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A Culturally Relevant Earth Science Curriculum: Engaging Students in Socioscientific Issues Through Socratic Seminars

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A CULTURALLY RELEVANT EARTH SCIENCE CURRICULUM:

ENGAGING STUDENTS IN SOCIOSCIENTIFIC ISSUES THROUGH

SOCRATIC SEMINARS

by

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CHAPTER ONE

Introduction

Background

Opportunity for oral discussion and scientific argument happens almost every day in my classroom. It was my understanding, as a first year teacher, that offering ways for students to practice their scientific language, questioning, and argumentation skills was an important part of improving my students' science literacy. Despite the opportunities that I provided, however, students were struggling to make meaningful conversations happen. Instead, their discourse (when there was any) would often become disengaged from any scientific or scholarly meaning.

To better understand how to engage my students in meaningful conversations about science and to challenge my understanding of students' use of voice, I reviewed literature to answer the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?* In my current curriculum planning, I include group collaboration, turn-and-talks, presentations, debates, argumentation, and other oral activities as ways of including students' voices. While all of these methods of learning have, in some small ways, been effective at engaging students in academic conversation, most are teacher-driven and leave little room for authentic open-ended discussion.

Science is essentially a social endeavor, and scientific knowledge is advanced through collaboration. Being able to argue in a way that promotes understanding of a problem and persuades peers of the validity of a specific idea using evidence is essential to the work of scientists to identify the best explanation for a phenomenon (NRC, 2012). Moreover, allowing students to use their own voices is an essential part of culturally-responsive teaching (CRT). According to Gloria Ladson-Billings, a leading scholar on CRT, the practice is “committed to collective, not merely individual, empowerment” (Ladson-Billings, 1995a). In order to improve students’ use of academic language, skills in arguing from evidence, and overall science literacy, I try to infuse oral activities into every lesson along with less dialogue-based activities such as pre and summative assessments, silent reading, note taking, and other individual work. It is my hope to determine whether Socratic discussion (also known as Socratic seminars) can be an effective addition to my teaching toolbox as I work toward promoting science literacy and social engagement.

In this chapter I will share my experience as a student, my work as a non-traditional outdoor educator, and the experience I had as a first year teacher in a large urban middle school. Through these personal and professional experiences, I will try to underscore the importance of the question I am asking: How can Socratic discussion improve science literacy and student engagement? To begin, I will share why I once shuddered at the thought of oral discussions in the classroom.

Professional experience.

The student. When I was a student in middle and high school, my teachers followed what seemed to be a common practice at the time of presenting lectures, assigning readings, and giving individual homework. What opportunities there were for collaboration came in the form of "cookie-cutter" labs and cooking groups in home economics class. More often than not we worked in isolation, remaining silent for most of the period. When we did talk, it was usually to regurgitate information that had already been given to us in response to a teacher prompt.

While there were very few opportunities for collaboration, there were even fewer for presenting and arguing ideas with evidence. Most of the questions that were asked had right and wrong answers. With time I became comfortable with this call and response form of verbal learning. I was not, however, prepared for deeper, more thoughtful discussions. As a result, on the rare occasions when a teacher asked an open ended question, I was left scrambling for what might be an appropriate response. I felt I lacked both the academic language to articulate my thoughts and the confidence that my response would be accepted in the community of my peers and teachers

My culture and upbringing largely depends on three factors; I am white. I am of Scandinavian descent. I'm from a small rural community. As a quiet student trying to conform to a relatively quiet culture, remaining unnoticed and reciting facts was just as I liked it. I was confident in answering questions that had right or wrong answers. Math and science became my favorite subjects because both required little more than memorizing steps to solving problems. I felt pretty good about myself as a student as I walked across the stage for graduation in 2004. What I didn't realize at the time was that no one had prepared me for the type of learning that I would need to be competent in college.

The college student. In the fall of 2004 I left my small town in northern Minnesota to begin college. At the time, I thought I was something pretty hot. I had graduated at the top of my class, I had received high praise from my teachers for being hard-working and diligent, and I was considering a degree in science; something I felt particularly good at. As the first semester of freshman year got underway, however, I realized that I was in for something I had not anticipated.

Science, it turned out, was not simply learning the names of smart people and fancy glassware. It wasn't even really about how to properly complete equations or follow procedures. It was so much more: it was a way of thinking. Science required arguing and having strong evidence to back up arguments. It was about asking good questions and properly and creatively seeking answers. Science, in other words, was not actually something I was prepared to succeed in.

The Graduate. I didn't continue on with a science degree in college. While I did get better at having meaningful academic conversations and I did learn the proper vocabulary for scientific discourse, I never truly felt competent in conducting good scientific inquiry. I took my love for the subject of science and brought it into the realm of policy and political science with a degree in environmental studies. With this degree I began my journey into education.

After several unsatisfying jobs in the hospitality and oil industries, I took an internship with the International Wolf Center. There, I realized two things: that I like teaching and that good teaching requires so much more from a teacher than engaging lectures and fun activities. Teaching requires making students see themselves in the subject. It requires challenging students to see the perspective of others. Maybe most importantly, it requires giving students the tools to make strong arguments from strong evidence.

I took this experience with me when I moved to Morocco, and a few years later, to Liberia to teach middle and high school science with the Peace Corps. The cultural context in which I found myself was profoundly different from my own, yet the type of learning happening was similar. As in my school, independent thinking was discouraged, but to a greater extent. By the time students were in middle school, creativity was almost nonexistent. In Liberia, students were lucky if they had a notebook and the school had a hired man to keep track of the chalk due to its scarcity. In both cases, the relationship that my students and their families had to education was different than my own. They valued it differently. Because of this, I was forced to confront my own cultural understanding of education. I quickly had to adapt to my students' ideas of what was engaging and implement a curriculum that allowed these students, in this context, to be the most successful they could be.

The Educator. All of the events that happened in college and early after I graduated led me to believe that I would love and succeed in a career as an educator. I moved back to the United States and landed in a large midwest city. There, I began working for one of the city's urban middle schools as a special education paraprofessional. I was immediately struck by how similar this experience was to the experience I had living in Africa.

There was a surprising culture shock as I entered the school for the first time. With a largely Latinx, African American, and African immigrant population, the students were quite different from the students I had gone to school with. Being quiet and blending in was not necessarily the modus operandi of the majority of the students. For many students, animated argument seemed to be an accepted way of interacting.

It also became for some a way of coping with scholarly difficulty. Other students, I found, just refused to do any work as a way of coping. In such an environment, disruption and distraction became commonplace. Even some of the many students who looked and acted successfully were having a very difficult time when asked to complete reading and writing assignments. Overall, my students were struggling to fit in to the academic structure that I had grown up with; one where reading, writing, and independent work were the main routes to academic success.

