DOI: 10.1002/sce.21721

# RESEARCH ARTICLE



# Utilizing theory to elucidate the work of creating equity for transformation within the science classroom

Terrance Burgess<sup>1</sup> | Alexis Patterson Williams<sup>2</sup>

<sup>2</sup>School of Education, University of California, Davis, California, USA

#### Correspondence

Terrance Burgess, Department of Teacher Education, Michigan State University College of Education, 620 Farm Ln Room 325, East Lansing, MI 48824, USA.

Email: tburgess@msu.edu

#### Abstract

In this paper, we outline how science teachers might engage in the work of creating educational equity. While acknowledging the historical inherent inequities associated with issues of access, opportunities to engage in science learning for individuals of marginalized identities (e.g., BIPOC individuals and women), and achievement, we broaden this definition to include social justice as a framework by which we can develop opportunities for the fostering of students' affinity identities with science. To this end, we draw on theorizations of equity within educational research, specifically discussed as excellence, equality, fairness, a zero-sum game, and most recently, social justice. Additionally, we utilize McKinney de Royston and Nasir's (2017) Racialized Learning Ecologies framework. This framework provides a useful lens to notice the layers of (in)equity within education. We then extend this ecological model into science education and present three lenses (i.e., layers) through which equity operates within science teaching and learning. We conclude with a discussion of the practical implications of doing the work of equity, that is, recognizing, interpreting, and redressing inequity in science classrooms. Ultimately, we provide an

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2022 The Authors. Science Education published by Wiley Periodicals LLC.

<sup>&</sup>lt;sup>1</sup>Department of Teacher Education, Michigan State University College of Education, East Lansing, Michigan, USA

actionable definition of equity that has the potential to facilitate transformative and socially just science teaching and learning.

#### **KEYWORDS**

ecological framework, equity, justice, science teaching, theory

#### 1 | INTRODUCTION

We reside on the cusp of a pivotal moment in our educational history. The compounding effects of capitalism, coupled with the overuse of fossil fuels by industrialized nations have led to deleterious consequences for the physical Earth. This climate crisis is disproportionately impacting poorer countries, especially countries inhabited by people of color. Simultaneously, we are in the midst of a global health pandemic, the rapid spread of COVID-19, which is disproportionately ravishing historically marginalized communities and third-world countries. Science has been used to elucidate the causes of-and propose solutions to-these global crises, while politicians have politicized and weaponized science at the expense of communities of color and progress toward racial equity and justice. Thus, the foundations of our institutions have been shaken, requiring us to reckon with our past as we rebuild a future devoid of the cracks that would perpetuate these historical failures. Within classrooms, science teachers are uniquely positioned to establish a foundation vis-à-vis a transformative model of instruction, moving beyond traditional pedagogical models and strategies (Rahmawati & Taylor, 2015) to support critical thinking in students. Mezirow (1997) posits that transformative learning is a process where learners use discourse and critical reflection to make sense of and challenge their current experiences and assumptions while establishing additional frames for understanding those experiences and assumptions in new contexts. Taken together, transformative and just science instruction requires teachers to work to develop an equity orientation toward students, their community, and in their worldview.

The aim of this study is to outline how science teachers might engage in the work of creating educational equity. To support the ability to recognize how inequities manifest within formal and informal learning environments, we must acknowledge the sociocultural contextual factors which undergird the foundation of said institutions. Consequently, we utilize McKinney de Royston and Nasir's (2017) Racialized Learning Ecologies framework. This framework offers a lens for noticing layers of (in)equity by arguing that the very nature of learning itself is racialized, and science learning is no exception. Such examples abound science curricula, which frequently present foundational theories as "objective" without interrogating the harm inflicted to generate such findings (Donovan, 2016). Science policies intended to support all continue to center a few, due to the failure to explicitly name Western science's colonizing foundation. For example, in her 2000 work, Mary Atwater asked: "How can "science for all Americans" meet the needs of the many different Black Americans with distinctive histories in this country?" (p. 155). Her timely question retains its significance two decades later. Accordingly, we extend this ecological model into science education to identify the three layers by which equity operates within science teaching and learning. Specifically, we highlight ways teachers can notice for equity and commit to an ever-developing self-awareness (Patterson Williams et al., 2020). In the process, we emphasize the role of theory as a means for understanding and explaining the influences of equity—including when inequities are evidenced. Through this study, we leverage theory to provide an actionable definition of equity that has the potential to facilitate transformative and socially just science teaching and learning.

# 2 | THE EVOLUTION OF EQUITY

# 2.1 | Equity according to the literature

Throughout the study and development of the term in the field of education, "equity" has been discussed in a variety of ways: excellence (Secada, 1989), equality (Secada, 1989), fairness (Grant & Ladson-Billings, 1997), a zero-sum game (Blankstein & Noguera, 2016), and most recently, social justice (Secada, 2012). The topic of equity has been at the fore within current discussions about education—and yet the concerns about equity within our educational system have deep historical roots. For example, the Supreme court rulings of *Mendez v Westminster* (Santiago, 2016) and *Brown v Board of Education* (Secada, 1989) cases declared that segregated schools were not providing all students with the same quality of education.

