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Multicultural Education in Secondary Science Classrooms

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> "Why aren't women and minorities rushing into the science vacuum? I contend that an important reason is that the science curriculum itself and the dominant views of science as an a-historical and hyper-rational system of thought makes the science classroom an alien and hostile place for women and people of color. Students often decide whether to pursue a particular line of study based on a combination of intrinsic interest in the subject and something I might call the "comfort zone." Baldly stated, the science classroom is usually an uncomfortable place for women and people of color. If we are to address the crisis in science personnel we must ask not only about how we teach science but also about the subject matter itself." (Fausto-Sterling, 1991, p. 5)

To begin to understand the nature of the problem, the following are data collected by the National Science Foundation. Women were awarded about half of all science and engineering bachelor's degrees in 2016, but less than half of all advanced degrees. Among scientists and engineers working full-time, women on average made $24,000 less than men in 2017. Underrepresented racial minorities (Black, Latinx, and Indigenous in the fields of STEM) had a lower median salary by about $12,000. Female scientists or engineers who are Latina or Black had a $10,000 lower median salary than their White counterparts. People with disabilities or those from underrepresented racial minorities make up only about 9% of employed science and engineering doctorate holders at universities in 2017. Within certain disciplines of STEM, it is even more disproportionate. Women make up 12% of bachelor's degrees in electrical engineering and 19% of computer science and physics bachelor's degrees awarded in 2016. The disparity begins even before post-secondary education. A 2015 survey by the U.S. Department of Education found that 82.5% of public school teachers that instruct grades 9-12 in the natural sciences identify as White. In the 2015-16 school year, high schools with more than 75% Black and Latinx enrollment offered fewer advanced mathematics courses, biology, chemistry, and physics classes when compared to all high schools in the nation (U.S. DoE).

This reality is the result of the heteronormative, racist, sexist, ableist, and classist discriminatory policies and practices systematically embedded in our society. U.S. public schools are a social institution that operates within these systems of oppression. Educators have the power to transform the lives of students, and the choices teachers make play a significant role in how their students come to see and engage with the world around them. Science teachers do have options, like multicultural education, to disrupt the systems of oppression that continue to make the field of science inequitable.

My Positionality

I am a White, female scientist and pre-service teacher. Unlike most students I will be teaching, I found success in Freire's (1970) banking model of education. I also thrived (but did not enjoy) my time in the meritocracy of our public education system. I was lucky enough to be enrolled in a public school district composed of racially and socioeconomically diverse students. I was valedictorian, a Washington Scholar, and received the award of my graduating class for Science and Foreign Language. My mother, an agricultural research technologist with a bachelor's in chemistry, was always involved in and supported my education. I had never spent much time considering my Whiteness or the advantages I was afforded as a member of my socioeconomic status. The fact that my race was not something I thought about for the first two decades of my life is the epitome of White privilege. DiAngelo claims that "white progressives cause the most daily damage to people of color" (2018, p. 5). I consider myself to be a progressive, so this seriously worries me. Since starting at my university and especially during my teacher certification program, I began to engage in reflexivity, explore my positions of privilege, and critically examine the world around me.

In doing so, I noticed the discrepancies between what my community is and how it was reflected in the sciences. My K-12 and college education taught me science through a Western perspective. Not only that, but I was taught that other knowledge making systems are invalid within science. All of my education has been from a Western science perspective, so I have no formal training in other methods of how different cultures and peoples study the natural world. Most of my advanced science and mathematics instructors in high school were male, all were White, and every scientist we discussed in class were White men. Of the startling 32 science and mathematics courses I have taken at Western Washington University, I had two professors of color. My classmates in biology courses were majority female, chemistry courses were fairly equal, and physics courses were vast majority male. As I watched my male classmates in these academic settings, I was amazed at their confidence and assurance. They believed that they belonged, had a right to take up space, and to be listened to and heard. I *still* struggle to feel comfortable in science contexts, despite earning degrees in biology and chemistry. Because of this, I cannot help but wonder if being exposed to science education from a non-dominant perspective at a younger age could have altered my experiences with socialization and internalized oppression.