The Teacher. As a paraprofessional it was my job to work specifically with students who had diagnosed academic needs. Each of the students I was working with had an IEP in which were stated specific needs and strategies for academic success. Yet, as my students were pushed more and more into the regular classrooms, I was able to observe students without this additional academic support. I began to notice that many, even sometimes a majority, of the other students struggled with academics in many of the same ways as my students, but didn't have help. As an observer of the class and its teacher I could easily see that many of these students' learning needs were not being met.

I am now a teacher in my own classroom. As I saw when I was a paraprofessional most of my students' academic needs are regularly not being met. I struggled with this as a first year teacher. I found myself trying to balance the different learning styles with engaging lessons and classroom management. With so little time and resources, there was very little room to be responsive to the culture of my students. I, instead, found myself falling back on what I knew and felt comfortable with myself; a very teacher centered curriculum.

My Students. As a result of academic needs not being met and culturally irrelevant lessons, the behavior of many of my students became an issue. This added layer of complexity took even more time and resources away from developing and implementing a more culturally appropriate curriculum. I struggled to look at the problem introspectively.

While many of the behavioral issues were out of my control, some of them were not. My students as a whole had cultural layers that I was missing: many were struggling with traumatic experiences at home including poverty, neglect, abuse, fear of deportation, gang violence, and homelessness. As related to Maslow's hierarchy of needs (Lester, 2013), academic achievement was not the most pressing or relevant issue for them. I was not effectively addressing these issues. I was not tying the real-world issues of my students into my science lessons.

Additionally, while I offered my students many different ways to express their knowledge through projects, presentations, and more formal assessments, I don't think I did an adequate job scaffolding the learning and appropriately modeling how to be successful in my classroom. Moreover, nearly all of the learning was teacher led and the drive for academic success was extrinsic. For many of my students, grades and the promise of an intellectual future were not enough to motivate them to learn and succeed. I needed a better, more culturally responsive, way to motivate and inspire my students to learn the materials needed to meet the appropriate state standards.

In response to all of these perceived reasons for my students' lack of academic success, I began to try to implement different strategies. I opened the class up to more movement, I tried scaffolding the use of scientific dialogue and argument, and inserted more opportunity for peer discussion. The results were mixed. While many of the students seemed more interested in being in class, I noticed that many students quickly shifted from preferred academic behaviors to non-academic conversations. Others seemed to feel the lack of structure and accountability was reason enough to not engage in conversation at all.

I then tried to structure and scaffold the conversation a little more. To do this, I introduced the practice of Socratic seminars to my students. I gave them limited but culturally relevant readings on climate change. We then used close-reading strategies to accumulate evidence to discuss whether humans should spend resources on technology to react and adapt to climate change or make an effort to reduce the negative effects of climate change before they happen. With this evidence, I had students sit in a circle and use sentence starters to have a student-led conversation on the issue. I was nervous about giving the students such control over their learning, but it quickly became evident that many of my students who never participated in academics were suddenly engaged and interested in talking with their classmates about the subject.

Conclusion

To improve my practice as a science teacher, address the academic disengagement in my class, and increase my students' science literacy and use of academic language, I decided to ask the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?* In this chapter I introduced how as a student I succeeded, but ultimately struggled as a creative and thoughtful learner. I also discussed my experience as an educator and my struggles to address the cultural and academic needs of my diverse students. In chapter two, I will explore classroom routines and expectations, physical arrangements, science literacy and culturally-relevant pedagogy before reviewing the literature for Socratic discussion as a strategy for engaging middle school students in learning and improving science literacy. In chapter three I will introduce two 8th grade Earth science units anchored with Socratic seminars and explore how each will be implemented in my classroom as a means of engaging students and improving science literacy. Finally, in chapter four I will review the effectiveness of the curriculum and make recommendations on how it might be improved in the future.

CHAPTER TWO

Review of the Literature

Overview of Chapter Two

The goal for Chapter Two is to gain a better understanding of the answer to the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?* This question is an important one because it seeks strategies to improve the long-proven practice of oral learning through Socratic discussion. Moreover, the question looks for ways to make learning for traditionally underserved students more effective for the middle school science classroom. It seeks strategies for differentiating, making curriculum relevant, and providing language practice for difficult science concepts and vocabulary.

This chapter will begin with an exploration of how traditional classroom set-ups affect student dialogue and meaningful learning. It will then turn to strategies that address the problems with traditional classroom learning, focusing specifically on the enhancement of science literacy in a diverse urban middle school setting through the use of a culturally-relevant teaching (CRT) framework. This section will explore how CRT can effectively enhance learning equity and engagement. The chapter will then move into an examination of how Socratic discussion can work within this framework to impact science literacy and engagement in students. The chapter will finally conclude with an exploration of how Socratic seminars can simultaneously address students' needs for relevant curriculum and society's need for scientific literacy. A thorough research of all of these topics will help lead to a meaningful answer to the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?*

The Traditional Classroom

This research starts with a brief exploration of traditional learning models in order to establish a baseline from which to start. The average American student spends approximately 11,700 hours in school between kindergarten and 12th grade (Cheryan, Meltzoff, Plaut, & Ziegler, 2014). These students absorb and internalize the environment in which they sit. It is important, therefore, to recognize that the way a classroom is decorated and seats are arranged can portray a powerful message.

Traditional pedagogical models are generally characterized by rooms set up to make teachers the center of the learning experience. For thousands of years, teachers have stood in front of the students, providing the information that needs to be learned (Watkins 2005). Students, meanwhile, typically sit in desks arranged in straight columns or rows facing the front of the room. This model (a teacher transmitting information and students writing, listening, and answering questions in isolation) makes a basic assumption that students have little valuable input to contribute to the learning process and "fails to acknowledge the role that creative personal engagement and enjoyment play" (Hargreaves, Elhawary, & Mahgoub, 2019, p. 1).

Further, in this model, students do not have the opportunity to develop their own voices. Research agrees that in order for students to maximize their learning, they must have a voice in the classroom (Juzwick, Borsheim-Black, & Heintz, 2013). This thinking is based on pioneering cognitive psychologist, Lev Vygotsky's, research that suggests that for complex learning to occur, such as communicative language learning, two overlapping opportunities must be afforded: social interaction and some agency for the student to direct their own learning (Tice, 1997). Vygotsky's research further suggests that it is this "socially-situated sense-making" or construction that leads students to valuable academic and personal development (Hargreaves, et al, 2019, p. 3).

Wilson & Sperber (2006) elaborate on Vygotsky's constructivist approach by stating that learning material is relevant to an individual only when it connects with their own social context. It is only then that it can make a worthwhile difference to the student's representation of the world. This suggests that, in order for students to find learning relevant and engaging, teachers must relinquish some control of the teaching and empower students to think independently, work through complex thoughts, and express those thoughts through meaningful conversations. It also suggests that the classroom must be decorated and arranged in a way that brings relevance to students.

