ORIGINAL PAPER

Expanding and enacting transformative meanings of equity, diversity and social justice in science education

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Abstract

In this paper, we provide a conceptual critique of the various constructs often used to justify policies and/or research to promote equity, diversity and social justice in science education. As research expands in these areas, we seek to provide some clarity to support researchers in deepening their work toward transformative goals in science teaching and learning. First, we explore the ways in which researches often argue *why* equity, diversity or social justice should be addressed, detailing arguments for economic superiority, morality and sociotransformative action. Next, we outline *how* researchers have argued that equity, diversity and social justice should be addressed including approaches such as equal distribution, mandated policy and sociotransformative education. We conclude with some examples of recent research that bring into practice the lesser known of these, the sociotransformative approach, arguing that this approach provides the field of science education research with a more promising way to create sustainable change. The sociotransformative approach is centered on improving the lived experiences of historically marginalized youth and encourages researchers to focus on reporting research as *narratives of engagement.* That is, a more representative and balanced analysis of the challenges and successes of teaching and learning in culturally diverse schools and of the responsive (and responsible) role researchers can (and should) play in helping bring about positive social change. This paper helps situate the other articles in this special issue in the larger conversations on equity, diversity and social justice occurring within the field of science education.

Keywords Equity · Social justice · Sociotransformative constructivism · Critical · Cross-cultural education

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Resumen

En este artículo, ofrecemos una crítica conceptual de los diversos constructos utilizados a menudo para justificar políticas y / o investigación para promover la equidad, la diversidad y la justicia social en la educación científica. A medida que la investigación se expande en estas áreas, buscamos proporcionar cierta claridad para apoyar a los investigadores a profundizar su trabajo hacia objetivos transformadores en la enseñanza y el aprendizaje de las ciencias. Primero, exploramos las formas en que los investigadores a menudo discuten *por qué* deben abordarse la equidad, la diversidad o la justicia social, detallando sus argumentos para la superioridad económica, la moralidad o la acción sociotransformativa. A continuación, describimos *cómo* los investigadores han argumentado que se deben abordar la equidad, la diversidad y la justicia social, incluyendo enfoques como la distribución equitativa, las políticas obligatorias y la educación sociotransformativa. Concluimos con algunos ejemplos de investigaciones recientes que ponen en práctica el enfoque menos conocido, el enfoque sociotransformativo--argumentando que este enfoque proporciona al campo de la investigación en educación científica una forma más prometedora de crear un cambio sostenible. El enfoque sociotransformativo se centra en la mejora de las experiencias vividas de los jóvenes históricamente marginados y alienta a los investigadores a centrar sus reportes científicos en unas *narrativas de activismo*. Es decir, un análisis más representativo y equilibrado de los desafíos y éxitos de la enseñanza y el aprendizaje en escuelas culturalmente diversas y del papel receptivo (y responsable) que los investigadores pueden (y deben) desempeñar para ayudar a lograr un cambio social positivo. Este documento ayuda a situar los otros artículos en este número especial en las conversaciones más amplias sobre equidad, diversidad y justicia social que se producen en el campo de la educación científica.

Diversity, equity and social justice are constructs that have increasingly gained more attention in the USA since the advent of the civil rights movement in the mid-50's. More recently, however, the transformative meanings of these constructs seem to be taken for granted in educational research. In this manuscript, we argue that it is essential for researchers, teacher educators and policy makers to more explicitly define (and adhere to) their ideological and conceptual positionalities in regard to diversity, equity and social justice throughout their work. This is particularly crucial during this current and contradictory climate in which a neoliberal agenda continues to undermine whatever gains the civil rights movement and educational research have made in the last six decades.

Motivated by similar concerns, in the late 90's, Sharon Gewirtz (1998) sought to "map the territory" of what education policy researchers meant by "social justice" using a postmodern lens. She offered a set of questions to assist in creating a broader conceptualization of social justice that moves beyond just the redistribution of material goods or opportunities to a better understanding of relational justice (i.e., unpacking the role of oppressive relationships between those in power and the marginalized within and outside school; unpacking cultural imperialism; and nurturing mutual respect and collaboration). Building on Gewirtz's (1998) work, Connie North (2008) offered a postmodern analysis of "the complex, frequently contradictory, and relational aspects of social justice theories" (p. 528). North's main goal was to bring attention to the (unavoidable) tensions emerging from the messiness of striving for social justice across so many different groups and levels. She suggested that our understanding of social justice must move beyond notions of this construct as having arrived at some fixed end point in artificial binaries, such as macro (institutional/social) versus micro (individual/

interpersonal) levels; redistribution (of material goods/opportunities) versus official recognition/respect; or sameness (e.g., melting pot) versus difference (e.g., embracing/diversity/tapestry of cultures). Instead, we should work for social justice with the understanding that this construct cannot be tamed into a one fits-all neat definition or political slogan. Meanings and operationalizations of social justice are constantly evolving and shifting in the same proportion as cultural groups act on their emerging sense of agency.