More recent visions of equity as social justice align with its original definition outlined by ancient Egyptian civilizations, which was later taken up by Aristotle; it is also the one taken up in this paper. The notion of equity traces back to the fourth century, when Aristotle argued that equity was behavior measured not just by the set law but also by whether justice was achieved—equity "makes up for the defects in a community's written code of law" (Secada, 1989, p. 68). Secada (1989), building on Aristotle's notion of equity, argued that equity in an educational context "should be construed as a check on the justice of specific actions that are carried out within the educational arena and the arrangements that result from those actions" (p. 69). Thus, educational equity is both a goal to be attained and enjoyed within the classroom and a process created by the participants in a classroom. We argue that the process of creating equity is ongoing—one that requires both student and teacher engagement.

It is important to note the idea of justice as a governing principle of society pre-dates Aristotle to the Kemetic teachings of Maat, which is traced back to 2375 BCE (Browder, 1992; Martin, 2008). Among the governing principles of Maat is the notion of justice, defined as the operationalization of equity for all persons such that the necessities to sustain life are met. Consequently, this allows individuals to live in peace and to be active and meaningful contributors to their community, thus advancing the lives of all (Browder, 1992). This notion of equity and justice is the work of the individual and the collective, with societal leaders particularly responsible for working out the ideals of doing right and creating opportunities for dignity for all.

# 2.2 | Equity work

Centering equity within contemporary education requires incorporating it within teaching practices of instruction, management, and assessment. Maisha Winn offers a vision for teaching that simultaneously endorses students' humanity and supports intellectually stimulating curriculum as necessary for education to be just and equitable. Among Winn's (2018) pedagogical stances (i.e., History Matters, Race Matters, and Language Matters), her final stance, *Justice Matters*, aligns with these principles of equity and justice designed to create and imagine "a world where everyone—irrespective of race, ethnicity, socioeconomic status, gender, sexuality, or ability—is able to live with dignity and is recognized as belonging. This pedagogical stance is guided by a moral compass insisting we do right by people" (pp. 36–37). Winn (2018) centers students' experiences within school and thus identifies teachers as playing an integral role in doing right by the students for whom they serve. The Justice Matters stance asks teachers to "grapple with history and engage in what needs to be done so that all children and their families receive justice in the form of access to high-quality teaching and learning opportunities" (Winn, 2018, p. 37). We argue that grappling with the history of racial and linguistic inequality is imperative work among teachers interested in creating and sustaining educational equity within classrooms and school communities. This also supports the notion that equity deserves to be centered within science education.

Swadener's (1997) perspective on educational equity further elaborates on the "work" promoted by Winn (2018) and is consistent with the agendas we advance in this essay:

Justice and respect for individual and group rights, which actively promotes the view that all persons are equal, personally and socially, although living within a fundamentally unequal, stratified, and biased dominant culture. Thus, the pursuit of equity in education is a dynamic process that recognizes contextual realities (e.g. institutionalized racism and sexism) and barriers to the achievement of a truly just distribution of power and opportunity, and works constantly to name, address, and dismantle systems of oppression which keep inequality in place" (p. 103, emphases added).

Accordingly, equity work requires actively promoting all persons as equally entitled to the amenities of personhood, while acknowledging the contextual realities and barriers that foster inequities, and constantly working to name, address, and dismantle oppression. Legal scholar Angela P. Harris (1990) describes this process as education work—a process emblematic of both education and work. This study is educative, requiring teachers to move beyond a focus on content knowledge as the most important factor driving their pedagogical moves in the classroom. Instead, transformative, just, and equitable science classrooms are created by teachers who do the labor-intensive work that requires cultivating a critical consciousness (Shuster & Giesemann, 2021). More specifically, teachers understand the relationship between a child's multiple intersectional identities and its role in shaping their education (Crenshaw, 1989), reckon with their own positionality, and adopt an analytical approach to curricula, situating their students as agents of change. Thus, the work of creating equity requires science educators to notice the inequities that disenfranchise students to dismantle oppression such that they can thrive within science classrooms.

For us, this signifies the vital need to learn and appreciate the dynamics of self, community, and institutions—as prerequisites and ongoing referents for equity work. Applied to those who teach science and seek to advance equity, we encourage greater attention to the influences, power, and responsibilities accompanying the role of "science teacher." Science teachers working toward equity would benefit from developing deeper understandings of and regard for the dynamics of student identity—individually and collectively—while also embracing the utility and value of the students' varied communities. Added to such human connection-making, equity-centered science teachers should more readily recognize the ways institutions create and maintain structures that restrict certain students from freely participating with and learning about science. Both conventional practices that continually oppress as well as "benign" (e.g., *Science for All* manifestos) routines that maintain outcomes that are unevenly distributed must be recognized as genuine and not contrived. Unveiling one's ignorance of the systemic inequities is admittedly a disruptive—but necessary—request, since "one has a better chance of getting things right through a self-conscious recognition of their existence." (Mills, 2007, p. 23). We would argue that developing an awareness of these phenomena would help teachers recognize and interpret examples of injustice and inequities within one's science classroom. In this way, teachers would be able to apply equity-centered theorizing to their efforts to understand and respond to social forces that may otherwise go unnoticed.