Race in the traditional classroom. There is evidence to suggest that the traditional pedagogical model, common in many British controlled colonies, has historically been employed as a way of reducing the risk of potentially disruptive, educated leaders who might emerge to challenge the prevailing authority (Loveluck, 2012). While teacher trainings universally denounce this approach as bad practice, inadequate resources, inexperienced teachers, and poorly designed school environments have all led to the traditional pedagogical model perpetuating in many schools that serve higher concentrations of students on free and reduced lunch plans (Barton, 2003). According to studies done on structural inadequacies in schools, even by statistically controlling for socioeconomic status and racial makeup, test scores were adversely affected by environments with less interaction, light, sound control, etc. (Cheryan, et. al, 2014).

This suggests that the traditional pedagogical model, although repudiated as being inconsistent with best practices in the education field, persists where resources are lacking. It can be argued, then, that this type of practice is more disruptive to students of color, who often make up a large percentage of students in resource-poor schools. And just as the traditional pedagogical model resulted in the suppression of disruptive independent thought in Colonial Britain, so to is it having that effect on many of these students in our schools today (Sleeter, 2012). Our global society has a history of hierarchical relationships between those who know and those who do not and the continuation of a traditional pedagogical model perpetuates this (Adams & Laughter, 2012).

Vygotsky's constructivist approach encourages discourse between students and suggests that the teacher gives up their position as the "sage on the stage" and become the "guide on the side." This has become a widely accepted model. The rest of this paper will look at ways of incorporating more evidence-based classroom design and practice to maximize educational outcomes for all with significant emphasis on African American students.

Culturally Responsive Classrooms

Introduction. Students in today's public pre-K-12 school environment are encountering unprecedented ethnic and racial diversity. Yet, as student diversity is growing, diversity among the teacher population continues to decline (Boutte, Kelly-Jackson, & Johnson, 2010). Schools with the highest diversity, and concurrently often the least money, often encounter science classrooms with limited resources and pedagogical practices that don't reflect their cultural understanding of the world (Johnson, 2011). Additionally, despite science pedagogical literature suggesting that it is not best practice, science education commonly remains within the narrow definition of teaching "facts" (Boutte, Kelly-Jackson, & Johnson, 2010).

In these schools we see a disproportionate number of struggling, underserved students of color, many of whom have difficulty in engaging in higher-order thinking and/or reading on grade level (Barton, 2003; Boutte, Kelly-Jackson, & Johnson, 2010; Johnson, 2011; Johnson, 2011). And while teachers attempt to make content relevant for their students, they often believe that successful teaching for students of color is primarily about “what we do.” Instead, as Ladson-Billings (2006) points out, it should be about “how we think” (p. 30). The disconnect between teachers and their students is further complicated by the fact that many educators don’t see some of their disenfranchised students in cultural terms. This is especially true of the group this project will focus on: African Americans. “African Americans are [in fact] a distinct cultural group with shared collective experiences and lived realities” (Ladson-Billings, 2000, p. 207). It is extremely important, therefore, to study and implement data-driven, culturally authentic approaches to science education.

Culturally Relevant Pedagogy. In answer to the cultural discord between students and educators, culturally relevant pedagogy (CRP) has become a promising educational and ethical movement (Castagno & Brayboy, 2008). Yet, while the idea is gaining prominence in the education world, it remains a theory more often talked about in academic circles than practiced in classrooms. This is shown in how few exemplars there are in academic literature of its effective implementation. When CRT is practiced, it is often understood in limited and over-simplified ways (Sleeter, 2012). For example, teachers often start with the practice of incorporating cultural celebrations into their classroom calendars and putting up decorations that represent other cultures on their walls. They might consider the incorporation of this surface level cultural knowledge as a significant start to cultural relevance or even the end in and of itself. CRT, however, is much more than a limited selection of cultural events and colorful classroom decorations.

At the heart of culturally relevant pedagogy is the belief that students are at the center of learning and that academic achievement is essential to combat endemic racism in society. To realize this, students need to "recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture, where they are likely to have a chance of improving their socioeconomic status and making informed decisions about the lives they wish to lead" (Ladson-Billings, 2006, p. 36). This teaching philosophy recognizes that teachers, then, play a role in helping students use the various skills and "facts" they learn in class to better understand their position in society and the context for why it is that way.

Teachers who use CRP "assume that an asymmetrical relationship exists between poor students of color and society" (Ladson-Billings, 2006, p.30). Culturally relevant pedagogy does not maintain silence about the conditions of racism and other forms of oppression that underlie the achievement gaps and alienation from school commonly experienced by specific groups of students. Instead, it is rich with sociopolitical dialogue and engages students in conversation about systemic problems that exist within society and the academic curriculum.

Culturally Relevant Science Teaching (CRST). In her foundational work in the area of culturally relevant science teaching, Barton (2003) examined how policy is moving toward *scientific literacy for all.* In response to what she considered a deficit model of looking at science education (meaning a focus on what urban students lack regarding achievement, resources, and academic opportunity), she called for a critical approach to science: "Viewing the sciences from a critical, social constructivist standpoint leads to a refutation of a positivist myth that there is an unbiased knowledge" (p. 28).

This myth is all too common in the math and science fields. As a result, many students view science as an exclusive field, a "mysterious and secret body of knowledge understood by only a few" (Adams & Laughter, 2012, p. 1106). There remains a disconnect between science instruction and the lives of students (Buxton as cited by Djonko-Moore, Leonard, Holifield, Bailey, & Almughyira, 2018) And while CRST, as envisioned by Barton (2003) and Ladson-Billings (1995a), has grown as a response to this disconnect between students and science, there remains a gap in the relevance and approachability of science learning between students' academic and professional aspirations. According to the National Science Foundation's 2013 survey of science and engineering professions, 73% of scientists and engineers at all degree levels identify as white while only 6% identify as black or African American (National Science Foundation, 2013).

With so much momentum towards implementing CRP and increasing the diversity of the scientific field, why do these disparities persist? Barton argues that one explanation is how science is taught in middle schools:

> Our global society has a history of environmental racism and hierarchical relationships between those who know science (and how to manipulate scientific findings) and those who do not. Yet, some US-based studies suggest that the vast majority of urban students lose interest in and develop negative attitudes toward science by the time they complete middle school. (Barton, 2002, pp. 1-2)

The traditional method of teaching science as unbiased "facts," it can be argued, has played a large role in keeping going the myth that science is not for all. In the past, science and math educational standards have been "cloaked in national defense or global economic competition, rather than genuine ethical actions devoted to increasing the scientific competencies of students of color, students acquiring English, and other traditionally underserved urban students" (Adams & Laughter, 2012, p. 1107). Thus, in order for students to find relevance in science, teachers need to go beyond simply making science interesting to all students. They need to take a culturally relevant approach by asking the question: who benefits from the practice of science (Tate, 2001)? By doing this, it can be argued, we can not only broaden the diversity of scientists, we can develop scientists who view their work through a broader socio-political lens; a lens that sees the humanity of science and the ethical implications of its use.