What is Multicultural Education?

The phrase "multicultural education" is complex. Scholars have written and rewritten its components for years, but no singular definition has been established because of its dependence on the local context. Multicultural education is considered to be an idea, an education reform movement, and a process (Banks, 1997). The beginning of multicultural education sentiments in the United States was rooted in the work of W.E.B. DuBois and Carter Woodson, amongst other thinkers, in the 1880s. The modern movement grew in response to many social campaigns, including the Civil Rights, feminist, LGBT, and American Indian movements. Much of the founding work started with Dr. Gordon Allport's book *The Nature of Prejudice* in 1954 and by Dr. James A. Banks' writings beginning in the 1980's.

Due to the complexities of multicultural education, no one definition exists of what it is, but there is almost universal consensus regarding some of the major goals of multicultural education. Banks (1995) identified the following five dimensions of multicultural education: content integration, the knowledge construction process, prejudice reduction, an equity pedagogy, and an empowering school structure and social structure. Nieto (1992) characterized it using seven fundamental traits, writing multicultural education is: antiracist education; basic education; important for all students; pervasive; education for social justice; a process; critical pedagogy.

As a pre-service science educator, I was immediately drawn to one of the similarities between these definitions: the content integration and pervasive characteristics. Multicultural education is not just the discrete celebration of diversity during Black History Month or Gay Pride Day. Not only should multicultural education be addressed continuously, but it also must permeate every subject within schools. Some disciplines better lend themselves to integrating multicultural perspectives, like social studies and language arts, where a teacher can bring in literature and accounts of history from underrepresented voices in their fields. Subjects like science and math traditionally did not address multicultural education, and many even thought it would be irrelevant to do so because they are disciplines which are thought to be objective or apolitical. Despite their popular name of "hard sciences", these fields are neither objective nor neutral. So how does a science educator infuse their classroom with a multicultural philosophy?

The National Association of Multicultural Education (NAME) organized three separate approaches educators can take to integrate multicultural education into science:

a. Attention to and use of culture towards understanding the cultural contexts that shape science;
b. An equity-orientation that facilitates access to science for all students; and
c. Efforts to leverage the skills and content of science to advance justice in schools and communities.

This literature review will address these stances and explain why the incorporation of all three approaches (cultural context, equity, and social justice) is necessary to properly integrate multicultural education within secondary science classrooms.

Cultural Context

The traditional ideas about what science is and who does science are ingrained within our society and institutions. Western modern science (WMS) is only one among many ways of describing the natural world, despite its position of superiority in the American education system. Indigenous knowledge (IK) and traditional ecological knowledge (TEK) can rarely be found in the typical school science curriculum, which normally contains only ideas on which there is widespread consensus. Mind you, this "universal" agreement of scientific ideas is dictated by Western hegemony. The first question when confronted with a different knowledge-making system usually is: how close is it to mine? Just the fact that TEK is assessed to determine the degree to which it approximates WMS is intrinsically colonialist and imperialist. Western knowledge-making systems have always been the dominant educational paradigm, but why should that continue? The epistemic frame of a traditional science class only further benefits those in power and excludes those with marginalized identities. Whose knowledge is of most worth? By teaching only WMS, we are answering that question.

WMS is seen as the pillar of objectivity and truth, so much so that TEK is validated against it. Contrary to popular belief, Western science is political and subjective. The fact that science is a social process performed by people leaves room for bias. Scientific research is beholden to its community. It is funded by the trends in society and, more specifically, who has the money and power. For example, women have and continue to be excluded from medical knowledge production, which has resulted in a healthcare system that only knows how to best treat men. The norm in clinical trials has always been White men, and most laboratory studies continue to use only male animals in research (Pollitzer, 2013). Throughout the history of the U.S. (and still today) science has been political and misapplied as a weapon to advance oppressive agendas, like with Social Darwinism, the eugenics movement, and the suppression of scientific studies and data. The immortal cell line created from Henrietta Lacks without her consent and the Tuskegee Syphilis Study are just a few examples of how communities of color were used and harmed for research. Also, the scientists doing the research have in many ways been determined by society. Even if those with minoritized identities can challenge the socialization from birth that they cannot do science or mathematics, the path to becoming a scientist is fraught with systemic oppression.