These authors' arguments are thought provoking, but how have these interpretations of social justice been understood and operationalized in the context of science education? Maria Rivera Maulucci (2012) was the first to tackle this question by conducting a review of the science education literature from 1981 to 2008. She found that although the use of the term "social justice" had increased over the years, out of 106 identified articles, only very few (13) use the term substantially throughout the manuscripts. Rivera Maulucci (2012) provided a useful analysis of the theoretical underpinnings and actual (or suggested) operationalizations of social justice shared by the authors of the 13 manuscripts she reviewed in more depth, and we agree with her conclusion, that social justice should be more clearly defined and adhered to throughout the research enterprise. We also concur that we (researchers, educators and policy makers) should strive to make better distinctions among what we mean by equity, diversity and social justice in our work.

This latter concern is also an important issue to address in this manuscript because we (like many other researchers and including the aforementioned reviews) often omit to clearly differentiate and define what we mean by equity, diversity and social justice in our writing. In fact, researchers have often used these terms interchangeably, and—in our case—sometimes used them interchangeably only for literary reasons (e.g., to avoid being redundant). For the first author—who is Latino, male, an immigrant and English Language Learner, historically from low SES background, and a scholar of color, and who often experiences discrimination by virtue of all of the above—equity, diversity and social justice are more than "constructs" to be researched in relation to the Other. They are interlinked elements of his everyday life as a visible Other. In contrast, the second author—who is Caucasian, female, an immigrant and multi-lingual but English dominant, historically from low SES background, and a white scholar, and who often does not experience discrimination as a result of this positionality—came to work in equity, diversity and social justice through her experiences as a scientist and teacher. In particular, she observed students, peers, families and communities of color being Othered in a multitude of harmful ways and felt responsible in her own positionality to work with scientists and teachers to disrupt these everyday practices.

Therefore, for us, to address issues of equity and diversity is to simultaneously address issues of social justice in and out of our professional working contexts. However, we recognize the importance for all of us to expose our ideological and conceptual positionings more directly if we are to make more consistent and substantial progress in the advancement of social justice through (science) education. In addition, and to build on the previously discussed reviews, we argue that in order to expand and enact more transformative meanings of equity, diversity and social justice, we should deconstruct the broad arguments commonly used (or implied) in the literature to support why and how these constructs are important.

In this next section, we provide a brief discussion of the theoretical framing guiding our work, as well as how we define the aforementioned main constructs. This is followed by an analysis of the broad and most dominant arguments used to support why equity, diversity and/or social justice should be pursued in educational contexts, followed by a discussion

of the broad and most prominent arguments used to explain how to implement these constructs. Finally, we offer highlights from various studies that show promise in having significant impact on pre- and in-service teachers' practice, as well as on students' understandings and enactment of equity, diversity and social justice in their own social contexts. We close with some recommendations for further research.

Theoretical framing

We draw from Stephen May and Christine Sleeter's (2010) notion of critical multiculturalism to guide our thinking in this essay. They propose that

> As with antiracist education and critical theory, rather than prioritizing culture, critical multiculturalism gives priority to structural analysis of unequal power relationships, analyzing the role of institutionalized inequities, *including but not necessarily limited* to racism (p. 10, emphasis theirs).

We agree with their critique of predominant notions of multiculturalism (AKA liberal multiculturalism or multicultural education) as these notions have focused so much on discourses of "equality," "cultural acceptance/tolerance," "inclusion" or "cultural recognition," and it has failed to yield systemic, long-lasting institutional and social change. The reasons for this failure are abundant and visible on the daily news as we are horrified by the increasing incidence of hate-based violence across the country and around the world. However, a critique of liberal multicultural education is not the focus of this essay, but—in the spirit of calling for more ideological and conceptual clarity in our research work as it is our goal here—we wish to distance ourselves from the use of the term multicultural education or multiculturalism of any kind. We prefer to use the term *critical cross-cultural education* because it zooms in attention on the importance of teaching and learning about power dynamics across cultural groups and how power is at the core of effecting social change.

We also wish to disclose that we have often used the construct of multicultural education throughout our teaching and research in previous publications for the same reasons that we have viewed diversity, equity and social justice as inseparable and sometimes indistinguishable terms as explained above. Just like a tricycle cannot run properly with a missing wheel, and by default it is no longer a tricycle, given our historical, academic and social locations, the confluence of these constructs has always made good sense to us and inspired our work. However, given the dominant and narrow interpretation and use of multiculturalism, we have recently begun to use critical cross-cultural education instead. We are concerned that as the neoliberal agenda continues to stir confusion by appropriating (liberal) multiculturalism as just another commodity that will translate into profit, it is essential to use more specific terms in order to shift the conversation back to the roots of oppression, institutionalized racism, neocolonialism and power dynamics.

With this framing and disclosures in mind, and without attempting to essentialize, we use Alberto Rodriguez's (2016) definitions of equity, diversity and social justice below as contrasting markers to help guide this critique:

> *Diversity* involves the recognition of the visible and invisible physical and social characteristics that make an individual or group of individuals different from one another, and by doing so, celebrating that difference as a source of strength for the community at large (p. 242).