#### 2.3 | Defining equity

Our definition of equity builds on this body of literature and focuses on educational equity specifically. For us, educational equity can be measured as an outcome and a process (Patterson, 2019). That is, equity occurs within schools through developing educational environments where all children have access to high-quality instruction (Winn, 2018). It is a space where all children can thrive but also where those from marginalized communities can witness their authentic selves in the culture, curriculum, and infrastructure of the school. Given our malfunctioning education system, equity is also the commitment to making tangible adjustments to educational environments, policies, materials, and so on, that do not dignify all children, maintain their sense of belonging, or lead to high-quality instruction.



Equity as defined here can be achieved only when educators engage in their part of the work of equity across the educational system. In other papers, we describe how students engage in co-creating equity with teachers (Patterson, 2019). For this paper, our focus is the classroom, which is shaped by the teacher. The work of equity for the teacher requires critical self-reflection that leads to the ability to notice and address the contextual realities and barriers to equity (Madkins & McKinney de Royston, 2019; Patterson Williams et al., 2020). Further, equity work requires grappling with historical and institutional factors that create and maintain oppressive learning environments for children to develop one's capacity to address and dismantle said oppression, which manifests at the various levels of the educational system (Winn, 2018; see also: Harris, 1990; Mills, 2007). In the subsequent section, we posit that the work of creating equity within science education requires a multilensed perspective and approach. Relying upon theory, we elucidate the layers of equity within science education.

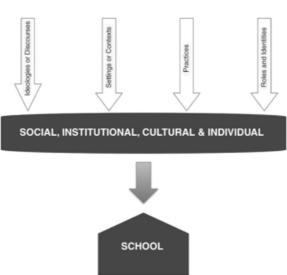
# 3 | USING THEORY TO IDENTIFY THE LAYERS OF EQUITY WITHIN SCIENCE EDUCATION

Scholars have argued that social justice vis-à-vis resistance can be achieved through equitable science instruction (Morales-Doyle, 2019; Williams & Tolbert, 2021). For those of marginalized identities, this resistance is especially necessary, as Rodriguez and Morrison (2019) argue that terms such as "equity, diversity, and social justice are more than "constructs" to be researched in relation to the Other. [Rather,] they are interlinked elements of [one's] everyday life as [the] visible Other" (p. 267). In other words, the oppressive systems which undergird the act of schooling are our entrenched reality, not merely an abstraction. As such, continuing to engage in canonical science learning only perpetuates this oppression.

To better unpack the various manifestations of equity within science education, we draw on McKinney de Royston and Nasir's (2017) *Racialized Learning Ecologies (RLE)* framework as the theoretical basis in which we situate equity. Considering place as an integral part of a child's development and learning, this framework identifies schools as racialized places that serve dual purposes as both "institutional spaces of knowledge acquisition, and as physically and discursively critical sites of human development" (p. 259). Centering race, this theory confronts structures of power to understand its presence within social and ecological systems—namely schools—to disrupt its colorblind and neoliberal nature (McKinney de Royston & Nasir, 2017). Further, the theory contends that schools are racialized spaces composed of several levels of learning and development (i.e., ideologies or discourses, settings or contexts, practices, and roles and identities) resulting in the co-construction of the sociopolitical contexts of learning. We argue that science learning *itself* is racialized, furthering the import of this study. To operationalize this theory, McKinney de Royston and Nasir (2017) situate the US city of Oakland, California as a racialized learning ecology, arguing "that understanding school-level learning ecologies in Oakland requires attending to how young people in that city are differentially racialized (and classed, gendered, etc.) based upon where they live and where they go to school" (p. 270).

Additionally, this operationalization accounts for how racialized experiences (e.g., individual identity within neighborhood racial and economic segregation) inform which policies are adopted at the district and city-wide levels. This offers a lens into the co-construction of the multiple contexts that undergird learning. Below, we offer a schematic representation of the framework (Figure 1) along with a description detailing its origins. We foresee great potential within this framework to guide how we both theorize and operationalize equity within contemporary science teaching and learning.

The RLE framework builds upon Bronfenbrenner's, (1979, 1994) ecological framework theory, which situates children's lived experiences within multiple dynamic contexts. Specifically, it addresses several critiques levied against Bronfenbrenner's work—namely, the interconnected nature of the macro-level factors (i.e., ideologies of discourse, settings or contexts, practices, and roles and identities) that shape the meso-level sociopolitical contexts for the learning which occurs within the micro-level institutions (e.g., schools). McKinney de Royston and Nasir (2017) argue that these institutions function as "nested and co-influential learning ecologies within which discourses about race permeate and



**FIGURE 1** Visual interpretation of the *Racialized Learning Ecologies* theoretical framework (McKinney de Royston & Nasir [2017]).

shift over time and scales of activity" (p. 270), hence the "layers" described throughout this paper. As such, we explore the ways in which equity has been theorized within science education research and the broader education community, while acknowledging these various institutions of learning as racialized.

Within Figure 1, the multiple contributors to the sociopolitical context of learning are represented as arrows. Rather than presenting these contributors hierarchically, they are represented as parallel structures, which comprise the

- 1. Social refers to the ways in which our society has normalized the social stratification of humans (by race, class, gender);
- 2. Institutional are the spaces where learning takes place;
- 3. Cultural defines the practices located within socializing; and
- 4. *Individual*, or the level where one's singular identity markers intersect with one another, forming the basis of their educational experiences.