Characteristics of Culturally Relevant Teachers. One problem that exists with academic success among African American students is that their success seems to come at the expense of their cultural and psychological well-being (Fine, 1986). According to Ladson-Billings (1995b), effective pedagogical practice should not only address students' academic achievement, but it should also help students accept and affirm their cultural identity while developing critical perspectives that challenge inequities that schools (and other institutions) perpetuate.

Within her framework for culturally relevant teaching, Ladson-Billings (2006, 1995b) has argued that teachers who effectively use CRT assume that an "asymmetrical relationship" exists between poor African American students and society. These teachers combat this notion by teaching their students to be "highly competent [academically] and critically conscious" (Ladson-Billings, 1995b, p. 30).

Culturally relevant teachers:

- believe that all students are capable of success.
- See their pedagogy as art; unpredictable and always in the process of "becoming."
- See themselves as members of the community, and teaching as a way to give back to the community.

- Consciously create social interaction to help them meet the goals of academic success, cultural competence, and critical consciousness (Ladson-Billings, 2006).
- Provide support for academic success including: scaffolding, modeling, harnessing students' strengths, having high behavioral expectations, etc. (Morrison, Robbins, & Rose, 2008)

Socratic Seminar

It is clear that traditional classroom approaches and arrangements do not engage every student equally. This is especially true in math and science classrooms. As Gibbons (2003) points out, "in traditional science instruction, concepts are [often] presented in an isolated manner without a strong tie to the real world" (p. 373) thus neglecting what students (specifically low income students of color) need in order to see the relationships between what they've learned and their own lives. It can be further argued that the way we traditionally teach science perpetuates the myths that science is an exclusionary set of "unbiased knowledge and is not for all" (Adams & Laughter, 2012).

Socratic seminars are a long-practiced and proven method of opposing this trend. As prescribed by the National Science Teachers Association, Socratic seminars use "science and engineering practices to actively engage students in science learning," expose bias in science, increase science literacy, and allow an authentic student voice in the classroom (NSTA, 2018). In so doing, it is an effective and culturally relevant way for students to maintain their cultural integrity while succeeding academically (Ladson-Billings, 1995b).

What is a Socratic Seminar. The Greek philosopher Socrates posited that to achieve greater understanding, students must be empowered through conversation and questioning to build their understanding and to learn to think critically and analytically (Chowning, 2009). Socrates intended these conversations to facilitate each of his students in becoming the master of their own mind and being state (Delić & Bećirović, 2016). In a practice that echoes this philosophy, Socratic seminars have been growing in popularity as an effective means to build literacy, increase student voice and argumentation skills, and address issues that are relevant to students. According to the National Paideia Center, which has developed much of the literature on using seminars in classrooms, Socratic seminars are "collaborative, intellectual dialogue facilitated with open ended questions about a text" (Billings & Roberts, 2013, p. 16). In these kinds of discussions, students can apply their understanding of science content, practice articulating a position, and collectively build a deeper understanding of a complex issue (Chowning, 2009; Delić, & Bećirović, 2016).

Components of a Socratic Seminar. The purpose of the Socratic method is inquiry (Cheryan, et al, 2014). The purpose of the Socratic seminar is to explore and more deeply understand the values and ideas of a particular text or set of texts (Chowning, 2009). Through the seminar, students are encouraged to actively learn by arguing their and the authors' ideas based on reasoning derived from evidence collected directly from the text, prior knowledge, and experience. This allows students to apply concepts in a number of ways (Perkins, 1993). To achieve this outcome, Chowning (2009) suggests several components of a successful Socratic seminar.

Text: First, text should be a starting point for the discussion. Texts can be articles, films, artifacts, graphs, or primary sources. So that all students can be successful, text should be appropriately leveled and relate to the core concepts of the science content. Additionally, the text should be purposely ambiguous. With increased textual ambiguity comes richer discussion. In congruence with the evidence-based "close reading" practice, paragraphs within the text(s) should be numbered for ease of reference (Chowning, 2009; Lehman & Roberts, 2014) and students should have opportunities to look at the text(s) through multiple lenses prior to the discussion.

Classroom Environment: Second, the classroom environment needs to reflect the goal of student-student engagement. While research is still lacking, there have been some studies that suggest just the simple rearrangement of a classroom into a circle can have profound changes on the overall attitude and engagement of students. When surveyed, students and staff agreed that a circular arrangement improved learning, creativity, engagement, and therefore, a desire to attend class (How Classroom Design, 2014). St. Onge & Eitel (2017) further studied this and found that both engagement and participation increased when students were situated in a circle facing each other. A circular arrangement is often the most effective way of promoting dialogue among students, and helps avoid discourse only between individuals or students and teacher (Chowning, 2009; Cheryan et al, 2014).

Questions: Questions are the foundation of a successful seminar, and the seminar should be anchored by a highly relevant and interesting question. The Next Generation Science Standards emphasize a phenomenon based approach to lesson planning and this can be a good jumping off point to develop interesting questions (Next Generation Science Standards [NGSS], 2013). Some teachers like to have students arrive in class with these questions ready for the discussion.

Classroom Norms: Clearly defined expectations are important for any classroom activity. Norms for discussion should be posted so that every student can easily reference them. It should be clearly stated that the Socratic seminar is not a debate, but rather a group discussion. Most seminars focus on questions that interpret a text or set of texts. It should be clearly stated that, within the confines of the discussion, the goal is to encourage well justified reasoning based on textual evidence rather than mere student opinion. Because the discussion is often focused through the lens of the author's intent or meaning, it can be kept from becoming too personal or conflicting with individual students' beliefs (Chowning, 2009; Griswold, Shaw, & Munn, 2017). This also helps students who might otherwise remain silent analyze and try to understand an author's argument as presented in a text.

During the seminar, teachers should take a hands-off approach to moderating. Questions such as "Who has a different perspective?" can be used to move a discussion along, but teachers are encouraged to not step in to rescue the conversation before students have had an appropriate amount of time to respond. To close the conversation, teachers might ask students their personal opinions or ask debriefing questions to help students reflect on the seminar process or important points that were brought up during discussion (Griswold, Shaw, & Munn, 2017; Kinslow & Sadler, 2018). This helps students to connect new information to prior learning.

Student Learning and Seminars. A growing body of research supports the use of text-based Socratic seminars. Several studies have reported the general effectiveness of using seminars to promote metacognition, increased engagement, and critical thinking skills (Chowning, 2009). Robinson (2008) examined academic achievement at nine Paideia schools (schools that regularly use Socratic seminars as a teaching strategy) and found positive academic impact as a result of Socratic seminars. In another independent study, Adams and Polite (1996) conducted an in-depth qualitative analysis of a middle school in Tennessee that had adopted Socratic seminar methodology. In the study they found that approximately 80% of the student sample engaged in higher order formal operational or metacognitive activity. Further, research done at the undergraduate level by Smith et al. (2009) indicates that peer discussion can enhance student understanding of a science concept.