Equity refers to the enactment of specific policies and practices that ensure equitable access and opportunities for success for everyone. It is important to differentiate equity from equality…in order to be equitable, we cannot treat everyone the same. To be equitable, we must treat individuals according to their needs and provide multiple opportunities for success (p. 243).

Social Justice is defined as the conceptual framework guiding the enactment of specific policies and practices to promote diversity and equity. It is important to note that we might be able to observe the presence of diversity and/or equity in any given context without the presence of social justice, but it is not possible to have social justice without the presence of diversity and equity (p. 243).

At the core of appreciating these interpretations of equity, diversity and social justice is coming to terms with how the terms "diversity" and "equality" have been appropriated and diluted by the neoliberal agenda. For example, for some corporations, universities and researchers seeking funding and productivity, "diversity" is more like a commodity that could ensure increased revenue and/or more chances for "different" kinds of individuals to "tolerate" each other, and thus increase productivity and reduce potential conflicts. Similarly, equality is often (mis)used interchangeably with equity to mean "fairness" or "equal treatment," and by doing so conveniently avoiding the need (responsibility) of addressing a long history of oppression and discrimination that continues to leave the disadvantaged behind. This kind of thinking is as disastrous as thinking that giving everyone the same swimming suit is all that is needed for everyone to enter and be successful in a mile-long swimming competition.

In the current educational and political climate, therefore, diversity and/or equity may be mandated, monitored and even rewarded or censured for abiding/breaching policies, but this only reflects superficial understanding of these constructs. We argue that working toward and enacting social justice involves "the deep understanding and presence of mind that enables an individual to internalize social justice as everyday practice—as something we must do because it is the right ideological and epistemological thing to do to enable our community to flourish" (Rodriguez 2016, p. 243).

We suggest that in order to expand and enact transformative meanings of equity, diversity and social justice, we should reflect on the arguments we use to articulate why and how these constructs are important elements of our research and practice, as well as how congruent our espoused beliefs match our beliefs in action. We turn our attention next to this issue and offer some reflection questions (in italics) to generate discussion.

What are some of the most commonly used arguments used to explain <u>why</u> diversity, equity and social justice should be addressed in education research, policy and practice?

1. The "Impending Doom and Gloom" or Economic Superiority argument

According to some education reformers and politicians, the USA appears to be constantly at the edge of an education and economic abyss. The "Impending Doom and Gloom" argument demands that the USA must maintain its economic and political superiority in the world, and it arguably started when the former Soviet Union successfully launched Sputnik into orbit in 1957. Since then, the USA has been caught in a perpetual education reform loop driven mainly by fearmongering, political opportunism and slogans,

but rarely informed by sound educational research. For example, a year after Sputnik, the US Congress passed what could be considered the first major wave of STEM education reform, the *National Defense Education Act* (1958). This new act sought to provide all sorts of incentives to increase the number of skilled engineers and scientists (reminiscent of the Obama's Administration's $4 billion Race for the Top Program in 2012). While space constraints do not permit a historical review here, another relevant example is former President Reagan's National Commission on Excellence in Education, which produced the aptly alarming titled *A Nation At Risk Report* (Gardner 1983). In this report, the Commissioners warned that unless tougher and more science and math courses were required in US schools, the country would be swept by a "the rising tide of mediocrity" (p. 11).

While there is no denying that some progress was made in STEM education as result of the funding allocated for these reform efforts, overall these programs were not focused on addressing equity, diversity and social justice issues, nor were they guided by relevant and available educational research. Consequently, the achievement and participation gap of historically underrepresented students (women and culturally diverse students) simply broadened and persisted through one reform to another. This became so much a social and political issue that then President Bill Clinton made it a campaign promise to eliminate the achievement gap between Anglo and culturally diverse students, and to raise US students' achievement to the number one spot on international testing by the year 2000 (U.S. Deparment of Education 2000; The White House 2001). We all know that these efforts met the same fate as that of President George W. Bush's No Child Left Behind Education Act (NCLB, The White House 2001), and that the student achievement and participation gap in STEM-related courses and careers continues to be an area of concern. In addition, US students' overall low performance on international assessments does not bear well on the efficacy of the **economic superiority** argument for bringing about change (Zhao 2009).

More recently, and what can be called the second largest wave of STEM education reform, is represented in the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC 2012) and in the Next Generation Science Standards (Achieve 2013). Unlike previous major science education reform efforts that tended to shroud ethnic diversity and educational inequities in a discourse of invisibility (Rodriguez, 1997), for the very first time, the *Framework* and NGSS standards documents make equity, diversity and social justice issues more visible (Rodriguez 2015a). For instance, the former has a chapter focused on equity and diversity (Chapter 11), and the latter has various appendixes making recommendations for working with second language learners, as well as addressing gender, equity and diversity issues. Even though the *Framework* document lists several ways in which equity is defined in the literature, a close read of the overall document and the NGSS illuminates the presence of the economic superiority argument:

> Equity as an expression of socially enlightened self-interest is reflected in calls to invest in the science and engineering education of underrepresented groups *simply because American labor needs can no longer be met by recruiting among the traditional populations* (emphasis ours, NRC 2012, p. 278).