The belief that WMS is superior typically hinges on its rationality, but that is an impossible feat to accomplish. In *Spirit and Reason* (1990), Vine Deloria, Jr. says that Western science "discards anything that has a remote relationship with the subjective experiences of human beings and other forms of life… the essence of science is to adopt the pretense that the rest of the natural world is without intelligence and knowledge and operates primarily if it were a machine" (p. 58). Deloria later goes on to explain attempts to insert TEK into the classroom. In one example, the Six Nations people traditionally planted corn, beans, and squash (the "Three Sisters") together which form a natural nitrogen cycle. In this case, it was only until after WMS discovered the nitrogen cycle and noticed that the Three Sisters formed a sustainable agricultural crop system that it was brought into the dominant discourse. When discussed in class, Deloria says that the TEK his ancestors held about nature are "believed to be merely ad hoc resolutions of the problem or lucky guesses and do not receive the credit that is theirs by right" (p. 107). In the American education system, IK has often been reduced to primitive or technical knowledge for its survival as "useful" to the Western world (Quigley, 2009). If TEK is ever inserted into the science classroom, it is usually only after WMS has validated it. In her beautiful book *Braiding Sweetgrass* (2013), Dr. Robin Wall Kimmerer, an Indigenous scientist with degrees in Western scientific methods, argues that "we see the world more fully when we use both [TEK and WMS]" (p. 46). Stanley and Brickhouse (2001) recommend an approach which shows students how "different views of science are firmly rooted in certain cultural assumptions that influence how they go about formulating and solving problems of significance" (p. 47). Dr. Kimmerer frequently mentions a reciprocal relationship with nature and an interconnected world with a democracy of species as part of indigenous wisdom. That is a poetic and necessary perspective that is often lacking from secondary science classrooms.

Terms like "insert" or "drop" often came up while researching the relationship between WMS and TEK. These words do not connote a very integrated curriculum. Much work still needs to be done on this front. An effective way to design a culturally-sustaining curriculum is to have people from these marginalized identities be involved. Although, if a Western science teacher takes TEK for use inside their classroom with no thought towards the responsibility of reciprocity in our relationship with Indigenous peoples, it is exploitative. It is vital to note that an educator must develop long-lasting, non-exploitative, empathetic, and authentic relationships with marginalized communities first, since the education system has often served as a weapon against these oppressed groups. American schools were designed to promote imperialism and allegiance and ultimately extinguish tribalism since their inception (Grande, 2004), and really how much has changed in the past 400 years?

Equity

As many states have adopted the Next Generation Science Standards (NGSS), curriculum has had to adapt. Ideally, units are now built around essential questions driven by inquiry of real-life phenomenon. Topics are not taught as though they are discrete; instead, their interrelatedness is thoroughly examined. So these changes ultimately lead to a more engaging, holistic curriculum, which lends to a more equal classroom. Equal, but not necessarily equitable. In order for a classroom to be rooted in equity, a priority must be made by the teacher to provide every student access to the discourses and literacies of science.