Socioscientific Issues (SSI) and Socratic Seminars.

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Research Council, 1996, p. 23).

As pointed out in the *National Science Education Standards* (National Research Council, 1996), inquiry is a natural way for students to learn and engage in many of the same activities and thinking processes as scientists who study the natural world. Culturally relevant teaching employing Socratic seminars is in agreement with this way of science education. Yet, while inquiry and CRP are in general agreement, according to Boutte & Johnson (2010), there is a key distinction between scientific inquiry and culturally relevant science. This distinction is found in the larger degree to which culturally relevant science emphasizes sociopolitical issues and critical analyses. For the purposes of this project, the term “sociopolitical” will be narrowed down to “socioscientific” to reflect the specific nature of the content used in the science classroom.

It is nearly impossible for students to avoid hearing or reading about some discussion of scientific issues that affect their lives. From climate change to natural resource extraction to DNA modification, these issues are inextricably linked to everyday occurrences and discussions. Furthermore, they often reflect society's systemic racial tendencies. Because students are often immersed in these discussions (both relevant to their lives and often confusing and contradictory) almost by default, these issues become an engaging jumping off point to discuss scientific concepts and societal dilemmas (Kahn & Zeidler, 2014).

By using socioscientific issues (SSI) to discuss complex scientific concepts, teachers can not only help their students achieve academic success, they can also encourage students to "recognize, understand, and critique current social inequalities" (Ladson-Billings, 1995a, p. 476). According to Kahn and Zeidler (2014), science literacy, or the ability derived from discussing socioscientific issues and applying scientific reasoning to real life, is key to understanding the uncertain and often ethically ambiguous nature of science and, therefore, the role it has in societal inequities.

Using Socratic Seminars to Develop Scientific Literacy. Over the last several years instructors have been encouraged to enhance students' learning by including opportunities to develop authentic literacy in their curriculum. This is especially true for science educators, who, under the Next Generation Science Standards have explicitly been mandated to incorporate reading standards into curricular development (NGSS, 2013). This can be especially tricky for science instructors as reading science content is very different than the readings students engage with in English classes (Franks, Kuol, McTigue, Serrano, & Wright, 2016). Like all other academic subjects, science has its own conventions for writing, reading, and speaking (Warren, 2013).

According to Franks et al. (2016) “science literacy” has two distinct meanings. The first describes the ability to write, read, and communicate scientifically. In other words, to apply the writing, reading, and literacy skills learned in science class. With a mastery of this fundamental sense of science literacy, they are capable of retrieving information from other science texts, organizing and connecting different conceptual ideas, and communicating their scientific understandings with other people. The second definition pertains to an individual’s derived sense of scientific knowledge; the kind of knowledge that focuses on raw information, often rote, that must be acquired and retrieved, most often for assessment purposes. While mastery of both of these definitions of science literacy are important for students to appropriately participate in the scientific field, the focus in science classrooms is too often focused on the derived sense of literacy (Franks, et al., 2016). By focusing on the knowledge side of science literacy, teachers neglect the fundamental science literacy skills that students need to construct real science knowledge in a socially relevant context.

A Socratic seminar can be a powerful tool for increasing students’ ability to retrieve, organize, connect, and communicate their scientific understanding. In science, text can mean data tables, graphs, lab procedures and conclusions, videos, or other nonfiction work. The Socratic seminar’s cornerstone of text-based discussion makes it a natural tool to promote literacy in these types of text. And, as Griswold, Shaw, and Munn (2017) found in a study of Socratic seminars, when used as a strategy for engagement with data, they markedly increased student understanding, interpretation, and communication skills.

Beyond meeting standards, teachers also have a moral obligation to “view literacy as both pedagogy and social action” rather than a “method that is apolitical” (Cadiero-Kaplan & Smith, 2002). Illiteracy, whether in reading comprehension or science, is a tremendous disadvantage politically, socially, and economically (Alger, 2007). Being able to understand text and communicate thoughts in writing is an essential skill for the twenty-first century professions (Franks, et al., 2016). Without these skills, students are less likely to be prepared for post-academic careers. Moreover, students who traditionally disengage from science are at the highest risk of being scientifically illiterate and, therefore, are less likely to take part in meaningful ethical and scientific discussions that demand their attention, their input, and perhaps their vote (Zeidler & Kahn, 2010).

Despite the research-backed need for explicitly using and teaching reading strategies, literacy instruction is often avoided in content area classes, including science (Franks, et al., 2016; Alger, 2007). Instead, teachers often hold the view that their focus should be on content and that learning to “read” should have happened in elementary school (Greenleaf, Schoenbach, Cziko, & Mueller, 2001). Research also indicates that new teachers rely heavily on teaching strategies that their master teachers use or base teaching decisions on past experiences as a learner (Zulich, Bean, & Herrick, 1992). These are often teacher-centered strategies such as round-robin reading and assigning questions at the end of chapters to assess comprehension (Alger, 2007). Socratic seminars are, arguably, a way for science teachers to reverse this trend. By engaging students through text-based discussion on highly relevant issues, teachers can comply with the NGSS's emphasis on applying scientific understanding through science literacy (Franks, et al., 2016; Zeidler & Kahn, 2014). In doing so, they can help students become critical and analytical science thinkers.

Socratic Seminars as Culturally Relevant Teaching. Socratic seminars using texts that examine socioscientific issues are a natural way to integrate culturally relevant pedagogy into the classroom. By allowing students to draw from personal experience, engage in meaningful dialogue about ethics and values, and use academic, science-based evidence, teachers can elicit deeper thinking about questions that do not often have a clear answer. In doing so, teachers can create a rich learning environment that allows students of color to be authentic in their cultures, succeed in academic learning, and develop a science literacy that will inform their role in meaningful public discourse.

Conclusion

The literature review began with a look at the structure of traditional classrooms. Within this discussion we looked at how traditional classroom teaching has affected and continues to affect student learning. The suppression of voice and creativity have caused an academic discord between teachers and students and students and society that profoundly impact social inequity.

In response to this, the literature review explored the theory of culturally responsive teaching (CRT): a framework that might simultaneously address student engagement and the achievement gap that exists between students of color and their white counterparts. As a part of this, there was an emphasis on CRT in science education. The discussion focused on how traditional teaching of science as “facts” has had an exclusionary effect on a large number of students of color and how, in order to address this, science teaching needs to be refocused in a culturally relevant way.

The culturally relevant approach the literature review went on to explore was the Socratic seminar. Socratic seminars are a discussion-based approach to education that are predicated on principles of argumentation practiced by the ancient Greek philosopher, Socretes. The review asserted that, in order to make Socratic seminars truly relevant, they need to address issues that are relevant to students’ lives. This research focused specifically on socioscientific issues (SSI): issues of great relevance to the students’ lives that involve both ambiguity and room to explore social injustice in and around science.