We argue instead that we should be enhancing the broad education of K-12 students so that they could become critically engaged and informed citizens. In addition, standards frameworks such as this that are not accompanied by specific policies to ensure equitable funding for all schools, leads us to ask: Whose interests are really being served by this new wave of STEM education reform? Who will again be left behind during the implementation of such reform efforts?

The observations shared thus far show that the economic superiority argument seems to mainly benefit politicians and corporations. Furthermore, this approach has had little to no significant effect in undoing the root causes of school inequities. Therefore, if this argument is chosen to support equity, diversity and social justice concerns, we should reflect about the extent to which we might inadvertently contribute to perpetuating this narrative by not linking project findings back to issues of equity, diversity and social justice. All too often, when we review research grant proposals or journal manuscripts, some authors provide truncated narratives by which the urgency of the study or grant proposal is fueled by the economic superiority argument, but then the findings and conclusions are divorced from the arguments that instigated the study. Therefore, if this is the (or one of the) arguments we choose, we should be able to answer the question: *How exactly our work has tackled equity, diversity and social justice issues, as well as show what evidence we have gathered to produce transformative change?*

2.   The moral argument

Another commonly used argument in support of establishing equity, diversity and social justice in our schools is the moral argument. Essentially, this approach appeals to our collective sense of responsibility for the welfare of all members of society. In the USA, this construct is at the core of the country's democratic identity and entrenched in one of its most honored documents—the Declaration of Independence: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness" (Congress 1776). However, we know that since this declaration in 1776, the enactment of these moral tenets in US schools and society at large continues to be a work in progress.

In that vein, Gloria Ladson-Billings (2006) eloquently urged us to pay more attention to the moral argument during her presidential address at the Annual Meeting of the American Educational Research Association. Essentially, she proposed that instead of focusing so much on "the achievement gap" and on how marginalized students are falling behind, or on threads to the US economic superiority as mentioned above, we should be talking about the "educational debt" owed to all those groups of individuals who have been historically marginalized, and thus prevented from fully accessing their aforementioned unalienable rights of life, liberty and the pursuit of happiness. She adds,

> So we must address the educational debt because it has implications for the kinds of lives we can live and the kind of education the society can expect for most of its children (p. 9)

If we choose then to use the moral argument to support our desire to ameliorate pervasive inequalities, we need to ask such questions as: *In what ways exactly is our work helping reduce the educational debt we owe to historically marginalized students? What accommodations are we making to provide more equitable opportunities for access and success of all students participating in our research projects and what evidence can we provide from the participants' perspective that their needs are being met?*

3.   The demographic shift argument

 Citing the dramatic demographic changes of ethnic groups in the USA, as well as the need to respond to the increasing language and cultural needs of the student population, has

become two of the most popular clichés in educational research. Many scholars (including the authors of this manuscript) have not been able to escape the inexorable allure of using charts and percentages to draw attention to this important issue. Nevertheless, the use of the demographic shift argument is significantly weakened when all researchers do is highlight these demographic changes and then shift into the economic superiority argument described above. It is now well established that all demographic predictions were right on target since the US Government appropriated the ill-conceived term "Hispanic" (meaning of Spain or Spanish speaking students) to monitor the educational achievement of Latin@s in 1978 (Rodriguez 2014). We know that Latin@s are now the second largest ethnic group in the USA (57 million), that this population will likely double by 2060, and that one in three residents of the USA will be Latin@ by then (US Census 2012). Since the US Census Bureau and National Center for Education Statistics releases comprehensive annual reports on demographics and educational attainment trends (Condition of Education Reports), we have known for decades that the student demographics are changing and in which direction, and we know that these patterns demand changes in funding and professional development support for teachers to meet their students' language, cognitive and cultural needs—and we know that these needs are not being met.

Therefore, if we choose to use the demographic shift argument in our research efforts to address equity, diversity and social justice issues, we need to ask: *In what way is our research really addressing what we already know well? What evidence can we provide to show that our study is contributing to better understanding the dynamics of a changing student population when the teacher workforce remains mainly Anglo?* If we think it is important to use the demographic shift argument, *should not we then also disclose our own ethnic and gender locations as researchers/educators*? *From a critical sociocultural perspective that considers power in the educational system, should our own positioning not matter when conducting research in culturally diverse contexts? Whose research work are we using to guide our work in culturally diverse contexts (i.e., do we also seek and cite research from underrepresented scholars)?*

4.   The sociotransformative argument

 While solely focusing on any of the above arguments might distract readers with a great deal of "gap gazing" or with alarming prophecies of impending doom of the US economic superiority sliding down a dark abyss (Rodriguez 2001), the sociotransformative argument provides a more tempered yet challenging path. It is more challenging because it requires researchers/educators to better connect their espoused beliefs (ideological and conceptual framings) with their beliefs in action. In other words, making the argument for why equity, diversity and social justice are important to address is inseparably tied to how these issues are collaboratively tackled in a given context through mutually beneficial relationships between researchers and participants (Bang, Faber, Gurneau, Marin and Soto 2016; Tolbert, Schindel and Rodriguez 2018). Thus, the aim is to produce social and/or personal transformative change as measured by what Lather (1991) calls *catalytic validity* or the degree by which the research enterprise yields significant and positive benefits to the participants from their point of view.