McKinney de Royston and Nasir (2017) consider these factors synergistic entities shaping the micro-layer interactions within a local learning space. In essence, this framework situates broader systems as macro-layer contributors to the parallel meso-layer contextual factors that create the micro learning ecologies (i.e., schools). Much like McKinney de Royston and Nasir (2017) position classroom-layer racialized learning experiences as nested within—rather than occurring hierarchically—social, institutional, cultural, and individual factors, we theorize around equity, explicating its functioning as *layered* rather than *stratified*. In so doing, we nuance the manifestations of equity within and across these layers to further argue the need to transform science teaching and learning, which occurs by doing the *work* of equity.

#### 4 | THREE LAYERS OF EQUITY IN SCIENCE LEARNING

Science as an enterprise can be a tool to disrupt and liberate; however, this requires us to rethink how we position it within our classrooms and society writ large. Scientific knowledge is not merely an objective and sterile discipline reserved for elite individuals. Science is conducted by humans. By nature, we are not objective; thus, science is not

neutral. This must be acknowledged for us to account for which forms of knowledge are privileged and which ones are stifled, necessitating a clearer articulation of equity within science teaching and learning. Therefore, when considering equity within the science classroom, each of these contributors (i.e., social, institutional, cultural, and individual) must be acknowledged to understand their nuanced nature within science education. Positioning equity in this way allows us to consider the multiple layers at which it functions. Akin to the macro-levels of learning for McKinney de Royston and Nasir (2017), at the macro-layer, educators doing the work of equity should consider the broader ideologies and discourses that shape the social and institutional sociopolitical factors of science learning. Similarly, within the meso-layer, educators doing the work of equity realize that learning is informed by culturally derived science epistemologies that may or may not align with canonical scientific understandings. Finally, within the micro-layer, equity work for educators focuses on their individual identities coupled with those of their students within the classroom whilst engaging in science teaching and learning. In the sections to follow, we explain how equity functions across these three layers, concluding with a vision of how these layers coalesce to transform the practice of science teaching and learning.

# 4.1 | Macro-layer equity

Leveraging scientific knowledge to enact systemic change is the premise of equity's macro-layer functioning. When considering the functioning of systems within the scope of McKinney de Royston and Nasir's (2017) framework, we may think of macro-layer equity as the symbiotic relationship forged between the social and institutional contributors to schooling. In this case, social contributors (e.g., racism) are informed by ideologies and discourses, while institutional contributors (e.g., curricula) are influenced by contextual factors such as politics. Taken together, these form the broad scope through which we engage macro-layer equity. Theorizing at the macro layer has been the work of a few science education researchers (e.g., Atwater, 2000; Parsons, 2008). Additionally, considerations about the way equity functions within the macro layer is not commonly addressed within reform documents (e.g., Basile & Lopez, 2015). The field needs to deepen its engagement with theories that recognize equity as more than a matter of personal interactions (i.e., at the micro-layer) to a broader acknowledgment of the intersectional nature of the systemic factors (i.e., ideologies, discourses, institutions) that shape science education.

To this end, Morales-Doyle (2019) advocates for *social justice science instruction* (SJSI) to "provide an opportunity for students to explore the usefulness, the limitations, and the problems of canonical scientific knowledge, while also ask[ing] critical questions about issues of justice and oppression" (p. 488). Originally conceptualized as justice-centered science pedagogy (Morales-Doyle, 2017), the framework "addresses inequity in science education as one component of oppression by challenging larger structures such as white supremacy, neoliberal capitalism, and heteropatriarchy" (p. 1035). Rather than focus on micro-layer science education context-specific factors (e.g., curriculum, classrooms, and learning), Morales-Doyle broadens the conversation to envision equitable science instruction as an application of canonical knowledge to address the social and institutional contributors to enact change, akin to Rodriguez's (2014) critical pedagogy for STEM education.

Similarly, macro-layer equity provides science educators with opportunities to challenge systems such that their teaching functions as a form of dissent (Morales-Doyle et al., 2021). This dissent requires acknowledging how one's positionality can further oppress students of marginalized identities within the classroom if left unchallenged (Mensah, 2008; 2016). If one's positionality operationalizes equity as mere equal treatment of all racial and other historically marginalized groups in STEM, this treatment fails to account for the contextual factors (e.g., tracking, systemic racism, socioeconomic factors, etc.) which necessitated its initial consideration. Through disrupting these foundational components, science teachers commit to the dynamic theorizing associated with enacting equitable, just, and transformative pedagogy within their classrooms (Patterson & Gray, 2019).

# 4.2 Meso-layer equity

Typically informed by culturally derived non-Western scientific epistemologies, meso-layer equity functions to disrupt White, Western, heteronormative epistemologies. These epistemological scientific perspectives have cultural influences which shape one's belief system (McKinney de Royston & Nasir, 2017). Similarly, disruptive epistemologies reflect a view of equity that is dynamic, interactive, and influenced by context (Fortney & Atwood, 2019). Through this disruption, we ensure that no additional harm is inflicted while simultaneously striving to make amends for these historical injustices (Morton et al., 2022). Extending to the notion of justice, a macro-layer perspective would suggest that Aristotle used the principles of *Maat* (James, 1954) to develop an epistemology of justice, which within education, was taken up and extended by Secada (1989). Although Aristotle is credited with this conceptualization of justice, a meso-layer approach to equity rejects and disrupts this notion, redefining justice as originally described via the Kemetic teachings of Maat. These mental models materialize from precursory experiences, thus informing one's positionality, resulting in the instructional decisions made within the classroom.