There is strong evidence to support the idea that students gain vocabulary and argumentation skills through Socratic seminars. This, in part, leads to an increase in science literacy within the community of learners. The literature found that increasing literacy of any kind (including science literacy) is a political act. Students who know more about the ethical nature of science, how to use data as evidence, and how to engage in evidence-based argumentation will more likely be able to make informed decisions that could have significant society-changing implications. Through this line of argument, the research in this chapter helped answer the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?*

In Chapter Three, the variables considered when developing the Earth Science Socratic Seminar Curriculum, along with the timeline of project implementation will be explored.

CHAPTER THREE

Project Description

Introduction

In the previous chapter, many of the pedagogical challenges facing urban middle school students and their teachers were presented. The underlying arguments for the proceeding curriculum were also presented in order to answer the research question of *how Socratic seminars can be used as a culturally relevant tool to increase student engagement and science literacy?*

The literature review found that classrooms that do not include authentic, engaging, and relevant questions, often leave underrepresented students feeling like science is an exclusive practice better left for someone else. It also explored how traditional methods of teaching science (cookbook labs, isolated activities, textbook instruction, and rote memorization) do not fully support learning for most students. Evidence supports moving beyond this type of instruction to a more contextualized and performance oriented approach. Students need to find what they are learning to be relevant to their lives and they need to be able to transfer what they have learned to different situations.

Culturally relevant pedagogy (CRP) is an approach to making curriculum relevant in students lives by focusing the content being taught through a lens that brings personal meaning to students in the classroom (Adams & Laughter, 2012; Atwater,1994; Ladson-Billings, 1995a). The intention is to go beyond simply celebrating cultural events and putting up decorations that represent different cultures in the classroom. Instead, teachers should teach their content through the lens of social justice. Curriculum should explore, rather than avoid, complicated social issues including dominant cultural practices that perpetuate inequality.

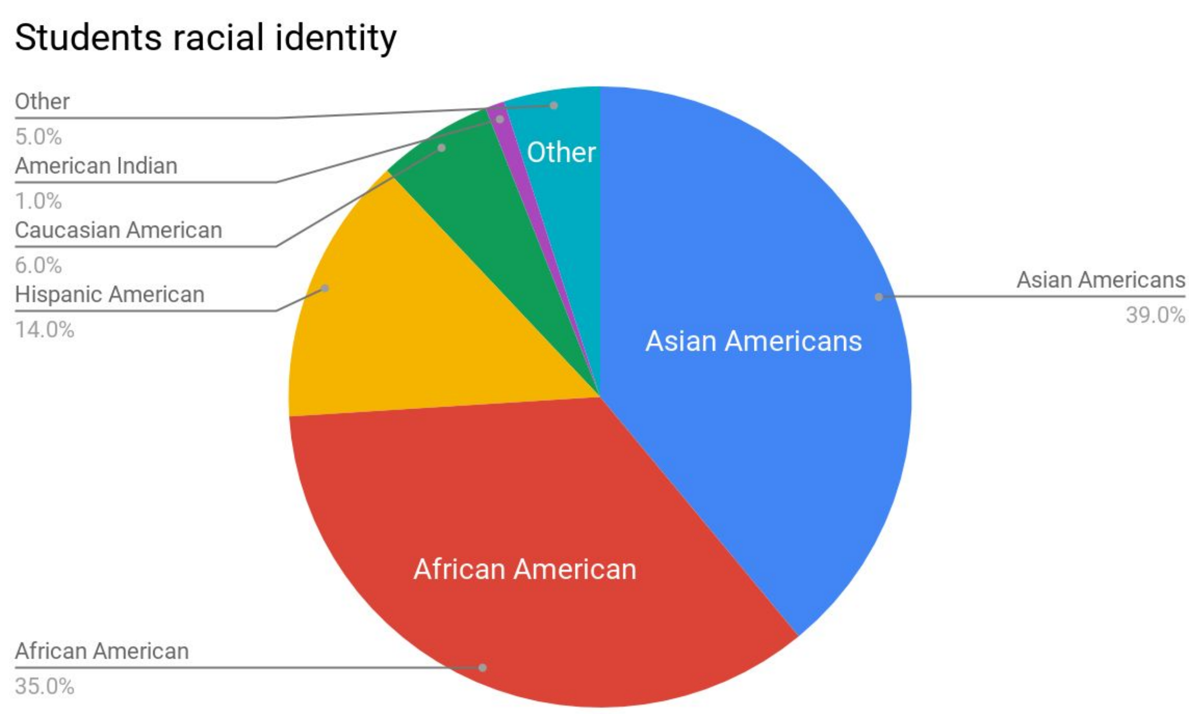
The goal of this project is to use data-backed best practices to develop curriculum that revolves around the principles of culturally relevant pedagogy. Each unit in the curriculum will center on a specific relevant socioscientific issue with the goal of engaging ALL students, but specifically focusing on historically underrepresented populations. Ultimately, the goal of this curriculum is twofold: meet state science standards and develop deep, ethical, science-based practices that can inform student thinking in the real-world.

Social Demographics

The school in which this curriculum will be implemented is an urban middle school in a medium sized midwest city. The participating students are 8th graders in an

Earth science classroom. The school is a 6th through 8th grade middle school, and the majority of the students have attended this school for two years prior to their 8th grade year.

The student population at this school is approximately 750 students as of the 2018/2019 school year. The chart below illustrates how students in this school racially identify.



Source: https://www.spps.org/Page/27991

Students Who Use:

- Special Education 15.7%
- Free and Reduced Lunch 79%
- English Language Learning 44.6%

Source: https://www.spps.org/Page/27991

Teaching Environment

The teacher is in his 2nd year of classroom teaching and 12th year in the field of education. Because of the large population of students who qualify for special education services and who are being integrated into the classroom, this teacher is assisted in nearly every class by at least one special education co-teacher and/or teaching assistant. The classroom itself, while being somewhat outdated, has seven lab tables, each equipped with a sink. Some sinks are not functioning, but the tables themselves provide ample space on which to do group work and participate in labs. The classroom is also stocked with some science equipment, though, in the opinion of the teacher, not ample enough for many labs. In the middle of the room are tables and chairs. Optimally, labs and group work would take place at the lab tables and direct instruction would take place at the center tables. This, however, is not possible as class sizes average around 31 students and all available seating is needed all of the time.