The sociotransformative argument is explained in more detail below as the *why* and *how* conceptualizations of this approach make better sense when considered together in order to truly meet its sociotransformative goals. However, some questions to ponder then when seeking to use this approach to address equity, diversity and social justice issues

are: *In what substantial ways are the voices (expressed interests and needs) of the partici-pants considered when designing and implementing a study? In what substantial ways do researchers make their voices explicit to the participants? In what ways are researchers documenting and sharing with participants (and readers) the successes—as well as the challenges—encountered during the study? In other words, are researchers sharing cheery narratives (only what works well), narratives of despair (deficit narratives or only what is not working, or blaming others) or narratives of engagement (honest accounts of successes and challenges encountered, as well as the strategies used to manage them)* (Rodriguez 2015b)?

What are some of the most commonly used arguments used to explain how equity, diversity and/or social justice should be addressed in education research, policy and practice?

In general, the research literature tends to focus on three broad approaches for how to address equity, diversity and/or social justice:

1. The equal distribution approach

This is the most widely used argument perhaps due to its legal and historical roots. Since the US Supreme Court's decisions, Brown vs. the Board of Education (1954), which pro-hibited school segregation by skin color, and the Lau vs. Nichols (1974), which mandated schools to provide language support to limited English proficiency students, the construct of *equality* or equal treatment and equal access to education has dominated how govern-ment, policy makers, researchers and educators conceive equity, diversity and social jus-tice issues. However, offering to treat marginalized groups equally or fairly in their present contexts is not enough without paying attention to those individuals' histories of strug-gle within complex webs of oppression. Neither it is enough to offer equal treatment to marginalized students without paying attention to the multiplying inequalities that have obstructed (and will likely continue to obstruct) their presumed equal rights to pursue their dreams and career goals.

Almost three decades ago today—and over three decades after the first aforementioned 1954 Supreme Court decision, Jennie Oakes (1990) found that marginalized students' social differences, such as socioeconomic status, ethnicity and skin color, were quantifi-ably tied to unequal access to educational opportunities. Furthermore, she articulated that these inequalities had a multiplying and detrimental effect on marginalized students. She explains:

> In addition to attending schools with less extensive and less rigorous science and mathematics programs, less qualified teachers, fewer resources, and less-engaging classroom environments, low-income and minority students often find themselves in low- track classes that focus on "general" mathematics and science content and pro-vide less access to the topics and curricular objectives that could prepare them for successful participation in academic courses in these subjects. They, more than other students, learn in classrooms where instructional activities appear to be directed toward control rather than educative purposes (p. 104).

Although Oakes' study did not focus directly on how the multiplying effects of unequal educational opportunities impacted marginalized students' academic achievement, others have re-affirmed her assertions and showed the strong negative impact of social inequalities on students' achievement through extensive meta-analyses of achievement data broken down by various social factors (i.e., gender, ethnicity, SES and English language proficiency) [for a discussion, see Rodriguez (2004) or the Journal of Research in Science Teaching Special Issue on Multicultural Education, Equity and Social Justice, edited by Mary Atwater (2011)]. The bottom line is that we have gathered a great deal of knowledge on the sociocultural, institutional and historical factors that influence teaching and learning in today's schools for almost 60 years. However, what we know from this research base continues to be used in such fragmented and uncoordinated ways that it yields no long-lasting and transformative change. It should be obvious by now that passing laws, policies or even providing some schools with equal distribution of material goods (e.g., computers, laboratory equipment, books, safe and well-maintained buildings, and other resources) is helpful, but not enough when these changes are not systematically implemented, sustained and in tandem with conceptual and ideological changes of the teaching and administrative staff. The equal distribution Approach—which has been mainly appropriated by a neoliberal agenda and that is deeply rooted in legalized framings of "equality" instead of equity—will continue to fuel instinctual notions that recognizing and treating everyone the "same" (equality) is all that is needed to right (erase) past wrongs. This approach has not produced, and will not produce, the advertised well-intended results. Using Band-Aids (fragmented approaches) and good wishes (political slogans) to repair deep social and historical wounds in the diverse cultural body of US society will not allow those wounds to heal and will only increase the pain and frustration that so many already feel.