Epistemological shifts in science education for equity can arguably occur through the incorporation of a sociopolitical lens. Such lens adoption would require deep interrogation of one's mental models coupled with noticing (Shah & Coles, 2020) to understand one's complicity within these macro-layer structures. Because of its perceived sterile and objective nature, scientific knowledge is rarely questioned; rather, it is used to justify such beliefs that perpetuate exclusionary policies and oppressive practices within science education (see Galamba & Matthews, 2021). Attention to the way equity functions within the meso-layer directly challenges this notion, requiring that science teachers, educators, and curricula acknowledge the influence of sociopolitical, macro-layer systems on the valuing of scientific knowledge (Jones & Donaldson, 2022). Additionally, the work of equity at the meso-layer actively resists, disrupts, and actively dismantles the foundations that sustain these beliefs.

Through the enactment of a sociopolitical lens within science education, teachers establish an environment of change within their classrooms, the curriculum, the school, and the community (Williams & Tolbert, 2021). This transformative approach is paradoxical to traditional school culture, as teachers are confined to the restrictions imposed by standardized testing, prescriptive curriculum, and so on. However, enacting agency allows teachers to challenge existing dominant epistemologies, thus connecting the work of equity at the meso and macro-layers. Such challenges require a deep exploration of questions such as: Who benefits from this instruction? Whose experiences/identities are further marginalized by this curriculum and instructional approach? How are children's multiple ways of knowing and experiencing the world captured through this instruction? These are all important considerations for science teaching and learning that function at the meso-layer such that conceptions of what counts as "authentic" scientific knowledge is an accurate encapsulation of the experiential mental models of those it seeks to engage. We argue that the answers to these questions require a capacity to cultivate one's "inner witness" toward equity (Patterson Williams et al., 2020) and to co-construct equity within the classroom at the micro-layer, thus undertaking the work of equity.

# 4.3 | Micro-layer equity

Constructing equity within the classroom requires an understanding of how lived experiences and multiple identities shape notions of equity (McKinney de Royston & Nasir, 2017). Additionally, we must further complicate these experiences, which require developing our capacity to notice the dispositions which impact our perspectives on equity (Patterson Williams et al., 2020; Shah & Coles, 2020). Patterson (2019) argues that equity, much like learning, is co-constructed. Within the classroom context, equity is co-constructed between the teacher and students as well as within intragroup interactions amongst students. These co-constructions should account for issues of power as well as the inequities which may arise within groups as students assume roles and negotiate the substance of one another's ideas.

While establishing equity within the science classroom, we argue that teachers must engage with the macro and meso layers of equity. Patterson Williams et al. (2020) constructed a multilayered framework for facilitating equity within the classroom during "fleeting moments of discourse" (p. 505): evidence of content learning, recognizing varied talk moves, and noticing for equity. These interactions are byproducts of the oppressive nature that undergirds opportunities within education, necessitating the development of an inner witness, a tool "akin to a magnifying glass that highlights information and interactions according to the lens or perspective the teacher has developed—it can be likened to a guide on your shoulder pointing out relevant information" (Patterson Williams et al., 2020, p. 507). When teachers are noticing potential inequities within their students' discussions and make efforts to reshape the classroom environment, such micro-layerl concerns involve "creating individual and collective safety and support by attending and responding to equitable distribution of talk *and* engaging larger historical and sociopolitical issues impacting the present discursive moment" (p. 509). Such larger issues suggest that equity does not exist within a vacuum (Morales-Doyle, 2019); therefore, to adequately construct a space for its existence directly involves engagement with systems (macro) and epistemologies (meso), as these systems are intersectional by their nature.

Co-constructing equity within the classroom broadens teachers' expectations beyond simply what transpires during lessons in classrooms to also include the product of a process (Patterson, 2019). Establishing equity amongst students requires student voice, visibility, authority, and agency. Students use these in dialogic spaces which allow for talk and the engagement with materials by all students in the group. While inequities may emerge during the process, it is the use of voice and agency that creates visibility of all students regardless of social and academic status. The teacher's role shifts from one in which they work for students to one in which they work with students (Rodriguez, 2014). And yet, uncertainties remain around how we develop teachers' lenses/inner witness to see, interpret, and, address issues of equity within the classroom, curriculum, and school site (Patterson Williams et al., 2020). Integrating moments that cause teachers—preservice as well as those across their career trajectories—to reckon with their own positionalities might address this (Mensah, 2008, 2016). We argue that for teachers to do the work of equity, they must notice its functioning within and across each layer and embrace the notion that such noticing is an ongoing part of their praxes. Through this, teachers work to transform rather than transgress (hooks, 1994).

