heavily. I have provided some resources for how to accommodate a lack of outdoor space, however adjusting the curriculum would require creativity. To be effective, this curriculum needs to be modified for the audience it serves. This could include adjusting the individual activities to be relevant to the local ecosystem, providing guided notes, and offering more scaffolded lessons.

In addition to being limited in the audience it serves, this curriculum is also limited in that it only applies to ecology concepts. This curriculum offers a strong resource for teachers hoping to incorporate student perspective into the science classroom, however it does not offer resources for how to do this with different science

concepts. To see real change within students' understanding of how their identity and histories are relevant and critical to the understanding and creation of science, they need to see this across all of their science units. To address this limitation, teachers would need to look more critically at how different science concepts are taught.

Possible Future Work

For this project, I created a two-week long ecology curriculum aimed at helping students see intersections between science and their cultural identities. To do this, I incorporated a variety of different perspectives on science. Students heard from scientists from a variety of cultural and scientific backgrounds. Students were also provided opportunities to reflect on their own identities and the role that they play in science. While this curriculum offered a strong foundation for teachers hoping to incorporate more student voices into their science curriculum, it was limited in its scope and audience. To address this, I recommend future research explore mechanisms for incorporating this type of inquiry into different subject areas.

One of the strengths of this project is it offers an opportunity for more exploration into how students learn and see themselves represented in the curriculum. As I further explore this curriculum with my students, I hope to communicate the effectiveness and strengths with my peers through professional learning communities and departmental meetings. In communicating with other science teachers specifically, I feel confident that I will be able to further adapt the curriculum. In creating this curriculum I have always known that it will need to be continuously adapted to best serve students. Critical to this adaptation is hearing from students, and providing students the opportunity to

communicate their learnings to myself and others. Moving forward, I hope to provide students opportunities to present their research to other students.

As I further examine the impacts of this curriculum on student learning, I hope to expand my research to implement this type of curriculum into different content areas. Specifically, I think that by looking critically at each of the units I teach, there is an opportunity to incorporate student voice and identity further into the classroom. Future research should explore how culturally relevant pedagogy can be used in different science units to help students see the relevancy of science in their lives, and intersections between their scientific and cultural identities.

The ecology curriculum created in this unit, as well as future research created through this lens offers an opportunity to shift the way we teach science to be more relevant to students. By providing students opportunities to see themselves reflected in science and see the direct connections between the concepts taught and their daily lives, there is an opportunity for students to more deeply engage in the sciences. My hope is that this curriculum offers teachers, and the broader educational community, a guide and starting point for incorporating culturally relevant practices into the science classroom. By doing this I truly believe that students will be able to more deeply engage and understand the practice of science.

Summary

In this chapter, I discussed my major learnings from this experience, the key literature that guided my process, the implications of this work, and its limitations. In building this curriculum, I learned the importance of revision and critical evaluation. I gained a better understanding of how to create authentic assessments. I was guided by

authors such as Savoy (2015), Kimmerer (2013), Robbins (2004), Gay (2002), Jackson (2005), and Ladson-Billings (1995), whose discussions of science and culturally relevant pedagogy were critical to the creation of an ecology curriculum. The two-week ecology unit that I created has strong potential to help students see the relevance of science in their lives, and intersections between their scientific and cultural identities. My hope is that this curriculum will act as a model for teachers hoping to incorporate more culturally relevant work into their science classrooms. While this curriculum is limited in its scope and audience, it offers a starting point for future research on how to incorporate culturally relevant approaches into science classrooms.

Throughout this project, I have aimed to address the question, *"How can utilizing a culturally relevant ecology curriculum help students see intersections between their scientific and cultural identities?"* To do this, I first began by considering my own history with science both inside and outside of the classroom. I discovered that my love of science, specifically ecology, was deeply rooted in my own connections to outdoor spaces. By reexamining my own past, I grew curious about how others found their way into the field of science. I learned more about the complex histories that people have with land. I read about authors such as Savoy (2015) and Kimmerer (2013) whose connections to land were influenced by race and history. I learned about the field of political ecology, as defined by Robbins (2004), which looks at the role that power and personal history have in shaping the way individuals approach science. These works led me to think about how this plays out in a classroom setting. I began to learn about culturally relevant pedagogy, which centers student identity in the classroom. I looked for ways that I could use this type of teaching to help my students see intersections between

their identities and science (Gay, 2002). These learnings and reflections guided me in creating a two-week long ecology unit for high school biology students. In working on this curriculum, I have discovered the importance of providing students opportunities to see the relevancy of science in their lives. This curriculum offers a stepping stone for teachers aiming to be more culturally relevant, however more research and work is needed. By incorporating more student voice and perspective, there is the opportunity for students to engage and connect to science in a meaningful way. This engagement is critical for student success, and for our understanding of science to grow.

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