For those interested in using the equal distribution Approach to support their vision of how equity, diversity and social justice should be addressed, the following questions should be considered: *If researchers are following a quasi-experimental design, in what ways is the equal distribution argument congruent with this methodology when it* de facto *requires that groups of participants (the control groups) be denied access to the presumed benefits of the intervention for comparison purposes? In what ways are researchers/educators providing equitable instead of equal access to resources in order to more accurately assess the impact of the research enterprise? For example, providing equal access to iPads for students to carry out inquiry-based projects while ignoring the needs of English language learners or the fact that some students may have limited to no access to laptops at home will disadvantage these students and skew the results of the study. What strategies are researchers putting in place—in advance—to manage and document progress on these issues? How is progress made as a result of the research intervention going to be sustained after the project's funding ends?*

The latter question has been a continuing source of frustration for both authors. For instance, we have managed to secure funding to acquire thousands of dollars for high-end learning technologies (e.g., Vernier probes, laptops, web-based instructional programs, etc.), and we have provided extensive professional development to assist teachers turn their overcrowded and underfunded classrooms from technology deserts into high-end science and technology laboratories, only to be required by the university to return all laptops and equipment to the university after the grant ends because grants are awarded to universities (meaning they own all the equipment) and not to schools. This opp(reg)ressive policy (a policy that is simultaneously oppressive and regressive) has prompted us to provide teachers with grant writing support so that they can secure similar technologies and resources

before our research grant expires. Another opp(reg)ressive approach that undermines effective research and professional development efforts is when a new principal/school district administrator is hired (during or after the research funding period) and this individual institutes different policies that end up reversing or obstructing gains made in professional development and/or student achievement (for a detailed example, see Rodriguez 2010).

There is a strong research base from various fields of study that show that the equal distribution Approach, while intuitive and well intended, cannot be sustained. We must use what we have learned from 60 years of educational research to investigate how systemic, sustainable, conceptual and ideological changes could be harmoniously coordinated to truly tackle equity, diversity and social justice issues in the twenty-first century for twenty-first century students. Section "The sociotransformative approach" offers more food for thought regarding this concern.

2. The mandated policy approach

 In an effort to enforce compliance to federal non-discrimination and equal opportunity laws, the US Government has instituted a variety of mechanisms. For instance, universities receiving federal funding for research grants must document and demonstrate adherence to affirmative action efforts by submitting annual reports to the Equal Employment Opportunity Commission (EEOC). Unfortunately, the neoliberal interpretation of the construct of diversity seems prevalent in this context. That is, universities seem more concerned with having some kind of representation of women and underrepresented scholars in administrative and faculty positions to demonstrate that the institution is "inclusive" "or at least trying." The ubiquitous pattern of low representation of women and faculty of color across universities in the USA, especially in higher administration and STEM positions, is proof enough. This superficial and formulaic approach to "addressing diversity" ends up creating a revolving door for underrepresented scholars who often find themselves unsupported as the sole or one of the very few women or people of color in a department/college (Joseph, Haynes and Cobb 2016).

To be clear, we are not arguing against the importance of having laws and policies designed to promote and protect equity, diversity and social justice goals. We are stressing that laws and policies—and even monitoring and enforcement agencies like the EEOC—are not enough if systemic efforts are not simultaneously in place to also promote conceptual and ideological changes within institutions. Structural changes (like policies and compliance agencies) have been as effective as painting a rainbow on the Titanic, whereas a significant change in direction (a cultural change) would have been more effective. If structural changes are to have any significant effect, they need to be fueled by cultural changes. As an example of the negative impact of not conceptually and ideologically addressing issues of equity, diversity and social justice—even when federal laws and well-intended policies are in place—we can consider the aftermath of the University of Missouri's students' protests in 2015. These protests were triggered by an indifferent and insensitive university administration that failed to acknowledge and properly respond to marginalized students' concerns in the wake of racist attacks against the student government president, who was African–American. This protest lead to the university president and chancellor resigning from their positions; however, it is very important to highlight here that two years after these events, the University of Missouri still continues to experience the consequences of having empty policies without significant cultural changes at all levels: Enrollment of freshman students has fallen by 35%; not surprising student enrollment from all ethnic

backgrounds has dropped (42% for African–American and 21% for Anglo); due to the low decline in tuition and accompanying budget cuts, the university closed 7 dormitories; and cut close to 400 positions (including non-tenured faculty and by implementing freezing hires) (Hartocollis 2017).

We must keep in mind that the *Missouri Effect* could have occurred anywhere and with similar results when marginalized individuals, who have been caught in a suffocating web of oppression for far too long, simply just had enough and demand transformative action. Some readers might be thinking what do the arguments presented thus far have to do with science education or research? In that case, Bronfenbrenner's ecological framework (2005) should provide some guidance, as this framework describes a system-level approach for understanding human development. None of us exist in isolated disciplinary bubbles, nor in personal bubbles, free of influence from the ecology of factors impacting our working and social lives.