# 5 | IMPLICATIONS: EQUITY FOR TRANSFORMATION

The positioning of equity as a justice-centered right within science education has the power to transform, as is noted in Patterson and Gray's (2019) (w)holistic science pedagogy. This framework charges teachers with five commitments, to "(1) [an] ever-developing self-awareness, (2) science and its practices, (3) science as a transformative agent, (4) their students' social emotional wellness, and (5) restorative practices" (p. 1). The framework situates science as an agent for change that is deeply rooted in the lives of students, requiring "teachers to develop the practices of deep self-analysis, attention to students' wellness, and a restorative stance that permeates their approach to teaching" (p. 3). Through engaging these requirements, teachers effectively attend to each layer of equity by actively centering the social, institutional, cultural, and individual layers (McKinney de Royston & Nasir, 2017), thereby privileging the entire student rather than canonical scientific knowledge. Science then becomes a means to disrupt the inherent oppressive nature of what it means to be "scientifically literate," shifting science epistemologies. This work involves an investment in one's community and its students as well as a deep interrogation of one's positionality, as teachers must be committed to "unlearning" many of the racist and oppressive systems that comprise schooling (Chen & Mensah, 2022).

# 5.1 | Transformation through the curriculum

In addition to the co-construction of equity within dialogic spaces, the science curriculum can be where students interrogate and critique macro-layer systems to then leverage their scientific knowledge to enact change (Morales-Doyle, 2019). Given the racialized underpinnings of Western science and curriculum, we must be critical of policies that conflate equity with access (i.e., the "Science for All" calls) despite their argued alignment with reformed science standards (Basile & Lopez, 2015; Mutegi, 2011; 2013). Rather, the curriculum may be used as a place in which students can leverage their multiple epistemologies to challenge these various systems (Galamba & Matthews, 2021).

Morales-Doyle and Frausto (2019) offer the Youth Participatory Science (YPS) framework as an example of leveraging scientific knowledge to disrupt. Referred to as a variation of "street science, which democratizes the tools of science in a way that values the wisdom and understandings that exist within communities marginalized by racism and economic dispossession" (p. 2), this framework emerged in response to the recent politicization of science. The framework consists of a cycle that involves (1) defining the SJSI (see Morales-Doyle, 2019), (2) applying a scientific lens, (3) planning and conducting an investigation, (4) analyzing data and assessing learning, and (5) reflecting, disseminating, and acting. This framework may be most recognizable when thinking about the issues leading to the water crisis in Flint, Michigan, USA. In short, the governor at the time realized that it was cheaper to route water into the financially dispossessed city (predominantly populated by Black-identifying people) through the Flint River rather than importing the treated water from a neighboring city. However, this rerouting redirected drinking water through the city's original infrastructure, which was constructed using lead pipes. The lead leached into the water and wreaked havoc on the lives of local citizens, predominantly affecting the neurological development of preadolescent children. This issue, while rooted in social justice, has implications for multidisciplinary science learning and directly applies to the lives of the children in the city. Rather than learning about the properties of lead devoid of context, as has traditionally been the case within the physical sciences, students can ground this learning in their own lives to then enact community-centered change. Through these actions, we allow learners an opportunity to establish affinity-related identities with science (Gray, 2014).

# 5.2 | Equity to support identities

Engaging issues of equity within science education fosters the development of affinity identities with science for students of historically marginalized identities (Gray, 2014). While research on the construction of science identities of students of color uses various theoretical perspectives (Brown, 2004; Carlone & Johnson, 2007; Varelas, et al., 2012) they all emphasize the dynamic—rather than fixed—nature of one's identity (Brown et al., 2017). As research on student science identities has evolved, the recognition of identity as dynamic and intersectional prompted the need for frameworks that leverage the nuanced layers of (in)equity that undergird science learning. To better position science and mathematics learning as a function of the historicized and oppressive nature of science knowledge and schooling writ large, Varelas, et al. (2012) developed the Content Learning and Identity Construction (CLIC) framework. Through centering Black elementary-aged youth and their multiple identity constructions (i.e.,disciplinary identity construction as a scientist and/or mathematician, racial identity construction as an emergent understanding of one's Blackness, and academic identity construction as a student engaged in classroom practices) and their intersections with one's content learning (science and/or mathematics learning) within the classroom and throughout their educational tenure. This is significant, as it situates schooling within a sociohistorical context (the macro-) while also centering individual (micro-) identities through the lenses of experiences while navigating the (meso-layer) institutional factors.

Varelas (2012) contends that studying identity allows researchers to develop a sense of "feeling for the learner" (p. 1). We extend this claim to argue that centering those of marginalized identities within the science classroom not



only fosters empathy for teachers and researchers; it promotes justice (Patterson & Gray, 2019; Tolbert et al., 2018; Winn, 2018). Through a justice-oriented approach to science teaching and learning, we are able to transform the ways in which science is presented and engaged by the public. Given that the dissemination of science is often billed as a public good, centering identity through its teaching and learning ensures that this good becomes one's civil right (Tate, 2001).

#### 

#### 6.1 Operationalizing equity

Reiterating our intent to use theory to inform practice—the work of creating equity—we argue that to best operationalize equity, we must understand its function across each layer. Establishing equity within the classroom (micro-layer) involves a deep understanding of how systemic issues (e.g., racism, xenophobia, gender discrimination, etc.) have shaped what constitutes learning (meso-layer). If we enact policies, implement curricula, or engage with students under the guise of equity without considering these varying interactions, we will continue to perpetuate the injustices we seek to disrupt. Stated differently, equitable science teaching and learning must be justiceoriented such that those of us who have historically been harmed within or felt alienated by science feel a part of this community. This orientation is what constitutes doing the work of creating equity. To do both well, science teachers must commit themselves to teaching science (w)holistically (Patterson & Gray, 2019), in addition to embracing multiple scientific epistemologies while affirming the identities of the learners who shape them. We contend that these commitments are not reserved only for teachers of minoritized backgrounds or a select few; rather, all teachers must commit to an ever-developing self-awareness that not only challenges bigotry (Harris, 1990), but disrupts the writ large perpetuation of systemic inequities within science and schools.

#### DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no data sets were generated or analyzed during the current study.

#### ORCID

Terrance Burgess https://orcid.org/0000-0001-5846-7381 Alexis Patterson Williams https://orcid.org/0000-0002-9096-6073

#### REFERENCES

Atwater, M. M. (2000). Equity for Black Americans in precollege science. Science Education, 84(2), 154-179. https://doi. org/10.1002/(SICI)1098-237X(200003)84:2%3C154::AID-SCE2%3E3.0.CO;2-R

Basile, V., & Lopez, E. (2015). And still I see no changes: Enduring views of students of color in science and mathematics education policy reports. Science Education, 99(3), 519-548. https://doi.org/10.1002/sce.21156

Blankstein, A. M., & Noguera, P. (2016). Introduction: Achieving excellence through equity for every student. In A. M. Blankstein, P. Noguera, & L. Kelly (Eds.), Excellence through equity: Five principles of courageous leadership to guide achievement for every student. ASCD.

Bronfenbrenner, U. (1979). Contexts of child rearing: Problems and prospects. American Psychologist, 34(10), 844-850. Bronfenbrenner, U. (1994). Ecological models of human development, Readings on the development of children (Vol. 2, pp. 37-43).

Browder, A. T. (1992). Nile Valley contributions to civilization: Exploding the myths (Vol. 1). Institute of Karmic Guidance. Brown, B. A. (2004). Discursive identity: Assimilation into the culture of science and its implications for minority students. Journal of Research in Science Teaching, 41(8), 810-834. https://doi.org/10.1002/tea.20228

Brown, B. A., Mangram, C., Sun, K., Cross, K., & Raab, E. (2017). Representing racial identity: Identity, Race, the construction of the African American STEM students. Urban Education, 52(2), 170-206. https://doi.org/10.1177/ 0042085916661385

- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218. https://doi.org/10.1002/tea.20237
- Chen, J. L., & Moore Mensah, F. (2022). Toward socially just science teaching through professional development: The science teacher identity development and agency of two elementary Teachers of Color. *Science Education*, 106(2), 385–411. https://doi.org/10.1002/sce.21699
- Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, 1989(1):8.
- Donovan, B. M. (2016). Framing the genetics curriculum for social justice: An experimental exploration of how the biology curriculum influences beliefs about racial difference. *Science Education*, 100(3), 586–616. https://doi.org/10.1002/sce.21221
- Fortney, B. S., & Atwood, E. D. (2019). Teaching with understanding while teaching for understanding. *Cultural Studies of Science Education*, 14(2), 465–484. https://doi.org/10.1007/s11422-019-09924-z
- Galamba, A., & Matthews, B. (2021). Science education against the rise of fascist and authoritarian movements: Towards the development of a pedagogy for democracy. *Cultural Studies of Science Education*, 1–27. https://doi.org/10.1007/s11422-020-10002-y
- Grant, C. A., & Ladson-Billings, G. (1997). Dictionary of multicultural education. Oryx Press.
- Gray, S. T. (2014). Is science for all?: The relationship between middle and high school science students' perceptions of race and their science affinity-identities [Doctoral dissertation]. Proquest. Stanford University. https://www-proquest-com. libezproxy2.syr.edu/docview/2464172184?pq-origsite=summon
- Harris, A. P. (1990). On doing the right thing: Education work in the academy. Vermont Law Review, 15(1), 125-138.
- Hooks, B. (1994). Teaching to transgress: Education as the practice of freedom. Routledge.
- James, G. G. (1954). Stolen legacy: Greek philosophy is stolen Egyptian philosophy. African World Press.
- Jones, B. L., & Donaldson, M. L. (2022). Preservice science teachers' sociopolitical consciousness: Analyzing descriptions of culturally relevant science teaching and students. Science Education, 106(1), 3–26. https://doi.org/10.1002/sce.21683
- Madkins, T. C., & McKinney de Royston, M. (2019). Illuminating political clarity in culturally relevant science instruction. Science Education, 103(6), 1319–1346. https://doi.org/10.1002/sce.21542
- Martin, D. (2008). Maat and order in African cosmology: A conceptual tool for understanding indigenous knowledge. *Journal of Black Studies*, 38(6), 951–967.
- McKinney de Royston, M., & Nasir, N. S. (2017). Racialized learning ecologies: Understanding race as a key feature of learning and developmental processes in schools. In N. Budwig, E. Turiel, & P. D. Zelazo (Eds.), New perspectives on human development (pp. 530–573). Cambridge University Press.
- Mensah, F. M. (2008). Positional identity and science teacher professional development. *Journal of Research in Science Teaching*, 45(6), 684–710. https://doi.org/10.1002/tea.20258
- Mensah, F. M. (2016). Positional identity as a framework to studying science teacher identity, *Studying science teacher identity* (pp. 49–69). Sense Publishers.
- Mezirow, J. (1997). Transformative learning: Theory to practice. New Directions for Adult and Continuing Education, 1997(74), 5–12. Mills, C. (2007). White ignorance. In S. Sullivan, & N. Tuana (Eds.), Race and epistemologies of ignorance (pp. 13–38). State University of New York Press.
- Morales-Doyle, D. (2017). Justice-centered science pedagogy: A catalyst for academic achievement and social transformation. *Science Education*, 101(6), 1034–1060. https://doi.org/10.1002/sce.21305
- Morales-Doyle, D. (2019). There is no equity in a vacuum: On the importance of historical, political, and moral considerations in science education. *Cultural Studies of Science Education*, 14(2), 485–491. https://doi.org/10.1007/s11422-019-09925-y
- Morales-Doyle, D., & Frausto, A. (2019). Youth participatory science: A grassroots science curriculum framework. *Educational Action Research*, 29(1), 60–78. https://doi.org/10.1080/09650792.2019.1706598
- Morales-Doyle, D., Varelas, M., Segura, D., & Bernal-Munera, M. (2021). Access, dissent, ethics, and politics: Pre-service teachers negotiating conceptions of the work of teaching science for equity. *Cognition and Instruction*, 39(1), 35–64. https://doi.org/10.1080/07370008.2020.1828421
- Morton, T. R., Miles, M. L., Roby, R. S., & Ortiz, N. A. (2022). "All we wanna do is be free": Advocating for black liberation in and through K-12 science education. *Journal of Science Teacher Education*, 33(2), 131–153. https://doi.org/10.1080/1046560X.2021.2008096
- Mutegi, J. W. (2011). The inadequacies of "Science for All" and the necessity and nature of a socially transformative curriculum approach for African American science education. *Journal of Research in Science Teaching*, 48(3), 301–316. https://doi.org/10.1002/tea.20410
- Mutegi, J. W. (2013). "Life's first need is for us to be realistic" and other reasons for examining the sociocultural construction of race in the science performance of African American students. *Journal of Research in Science Teaching*, 50(1), 82–103. https://doi.org/10.1002/tea.21065



