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Equity and diversity have not been a dominant focus of previous national reform initiatives in science education (Rodriguez, 1997). The political nature and context in which standards and reforms are initiated (Collins, 1998; Rodriguez, 1997) provide both opportunities for comment and critique of our most recent science education reforms, *A Framework for K-12 Science Education* (National Research Council [NRC], 2012) and the *Next Generation Science Standards* [*NGSS*] (NGSS Lead States, 2013). What has been promising for the *NGSS* is a more deliberate coming together of educational members who were given the task to make equity and diversity issues prominent in framing the standards. Spillane and Callahan (2000) argue that implementation of standards at the state or local level requires that teachers and policymakers understand the intent and vision of standards and that the implementation of standards do not undermine or hinder student learning. We agree with the idea that all educators need to know the function and vision of the standards. However, we argue that educators should not only understand the function and vision, but *should* manipulate the same to meet the needs of all learners. We raise a more critical or guiding question: *How will all educators and society have a deliberate coming together to envision equity as a guiding framework for the implementation of* NGSS*?* Part of the challenge in addressing this question lies in responding to the pressures of standardized tests and policies and practices that inhibit teaching and learning (Rodriguez, 2010). Another challenge lies in shaping our understanding of how to implement any standards and the *NGSS* specifically with an emphasis on equity and diversity, not as an add-on but as a transformative approach to teaching and learning (Mensah, 2010).

No matter how well intentioned the architects of the *NGSS* were, equity must be explicitly addressed and sustained in its implementation. In the following section, we offer as a starting point a vignette to help surface several important ideas that deserve serious consideration in thinking about the discourse of education, schooling, standards, and equity. We then discuss macro socio-political categories that make explicit and relevant connections to equity and diversity in achievement associated with science education. In the subsequent section, Geneva Gay's (2010) framework for culturally responsive teaching is used as an important source for designing a roadmap that addresses equity in the implementation of the *NGSS*. Finally, we extend some suggestions and provide additional examples and resources to help frame issues of equity and diversity in the context of implementing the *NGSS*.

Vignette: Challenging Equity and Diversity in the Classroom

In a mixed grade level group of K-16 teachers attending a summer science professional development workshop, the facilitator asks a male, secondary science teacher with twelve years of teaching experience in both urban and rural settings to make explicit how he is enacting culturally responsive teaching in his science classroom. The response is quite surprising in that

the teacher says: *"The students in my chemistry class are all Jewish, from the same economic background, operating at very high levels of achievement and all aspiring for the same goals in life. How can I teach in a culturally responsive manner when I have all of the same type of students in the same SES and ethnic backgrounds?"*

Then a female middle grades teacher responded, *"Well, I've been teaching for seven years in an urban middle school, and the students in my 6-8 science classes are very diverse and I find it challenging to make science fun and interesting for them. I wonder how to enact culturally relevant teaching too."*

The other member of the group is an elementary teacher who also teaches in a local urban elementary school. She comments, *"This year as a third grade teacher, I will have more students than last year who are English Language Learners, and more of them will have IEPs, and I was told that we are losing our instructional coaches. We had a faculty member from the university who worked with our science coach last year, and I recall her talking about culturally responsive teaching in the first session she had with all of the teachers. She worked with a few of the classroom teachers, but I admit I didn't pay any attention and didn't invite her into my classroom because I really only have time to teach mathematics and literacy. I don't see how I can teach science when I didn't teach it at all last year."*

Finally, the last member of the group is a former scientist and now science teacher educator who teaches at a nearby university. He also serves as the student teacher coordinator and teaches an introductory course on Teaching in the Content Areas. He sits quietly but pensive. The facilitator asks him, "Dr. Raymond, how is your program preparing culturally responsive teachers?" He takes a few seconds, and then remarks, *"We have one person of color in our teacher education program. Perhaps she can do a workshop with our preservice teachers on culturally responsive teaching and teaching diverse students."*

There are many issues that can be addressed in this vignette. First, we see the secondary science teacher who sees his classroom of students as a monolithic whole and negates how diversity influences his teaching and ability to create a classroom environment and curriculum that accounts for diversity; second, we have the middle school teacher who desires to make science engaging to her students, but she is unable to connect science and her students in relevant ways; third, we see an elementary teacher who finds it difficult to teach science due to pressures of accountability and thus emphasizes mathematics and literacy; and fourth, we have a university faculty member who nominates the only faculty member of color in his program to teach all preservice teachers about equity and diversity.