So, for those interested in using the mandated policy approach to stipulate how equity, diversity and social justice should be addressed might consider these questions: *In what ways do policies designed by institutions are supported by not only compliance mechanisms, but also by system-wide programs that focus on raising cultural awareness and promote ideological and conceptual changes? For example, if a university or a school district has policies in place to support equity, diversity and social justice goals, and a researcher/ educator cites these policies to reinforce her/his arguments, this approach would be incomplete without ascertaining first what programs are in place at that institution or school district to raise cultural awareness and understanding system wide.*

3. The sociotransformative approach

This is the activist argument, and it focuses on the process researcher(s) and participant(s) embark to collaboratively effect personal and/or social change (Rodriguez 1998). This approach could originate first from activist efforts in the community (e.g., the Black Lives Matter Movement; parents' concerns, etc.), or sometimes researchers/educators working together with community members to identify and tackle social justice issues (for an example, see Pouliot's paper this issue). The sociotransformative argument often involves the researcher/educator purposely acting as provocateur to instigate reflexivity and social action (Rodriguez 1998). Thus, some important aspects of this approach to highlight here are that equity, diversity and social justice issues are not assumed to be monolithic or immutable for all stakeholders, or that somehow the researchers/educators are omniscient and reached absolute ideological enlightenment. On the contrary, through the sociotransformative approach, researchers seek to learn with the participants and often use their subjectivities (historical, sociocultural and academic locations) to share relevant insights (Tolbert et al. 2018).

Another important aspect of the sociotransformative argument is that for it to be truly so, it must go beyond the passive presentation of arguments, or descriptions of enhanced states of awareness; the sociotransformative approach is expressed as an articulation of equity, diversity and social justice issues linked to concrete transformative action(s). The next section provides highlights from some studies that—from our perspective—use sociotransformative arguments for why and how equity, diversity and social justice issues should be addressed in science education research.

Examples of sociotransformative research

The examples of sociotransformative research in science education described below are a selection of the emerging work in this area and are provided to ground our shared understanding of what this work might look like. Some of the included researchers/practitioners may not explicitly define their interpretations or operationalizations of diversity, equity and/or social justice in the highlighted papers, or they might use these constructs interchangeably, and deeply embedded with one another (as we see these terms). In either case, again, we wish to stress that one of our goals is to encourage researchers/educators to be more explicit with the arguments (conceptual and ideological positions) they choose to guide their social justice work, and to reflect on how their espoused beliefs match their beliefs in action. We have chosen these specific studies as they exemplify innovative approaches for operationalizing equity, diversity and social justice in science education and highlight the kind of impact this work can have on teachers' professional growth and on students' learning.

Sociotransformative research on both teachers' and students' science learning is found in the work of multiple researchers. Aguilar-Valdez, López Leiva, Roberts-Harris, Torres-Velásquez, Lobo and Westby (2013) examined the multidimensionality of science learning experienced by Latin@ students and the subsequent responsibilities this placed on their teachers. They used a framing of Anzaldua (2002) to conceptualize Latin@ students as "living on the bridges" between their various communities and negotiating the spaces in between, referred to as *nepantla*. This work illustrates how teachers can act to facilitate learning opportunities for students with such multidimensional identities and how such culturally complex students are assets to science learning communities as they bring with them community bridging skills which many normatively positioned students may not have fully developed. This study saw the diversity of students' lived experiences as an asset and sought to develop teachers' capabilities to reorganize classroom structures—an act of equity—to expand opportunities for students to integrate their assets into classroom learning.

Tolbert, Snook, Knox and Udoinwang (2016) extend work in this area through their research on promoting youth empowerment and social change in science learning contexts. They engaged the framework explicated by Schindel Dimick (2012), which defined three categories of youth empowerment: academic, social and political. Within Tolbert et al's work, the academic youth empowerment activity was organized to "develop critical literacy skills, with a focus on using scientific knowledge and practices toward engaging with local and global science-related issues of justice" (p. 58) instead of on traditional science learning which emphasized factual learning. Within the social youth empowerment work of the classroom, the teachers emphasized that "changemaking requires collective problem solving, teamwork, and empathy" (p. 59) to increase productive collaborative behaviors among classroom participants. The political youth empowerment framing was used to help students identify injustices in the world and in their local communities that intersected science and society. One such project involved students in the identification of need, lobbying and eventual funding for a bridge to allow an easy pathway between a low-income neighborhood and the school. However, a remaining tension identified by this research team was the lack of identification of students as "science people" in this type of empowering and science learning context. These researchers are continuing to explore reasons for this finding and believe that it may be related to youth resistance given the participants historically marginalized role in science learning settings. This project integrated diversity, equity

and social justice into the classroom work through leveraging students' assets from their lived experiences, engaging in equitable classroom interactional structures and curricular choices, and engaging youth in using science to identify and solve real-world inequities.

An example of sociotransformative research with practicing teachers can be found in Tolbert, Calabrese Barton and Moll (2017)'s investigation of how teachers' perception of students is closely related to the choices they make to restructure power dynamics in science classrooms—an example of how equity intersects with both classroom pedagogy and curriculum. This study adds to the understanding of sociotransformative research in science education as it highlights the way in which the process of labeling, often a result of deficit thinking, can limit the pedagogical and curricular choices teachers make. In contrast, reflecting on such labeling and the implicit biases we hold can help educators restructure learning environments to be rich and productive spaces for historically marginalized youth.