Curricular Planning

Unit Planning Framework

Understanding by Design. The units being presented in this project were planned using the Understanding by Design® (UbD) framework. This framework for curricular design outlines a process and structure to guide curriculum development. At its core, UbD reflects the convergence of two key ideas: 1) teaching and assessing for understanding and 2) a data-driven process for curriculum development. UbD centers around the idea of understanding, or the ability to make meaning of the content's big ideas and to transfer that learning to other materials and situations. In order to achieve understanding, it offers a framework for unit planning. The framework is based off the long held practice of backward planning. Starting with the long-term desired results, the UbD process has three steps: Desired results, Evidence, and Learning Plan. By starting with an ultimate standards-based objective, teachers have a clear roadmap for where they want to go and how to get there. It is easier as well to tie every lesson together as opposed to teaching through isolated activities or disjointed daily goals (Wiggins & McTighe, 2011). The second stage of planning describes the process of designing when, where, and how to use assessments to accurately gauge student understanding. And, finally, the third stage of planning focuses on designing learning activities that are consistent with the ultimate objectives developed in the first step. Key to the UbD framework is alignment. All three stages must clearly align to national and state standards as well as to each other.

Unit Planning Lens

Culturally Relevant Pedagogy. The UbD unit planning framework has offered a clear outline for how to plan units. Yet, based on the research presented in Chapter Two, it is clear that good curricular design and classroom structure are not everything and that success should not be based just on high performance scores on assessments. In order for education to make impactful changes on students, communities, and society at large, content has to reflect relevant issues and challenge prevailing societal and educational norms (Ladson-Billings, 2006). The curriculum being presented in this project will approach every science standard through the lens of culturally relevant pedagogy. In other words, science content will not be taught in isolation of the societal realities facing the students.

Unit Planning Standards

Minnesota State Standards. The 8th grade Earth science unit topics that are the focus of this project are the Nature of Science and Matter units. These units will specifically address the following Minnesota state science standards:

Standard 8.1.1.1 Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.

Standard 8.1.3.3 Science and engineering operate in the context of society and both influence and are influenced by this context.

Standard 8.2.1.1 Pure substances can be identified by properties which are independent of the sample of the substance and the properties can be explained by a model of matter that is composed of small particles.

Standard 8.2.1.2 Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system.

Standard 8.3.1.3 Rocks and rock formations indicate evidence of the materials and conditions that produced them (Minnesota Department of Education, 2009. P. 31)

Next Generation Science Standards. While this unit is being planned for the academic year 2019-2020 in which the MN standards as presented above remain intact, it will incorporate ideas from the Next Generation Science Standards (NGSS). These national standards are core to the ongoing revision of the MN state standards and, thus, are an important component for making this curriculum relevant in years to come.

Within the Next Generation Science Standards, there are three distinct and equally important dimensions to science learning: 1) crosscutting concepts 2) science and engineering practices and 3) disciplinary core ideas. Crosscutting concepts, such as “cause and effect,” help students explore the connections between different sciences (NGSS, 2013). By exploring science and engineering practices students are better able to describe what scientists do to investigate the natural world and what engineers do to design and build systems along with all of the social implications of both. Finally, disciplinary core ideas are the big ideas in science that have broad importance through multiple engineering and science disciplines. These three dimensions together form the basis for each standard and each dimension works with the other two to build a cohesive understanding of science for students over time.

A framework for k-12 Science Education. In addition to and in alignment with the MN state state standards and their pursuant benchmarks as well as the Next Generation Standards, these units are guided by the scientific and engineering practices laid out in A Framework for K-12 Science Education. The following eight practices are essential elements of this framework:

1. Asking questions and defining problems.
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematical and computational thinking.
6. Constructing explanations and designing solutions.
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information (National Research Council, 2012).

Lesson Planning Design

The 5E Model. Lessons within these units will be guided by the BSCS 5E model of planning: Engage, Explore, Explain, Elaborate, and Evaluate. The developers of this model first wanted an instructional model that was research-based. Second, they felt it necessary to challenge students' current conceptions (i.e., misconceptions) and reconstruct their ideas and abilities. This, they felt, was in agreement with the constructivist view of learning. Third, developers wanted to give teachers perspective that was grounded in research. In other words, how should teachers look at building lessons into each other. Finally, the 5E model provides a simple and memorable sequence (Bybee,2014). Figure 1 illustrates the 5E model according to one of its developers, Rodger Bybee (2014).

FIGURE 1.

Summary of the BSCS 5Es instructional model.

Engagement
The teacher or a curriculum task helps students become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.

Exploration
Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions, and design and conduct an investigation.

Explanation
The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. In this phase teachers directly introduce a concept, process, or skill. An explanation from the teacher or other resources may guide learners toward a deeper understanding, which is a critical part of this phase.

Elaboration
Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept and abilities by conducting additional activities.

Evaluation
The evaluation phase encourages students to assess their understanding and abilities and allows teachers to evaluate student progress toward achieving the learning outcomes.

Assessments. According to the constructivist approach of the 5E lesson model, students must approach their learning with an understanding of their existing ideas. The use of a wide variety of formative probes throughout the unit helps students uncover their existing ideas and gives teachers useful information for targeted instruction. As a result, throughout the lesson students can continually break down misconceptions and build a correct base of conceptual knowledge (Keeley, 2011).

Timeline

This curricular project will be implemented between September, 2019 and December, 2019. While the units here are not sequential, they will both fall within the first semester of the 2019-2020 academic year.

Summary

There are many pedagogical challenges facing students of color and their teachers in urban schools. The purpose of this project is to provide a research-based approach to teaching two 8th grade Earth science units through a culturally relevant lens. Units will be planned backwards from MN standards based objectives according to the UbD planning framework. Lessons will be planned according to the 5E constructivist model. Throughout the units, formative assessments will be used to assess prior knowledge and gain important information for targeted instruction.

CHAPTER FOUR

Conclusion

Introduction

For the last six years I have worked in a large midwestern school district where, year after year, I have seen many minority students disengaged and uninterested in succeeding in their science classrooms. When I became a teacher I vowed that I would do everything in my power to disrupt that trend. As a result I have focused my research for this project on answering the question: *How can Socratic seminars be used as a culturally relevant tool to increase student engagement and science literacy?*

In this chapter I will synthesize the findings of my literature review. I will then reflect on the research process and the lessons I've learned. Next I then focus my attention on the possible implications this research and project development might have on my professional practice. Then, before I talk about how I expect to communicate my research and project as well as the broader implications that my curriculum might have for my colleagues and profession, I will reflect on the limitations I faced in developing the curriculum.

Literature Review Synthesized

When I started looking into ideas about what I wanted to research, I was quickly drawn to exploring the research done on Socratic discussions. I wanted to see if my inclination was right; that they could be a natural fit in a culturally relevant pedagogy. Furthermore, I wanted to see how easily they could be integrated into my school's work on increasing literacy through "close" reading strategies.

I had been introduced to the idea of Socratic discussions while student teaching, and, after one successful use of it in my classroom, I decided I would create a project centered around discussing socioscientific issues through the framework of the Socratic seminar. My final project includes two complete unit plans that center on an engaging and relevant socioscientific question. Each unit concludes with a Socratic seminar that incorporates arguing from evidence that has been collected throughout the unit and texts that specifically address the question.