The first and perhaps most obvious step to improve equity in your classroom is to highlight successful scientists from historically marginalized identities. When asked to draw a picture of a scientist, most children draw an elderly man with glasses in a white lab coat. The vast majority of famous scientists and ones found in textbooks are White males. For female students, these stereotypes both reflect and perpetuate women's underrepresentation in STEM fields (Lane et al., 2012). There is serious concern in the scientific community that its current homogeneity is self-perpetuating; since many minorities do not see others with identities similar to their own, they do not believe scientific careers are possible (Krieger and Gallois, 2017). Discussing people who provided successful contributions to STEM fields like Rosalind Franklin, Henrietta Lacks, Ada Lovelace, Katherine Johnson, Alan Turing, and Sally Ride would allow your indubitably diverse students to see themselves in the curriculum and maybe even envision their future as a scientist. Brickhouse et al. (2000) found that students were more likely to disengage from science and resist the development of a science identity when they believe scientists have different qualities compared with themselves or with those valued in their home communities.

Another step a teacher can take to promote equity is to countermeasure microaggressions with small acts that foster inclusion called microaffirmations. Dr. Derald Wing Sue defines microaggressions as brief, everyday exchanges that send denigrating messages to marginalized individuals because of their social group membership (2010). In his book *How to Be an Antiracist* (2019), Ibram X. Kendi makes a poignant case that microaggressions should instead be called abuse, because there is nothing small about the repeated and continuous trauma experienced from everyday language in the form of assaults, insults, and invalidations. Microaffirmations can be thought of as the antithesis of microaggressions. Jones and Rolon-Dow (2018) describe microaffirmations as small acts which have positive impacts on the lives of marginalized people "by promoting their success, by affirming, recognizing, validating, and protecting their identities, social positionality, and experiences" (p. 39). These small acts can be verbal, kinesthetic, or visual. Microaffirmations can either disrupt oppressive policies and practices or create new norms and policies that promote equity and justice (Jones and Rolon-

Dow, 2018). Addressing microaggressive behavior along with jointly using microaffirmative language and actions to advance inclusion, offer encouragement, and strengthen authentic relationships can have a positive impact in a science classroom (Harrison and Tanner, 2018).

The discourse of science classrooms and texts differs from the everyday discourse of students and from that of a mathematics or language arts classroom or textbook (Quinn et al., 2012). The language of science, and more specifically the jargon within each discipline of science, can be overwhelming. Many words are long, rooted in Latin or Greek, difficult to pronounce, and appear or sound similar to other words. Scientific writing is information dense, technical, full of extended noun phrases, passive tense, and nominalizations (Fang, 2005). Along with the fact that students learn an enormous amount of new terms, many words in science have different everyday meanings (e.g. state, work). The feeling of impenetrability towards science language is even connected to a lower scientific interest and perceived understanding with non-experts (Shulman et al., 2020). For students with disabilities, students who are learning English, and students who believe they cannot "do" science (often those from historically underrepresented groups), the language of science is a major hurdle. Learning to use the language of science is fundamental to learning science, but a reduction of unnecessary specialized terminology is needed (Wellington and Osborne, 2001). As Vgostsky (1962) noted, though, when a child uses words they are developing concepts and ultimately improving their ability to make sense of the world.

So, how we teach science language must become more explicit and purposeful. Lowering our expectations as educators is unacceptable and a disservice to all students, because it typically results in the removal of learning opportunities. Scaffolds must be put in place to support students with challenging work. Vocabulary should be refined so there are 6-8 new terms for middle-level students and 8-10 new terms for high school students per unit (Tweed, 2009). Assessments should include options for feedback and revision, because, otherwise they do not benefit the student.

As technology is becoming fully integrated into the school environment, the Universal Design for Learning (UDL) principles should be implemented in science classrooms (CAST, 2018). Its framework is deeply rooted in Vygotsky's concept of the zone of proximal development (ZPD). Students can utilize technology for customized support as they travel through the graduated levels of their ZPD. Augmented reality can create authentic opportunities for students with intellectual disabilities to aid with learning science vocabulary (McMahon et al., 2016) and web and program accessibility features (like Microsoft's Read Aloud, Dictate, and Translate features) can assist every type of learner in a classroom. There are so many available resources for use in the classroom, if one only takes the time to seek them out.