Rodriguez (2015b) provides an example of sociotransformative research in an ethnographic study documenting the transition of a pre-service high school teacher from the last year of his teacher preparation through his first 2 years as a full-time teacher. In this project, Gary, who is an Anglo-male and former scientist, secured a job as a physics and astronomy teacher in a high school with over 90% Latin@ population. Although committed to making his classroom culturally and socially relevant to all students, Gary encountered a myriad of sociocultural, historical and institutional socializing forces in his new job that conspired against his efforts of making science relevant, enjoyable and transformative for his students. In response, the research team worked with Gary to assist him navigate through and challenge the obstacles blocking his path for becoming the effective teacher he wished to be. This example highlights the responsive and more active role researchers need to take when using a sociotransformative approach. Unlike other studies in which researchers often passively observe and document the struggles of the Other and then mostly report narratives of despair, or when researchers actively document only what worked well in their projects and mostly report cheery narratives, a sociotransformative approach requires researchers to report *narratives of engagement*—more representative and balanced analysis of the challenges and successes of teaching and learning in culturally diverse schools and of the responsive (and responsible) role researchers can (and should) play in helping bring about positive social change.

Even before teachers reach the classroom, there are ways they can be engaged in sociotransformative perspectives on science teaching and learning. Felicia Moore Mensah (2012) engaged elementary pre-service teachers in critical reflection work on their positional identity within urban classroom contexts. In this work, Mensah was able to show that explicitly uncovering prospective teachers' views of self relative to science, teaching science in urban settings and relationships with students in urban classrooms facilitated their ability to unpack power dynamics. Dynamics they had not considered prior to understanding their own positionality relative to the sociocultural, sociohistorical and sociopolitical dimensions of their students lived experiences. Thus, Mensah, like Tolbert et al., stress the need for teacher learning and reflection on their own positionality and the way in which their lived experiences interact with their students lived experiences within the practices of teaching and learning science—an engagement in both diversity and equity work.

Rivera Maulucci (2013) expands on this critical reflection work further by bringing in the aspect of caring and emotion. In this study, she describes the journey of a teacher candidate's struggles to address social justice issues in her teaching. She concluded "emotions and emotional labor are implicated in all phases of teaching for social justice" (p. 473) and

as such teachers need to be supported in engaging in the work of critical dissonance to expand their engagement in social justice-centered teaching.

Finally, Daniel Morales-Doyle (2017) offers a teacher-scholar perspective of justice-centered science pedagogy from his sociotransformative work with high school chemistry students. In his work as a teacher engaged in social justice, Morales-Doyle gained important insights. First, he found that to effectively identify social justice issues that intersected with local communities and science content, teachers need to be deeply rooted in the community in which they teach. Second, he found that engaging in these types of emergent learning opportunities could challenge teachers' knowledge of content and their understandings of the nature of science. Third, in order to engage community partners and students in the community-based science learning teachers may need to reorganize the way in which they construct learning opportunities and that this new form of learning is often in contrast to how teachers themselves were taught. Finally, Morales-Doyle argues that in order to increase teacher retention, teachers must deepen their experiences in context of the specific communities in which they work. This structural change in teacher professional development is critical to improving the quality of instruction and curriculum available to historically marginalized youth in science, particularly those in high needs school settings that often have high teacher turn over.

Conclusion and implications for further research

Our main goal has been to demonstrate a need to better conceptualize and operationalize the constructs of diversity, equity and social justice in science education research. We need to have conceptual and ideological clarity about which arguments we are using to inform the *why* and *how* diversity, equity and social justice are important in our work. We also need to be more explicit about the ways in which we are implementing and measuring the impact of our research. We can have equity and diversity mandated by policies and still no have social justice, but to really operationalize social justice we must have equity and diversity—meaning a deeper conceptual understanding and ideological repositioning.

There are several implications for further research. First, more studies are needed that explicitly name ways that diversity and equity are leveraged toward the goal of social justice. Such research needs to occur within classrooms, in teacher professional development work, in pre-service teacher development programs as well as in administrator learning experiences, in informal science learning settings, and in other spaces that can inform ways to decolonize science teaching and learning, and science itself. Second, there is a need to further theorize and synthesize this field of work to guide future research and practice. Finally, there is a need to expand and enact anti-oppressive and liberatory research methodologies in science education research (e.g., Bang et al. 2016; Harper 2010). We have learned a great deal from research conducted in science education in the last six decades. In order to expand our understandings of what it means to address issues of equity, diversity and social justice in twenty-first century schools, we are proposing that we must willing to redirect our gaze from traditional gap gazing (e.g., focusing on what's lacking) to gazing inward and focusing on the transformative role we can (and should) play to make our research efforts more responsive (and responsible) to the communities with which we work. This retrospective turn can begin by asking ourselves whose interests are really served by our research and then critically examining the congruency of our arguments and approaches with the impact of our work on the Other from their standpoint.

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