When I began my research into culturally relevant teaching (CRT), scientific literacy, and Socratic learning, I had only a vague idea of what each was and how each could fit naturally with each other. Yet, as I got further into the literature, I noticed that these three ideas were, in many ways, different names for the same goal: that students, especially traditionally underrepresented students, see themselves in their learning in order to be prepared to challenge traditional structures of power and societal disenfranchisement.

I was surprised by how easily these ideas fit together and was pleased to find that the research around each of these ideas was fairly robust. I even found some literature that tied some of the ideas together. Yet, I did not find any research that incorporated CRT with science literacy and Socratic learning. This provided the impetus to continue my endeavor to see if these ideas were in agreement and if it made sense to build a curriculum around it.

According to Cheryan, et al (2014) the average American student spends 11,700 hours in school from kindergarten to 12th grade. Much of this time, especially in under-resourced schools, is filled with teacher-centered instruction. While teacher trainings universally denounce this approach as bad practice, this traditional pedagogical model perpetuates in many schools that serve higher concentrations of students on free and reduced lunch plans (Barton, 2003).

It came as no surprise to me, then, that the research done by Hargreaves, Elhawary, & Mahgoub (2019) suggested that this created a learning environment where students are made to feel like they have little valuable input to contribute. This, in turn, leads many students to view science as an exclusive field, a “mysterious and secret body of knowledge understood by only a few" (Adams & Laughter, 2012, p. 1106). I had, after all, seen this in my own classroom.

Lessons Learned

I found that through this process of exploring my question I rediscovered my passion for research. It was as if, by trying to build a solid grounding for my project in research, I was getting to practice the same thing I have been teaching my students; that to build a strong claim, you need evidence tied together with reasoning. Doing this, I have always found, is like piecing together a challenging puzzle.

In this project I also learned how to be an adult learner and researcher in the face of a new reality of time constraints. In the past, I have enjoyed the process of researching not only because I was interested in the topic, but because it allowed me to cloister myself and immerse in texts for hours at a time. I now have two small children, a time demanding job, and other responsibilities I did not have in college. This has made it a challenge to find uninterrupted time to research and work.

In this, I have had to adjust to a different approach to researching and writing. Through this project I learned ways of writing in smaller chunks and of organizing thoughts so that I could leave and come back to them at any time without having to start from the beginning every time. I have also relearned the importance of brevity. Keeping the writing shorter does not only help me with time management but generally makes my writing better.

Possible Implications

Because this traditional approach to teaching was something that I was struggling with myself, the writing and research done on culturally relevant pedagogy by Gloria Ladsen-Billings became an important foundation for the rest of my research and, ultimately, my project. At the heart of her argument is the belief that students are at the center of learning and that academic achievement is essential to combat endemic racism in society. To realize this, students need to “recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture, where they are likely to have a chance of improving their socioeconomic status and making informed decisions about the lives they wish to lead” (Ladson-Billings, 2006, p. 36).

Engaging students in discussions on relevant socioscientific questions, then, became a logical way for me to try to recognize and honor my students’ cultural beliefs and practices. As I researched, I found that a growing body of research supports the use of text-based Socratic seminars as a framework for in-class discussions. According to several studies, including one by Robinson (2008) that examined academic achievement at nine Paideia schools (schools that regularly use Socratic seminars as a teaching strategy) there are positive academic impacts for students as a result of Socratic seminars.

This agreed with my own experience with Socratic seminars and as I developed my curriculum I used the seminars as the foundational summative assessments for each unit.

As I think about the implications for my work, I can't help but think about my underachieving students who, when I told them they would be allowed to talk and "argue" almost as much as they wanted in class, were suddenly excited and eager to engage with academic material. Students who don't see themselves in science are less likely to pursue science related careers according to the National Science Foundation's 2013 survey of science and engineering professions. In this study 73% of scientists and engineers at all degree levels identify as white while only 6% identify as black or African American (National Science Foundation, 2013).

By engaging students in oral dialogue about socioscientific issues, it can be argued, we can not only broaden the diversity of scientists, but we can develop scientists who view their work through a broader socio-political lens; a lens that sees the humanity of science and the ethical implications of its use. Moreover, even those students who do not pursue careers in the sciences will hopefully gain similar understandings and be able to use their knowledge to make informed decisions about public policies and elected officials.

Limitations

Despite the potential for positive impacts on student engagement and science literacy, there are some significant challenges to developing and implementing such curriculum. First, as I discovered in the development of my own curriculum, effectively gathering resources to build appropriate science knowledge and language for an impactful Socratic discussion is time consuming. For many teachers, this may cause immediate dismissal of the idea. Second, in order for students to develop real and meaningful knowledge of a culturally relevant socioscientific issue takes class time. This is a luxury few teachers feel they can afford in a heavily standards-driven field. Finally, there is the challenge of defining what is culturally relevant. For many teachers in diverse classrooms, what may be culturally relevant to some, is likely to be irrelevant to others. There are few, if any, topics that can connect every single student in a diverse classroom.

Despite this, I believe that the research shows that the potential benefits outweigh these costs. As I continue to think about building curriculum around socioscientific issues I would like to focus in on finding or developing level appropriate texts that are differentiated for my diverse learners, specifically English Language learners. I would also like to build curriculum for the remaining units for Earth Science and connect them to specific Next Generation Science Standards.

Professional Implications and Future Development

I am currently sharing my curriculum with my school's science department and we are beginning to collect data on the effectiveness of the material I've already developed. As we implement the curriculum, we are continually reflecting on each lesson in PLC and discussing possible improvements. I hope that, as a department, we can continue trying out these ideas and finding better ways of implementing the lessons so that they have maximum impact on our students.

In addition to sharing the curriculum, I hope to share this strategy with other departments in my team. I believe that the interdisciplinary nature of socioscientific questions could lead to some interesting collaboration across subjects. This, in effect, will hopefully lead to a richer, deeper, and more integrated understanding of the topic.

I also hope that, by sharing this curriculum through Hamline's publishing, some of the ideas presented might inform other teachers' practices and spur some future curriculum development. As Minnesota attempts to make their integration of culturally relevant standards in science clearer, I believe socioscientific questions through Socratic seminars may be an appropriate vehicle to teach these. With this curriculum in place as a starting point, other teachers can modify and add to make the best possible learning available for our students.

I'm excited for what this project has taught me about being a researcher and learner. I'm even more excited to see how students learn through the process. As a reflective practitioner I see myself making modifications to this curriculum as its strengths and weaknesses expose themselves. I hope, as well, to develop at least one socioscientific-question-anchored Socratic seminar lesson sequence for each unit in the

Minnesota Earth science curriculum. As I make modifications and add material, I believe I can find and create more and better differentiated texts for each seminar. In the end, I hope to have a living work that is able to flex in relevance and with students' needs as time proceeds.

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