Social Justice

The ability to affect real social transformation is possible within science classrooms. Social justice refers to the equitable distribution of rights and opportunities within every aspect of society. It seeks to address and rectify issues of equity and oppression by actively working to critique and change the structures which maintain injustices. Gutstein (2006) argues STEM education needs to be reconceptualized to include "critical literacy for the purpose of transforming society, in its entirety, from the bottom up toward equity and justice, for all students whether from dominant or oppressed groups" (p. 11). This approach in education relies on strengths students bring to the classroom, not deficits. Every student has a litany of personal, cultural, and community assets that are often underutilized in the classroom setting. The skills students bring to the classroom can advance social justice and open up possibilities for imagining new forms of life. Science curriculum entrenched in social justice work positions teachers and students as active co-investigators of issues relevant to their community. Social justice education is "empowering", but not with the standard prefix meaning which implies those in power (teachers) give subordinates (students) power. Though the relationships in the classroom are indubitably hierarchical, I mean it here in the sense that teachers can foster an environment which allows students to take charge of their own education and empower themselves. Encouraging students who are burdened by all major sectors of our society a way to challenge their status can be extremely empowering.

Dimick (2012) proposed that there are three dimensions to student empowerment through social justice science education: social, political, and academic. Students become empowered with social justice education through democratic interactions between the teacher and fellow students, through their awareness, critical examination, and activism in regards to structures that maintain power inequities in their community, and by gaining skills for success in scientific discourse and as a global citizen.

Human health and climate change are two nearly limitless areas that have reaching effects to all communities in the world today. If one researches public health and environmental issues, they will find that marginalized identities are disproportionately impacted across the board. For example, from health issues ranging from adverse childhood experiences to COVID-19, minority communities are disproportionately affected for a multitude of reasons. Those in a lower socioeconomic status likely cannot afford quality healthcare. Communities of color also have an increased likelihood of living next to factory farms or industrial pollution sites (Tessum et. al, 2019), which often leads to chronic health conditions or death to nearby residents. These facets are also inextricably tied to environmental justice.

In reviewing the literature, I did find cases where educators are incorporating social justice in science spaces. An earth science unit designed by Mayberry and Rees (1997) integrated geology with political sociology by investigating oil reservoirs and traps and how businesses decide where to drill for oil. Barton (2003) taught and researched in an after-school science program with youth in homeless shelters in New York City and central Texas. In NYC, students converted an abandoned lot to a community garden while in Texas students designed and planted a butterfly garden and constructed picnic tables, planters, and bird feeders. Jurow et al. (2016) researched a community garden in an urban neighborhood with a high immigrant population that addressed inequitable food distribution practices and food insecurity by providing a viable economic alternative to commercial agriculture. This could readily be transferred into the classroom by relating all manner of topics like agriculture, the appropriation of natural resources, photosynthesis, and bioenergetics to higher incidences of pesticide poisoning, food deserts, poor water quality, chronic undernourishment, and obesity in low-income communities.

Social justice education emphasizes students' funds of knowledge and encourages learners to make connections between awareness and action with the ultimate goal of social transformation. It supports students to think critically about their local scientific issues as well as global problems and the relationship between the two. Social justice science education is one powerful way for us educators to move beyond just good intentions and teach for social change.

Conclusion

We as teachers must question every move we make in the classroom. If our answers include the phrases "that was how I was taught" or "this is what I was trained to do", that is unacceptable. The reproductive cycle which perpetuates inequities will only continue uninterrupted if that is our mindset. Constant critical reflexivity about our position in the classroom and proper scrutiny of our decisions is required.

Infusing a classroom with multicultural education can serve as an entry point to science and have life-long impacts for your students. There are countless ways to "do" multicultural education, which is only right seeing as 1) we as people are diverse and 2) the local community should heavily inform its design. The integration of all three approaches - cultural context, equity, and social justice - are necessary to create a science classroom environment that values the assets that every student brings to the table, provides access to a discipline which traditionally excludes, and empowers students to change their communities for the better.

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