Within the vignette and the experiences of the four teachers, there is a fundamental equity and diversity issue that is shared among them: *whose responsibility is it to address equity and diversity?* How do we address it in science and within our particular contexts, and with our particular student populations? What supports must be present to allow us to promote equity and diversity in our teaching, learning, and curriculum? What supports are present in the *NGSS* to assist all teachers to teach in culturally responsive ways so that teachers meet the educational science needs of all students? Our position and the ways in which we address these questions center on implementation of the *NGSS* with equity and diversity as theoretical and pedagogical

foundations to science teaching. In this way, equity and diversity becomes a vision and goal for implementation.

(In)equity in Science Education and Achievement

As we know, our schools are becoming more culturally, economically, and linguistically diverse, with achievement in education and science as primary areas for continued concern regarding equity and diversity. For example, between 1980 and 2008, the racial/ethnic composition of the United States shifted—the White population declined from 80 percent of the total population to 66 percent; the Hispanic population increased from 6 percent of the total to 15 percent; the Black population remained at about 12 percent; and the Asian/Pacific Islander population increased from less than 2 percent of the total population to 4 percent. In 2008, American Indians/Alaska Natives made up about 1 percent, and people of two or more races made up about 1 percent of the population (Aud, Fox, & KewalRamani, 2010). Furthermore, 48 percent of public school 4th-graders were eligible for free or reduced price lunches in 2009, including 77 percent of Hispanic, 74 percent of Black, 68 percent of American Indian/Alaska Native, 34 percent of Asian/Pacific Islander, and 29 percent of White 4th-graders (Aud, Fox, & KewalRamani, 2010).

The review of science education literature reveals several macro categories associated with equity and diversity: gender, socioeconomic status (SES), race, ethnicity, and diversity (Baker, 2002; Buccheri, Gürber, & Brühwiler, 2011; Clewell & Campbell, 2002; Darling-Hammond, 2007; Dentith, 2008). These macro issues of equity and diversity should be considered as contextual, mitigating factors that contribute science learning opportunities, resources in schools, and time to develop meaningful science education experiences, thus influencing achievement and future career opportunities for students of color in science (Kohlhaas, Lin, & Chu, 2010).

Considering these trends, what can be done to reduce inequities in science education throughout the schooling experiences from early childhood to college and beyond for cultural groups? Studies have suggested that closing the equity gap in science education can begin in teacher education since preservice teachers' experiences with equity and diversity issues stem from their own experiences and limited opportunities for equity education (Ferreira & Patterson, 2010; Mensah, 2009). In addition, curriculum has limited and/or marginalized students from cultural groups, thus additions to curriculum should include their experiences, worldviews, learning styles, funds of knowledge, and/or interests, which may also help to reduce the equity gap (Carlone, Haun-Frank, & Webb, 2011).

Moreover, equity is not a singular moment in time, nor is it an individual endeavor. It takes an educational system and groups of individuals in this system. This includes the school administration and community, school partners, community agencies and families as well as curriculum developers and professional development facilitators to work toward, promote, and maintain a focus on equity. We have to make obvious as many contextually mitigating factors as possible during implementation of the *NGSS*. We assert that by identifying and addressing contextually mitigating factors for our particular context and students, we can begin to address equity issues, but we must also do this in a theoretically and pedagogically sound way.

Theoretical and Pedagogical Approach to Equity Implementation of the *NGSS*: A Roadmap

How can we build or offer a conceptual roadmap for equity via a systems approach that will guide the implementation process of the *NGSS*? A first step is to unearth the complex and critical contexts in which teachers and students live. This means that we have to gain a deeper understanding of our individual contexts. Each state and district, school and classroom differs ideologically because all individuals within the system interact with life in distinctive ways based upon personal and collective experiences, and still find ways of appropriating science in our particular contexts. Therefore, flexible and empowering policies must be in place to allow for creative and transformative approaches to implementation that considers the multiple, mitigating factors while making diversity and equity a goal and practice in our schools (Mensah, 2010). Thus, we ask educational stakeholders to take risks in how they implement the standards with equity and diversity goals firmly in mind, realizing implementation is contextualized.

We offer below some key points (among many more that we can propose) for inclusion and movement toward equity and diversity during implementation of the *NGSS*. These points are theoretically and pedagogically grounded in the literature on culturally responsive teaching (Gay, 2010). Furthermore, we offer an additional resource from the science education research and practice. But first, Gay (2009) explains that culturally responsive teaching is both routine and radical:

> …routine because it does for Native American, Latino, Asian American, African American, and low-income students what traditional instructional ideologies and actions do for middle-class European Americans. That is, it filters curriculum content and teaching strategies through their cultural frames of reference to make the content more personally meaningful and easier to master. …radical because it makes explicit the previously implicit role of culture in teaching and learning, and it insists that educational institutions accept the legitimacy and viability of ethnic group cultures in improving learning outcomes. (pp. 24-25)

From Gay's framing of culturally responsive teaching, we offer three points for building a roadmap during implementation of the *NGSS* with equity and diversity as a goal. In addition, these points may address the needs of the four teachers in the opening vignette:

- Recognize and value the multiple cultures, experiences, ways of knowing, and diverse languages that are represented by students in the science classroom; for example, in a two-year professional development program, teachers were able to identify cultural intersection points by matching science concepts to Native American cultural practices (Grimberg & Gummer, 2013).

- Take time to learn about the various interests and experiences that students have out-side-of school that can be brought into school science learning; for example, researchers explore how a school-day science and nutrition curriculum, *Choice, Control and Change (C3) Curriculum*, shaped student thinking, decision-making, and actions outside the science classroom and engaged students in activities focused on analyzing and changing

their personal health choices (Mallya, Mensah, Contento, Koch, & Calabrese Barton, 2012).

- Create a strong, supportive, and caring sense of community among many members of an educational system, including the preparation of teachers and faculty members, scientists and science educators, along with professional developers and curriculum writers to support not only science learning but also learning to teach in equitable and culturally responsive ways; for example, two science educators investigate two beginning secondary science teachers' efforts to learn to teach science in ways that build from and celebrate the ethnic, gender, linguistic, and academic diversity of their students (Bianchini, & Cavazos, 2007).

Standards by nature imply similarity and familiarity, but when standards are brought to the implementation level, they are heavily influenced by the contexts in which they reside. For example, how is a science teacher to capture and utilize the full range of language experiences in California, a state that mandates English only? Should students in Hawaii learn about the traditional four seasons in the same way students in North Carolina do, or how might urban high school students in Chicago find relevancy in learning about farming practices in Idaho or on an Indian reservation? It is critical to understand that within systems, there is no isolation from the context, though we often view context as the invisible elephant in the room. When context is not addressed explicitly, equity issues are overlooked, and conversations about diversity in the science curriculum become only necessary for the poor, or students of color, or bilingual students. Issues of equity and context must be integrated in a wider systemic approach for the implementation of the *NGSS* to be deemed useful. We have to allow for boundary crossing and interdisciplinary connections into domains that make context and students from lower socioeconomic backgrounds, girls, students of cultural and linguistic diversity, and students in urban, suburban, and rural areas want to engage in science and see themselves in science. We believe that a culturally responsive approach to the implementation of the *NGSS* will achieve this goal.

Then, we must always be cognizant of macro and micro level influences during enactment of the *NGSS*. The *NGSS* can either become a source of inspiration or a law of regulation, leaving us in a condition far worse than we were previously. Perhaps one way of looking at the *NGSS* and its implementation is to address the potential for meaningful interpretation as opposed to blind obedience. As long as there is wiggle room for states, school districts, schools, science teachers, and students to go beyond the minimum, we may indeed capture the spirit of standards aimed at improving teaching and learning for all students (Gallard & Gonzalez, 2013).

Conclusion

If we do not have a concrete vision, framework, or roadmap of how equity and diversity can be addressed theoretically and pedagogically to inform the implementation of the *NGSS*, then we continue to spend our time, as our children matriculate in the educational system, without making any significant educational progress in science achievement and inequities. Therefore, the four educators in the opening vignette need support and assistance to make equity and diversity an active part of their teaching. It is not the sole responsibility of teachers and faculty

of color; it is a concerted effort of the whole educational system, to work toward a shared vision for science learning for all students. So, simple implementation of the *NGSS* will not be sufficient or effective. Merely translating the *NGSS* into science curriculum, professional development, or teacher preparation programs, without explicit attention to equity will result in maintaining existing inequities and will not move us toward decreasing the science equity gap. Consequently, for the many states and school districts who will implement the *NGSS*, we encourage them to develop a working framework for equity—a roadmap that considers the variable, contextual, mitigating factors for their particular districts, goals, teachers, and students. This means utilizing cultural, material, and social resources to build a strong science program (Rivera Maulucci, 2010), and employing a culturally responsive approach to teaching and curriculum (Gay, 2010). Thus, unwavering support with institutions of higher education, community resources, and deeper relationships with families are highly encouraged. A critical first step in implementation is to create a shared vision of equity for all.

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Additional Resources

This list of additional resources introduces activities that are developed within a culturally responsive or multicultural framework.

Atwater, M. M. (2010). Multicultural science education and curriculum materials. *Science Activities*, *47*(4), 103-108.

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