- Parsons, E. R. C. (2008). Positionality of African Americans and a theoretical accommodation of it: Rethinking science education research. *Science Education*, 92(6), 1127–1144. https://doi.org/10.1002/sce.20273
- Patterson, A., & Gray, S. (2019). Teaching to transform:(W) holistic Science Pedagogy. *Theory Into Practice*, 58(4), 328–337. https://doi.org/10.1080/00405841.2019.1626616
- Patterson, A. D. (2019). Equity in groupwork: The social process of creating justice in a science classroom. *Cultural Studies of Science Education*, 14(2), 361–381. https://doi.org/10.1007/s11422-019-09918-x
- Patterson Williams, A. D., Athanases, S. Z., Higgs, J. M., & Martinez, D. C. (2020). Developing an inner witness to notice for equity in the fleeting moments of talk for content learning. *Equity & Excellence in Education*, 53(4), 505–518. https://doi.org/10.1080/10665684.2020.1791282
- Rahmawati, Y., & Taylor, P. C. (2015). Moments of critical realisation and appreciation: A transformative chemistry teacher reflects. *Reflective Practice*, 16(1), 31–42. https://doi.org/10.1080/14623943.2014.944142
- Rodriguez, A. (2014). A critical pedagogy for STEM education, Activist science and technology education (pp. 55-66). Springer. https://doi.org/10.1007/978-94-007-4360-1\_4
- Rodriguez, A. J., & Morrison, D. (2019). Expanding and enacting transformative meanings of equity, diversity and social justice in science education. *Cultural Studies of Science Education*, 14(2), 265–281. https://doi.org/10.1007/s11422-019-09938-7
- Santiago, M. (2016). Erasing differences for the sake of inclusion: How Mexican/Mexican American students construct historical narratives. *Theory & Research in Social Education*, 45(1), 43–74.
- Secada, W. G. (1989). Educational equity versus equality of education: An alternative conception. In W. G. Secada (Ed.), *Equity in education* (pp. 68–88). The Falmer Press.
- Shah, N., & Coles, J. A. (2020). Preparing teachers to notice race in classrooms: Contextualizing the competencies of preservice teachers with antiracist inclinations. *Journal of Teacher Education*, 71(5), 584–599. https://doi.org/10. 1177/00224871199002
- Shuster, K. & Giesemann, X. (2021). Embrace historical truths. Center for Anti Racist Education.
- Swadener, B. B. (1997). Educational equity. In C. A. Grant, & G. Ladson-Billings (Eds.), *Dictionary of multicultural education*. Oryx Press.
- Tate, W. (2001). Science education as a civil right: Urban schools and opportunity-to-learn considerations. *Journal of Research in Science Teaching*, 38(9), 1015–1028. https://doi.org/10.1002/tea.1045
- Tolbert, S., Schindel, A., & Rodriguez, A. J. (2018). Relevance and relational responsibility in justice-oriented science education research. *Science Education*, 102(4), 796–819. https://doi.org/10.1002/sce.21446
- Varelas, M. (Ed.). (2012). Identity construction and science education research: Learning, teaching, and being in multiple contexts (Vol. 35). Springer Science & Business Media.
- Varelas, M., Martin, D. B., & Kane, J. M. (2012). Content learning and identity construction: A framework to strengthen African American students' mathematics and science learning in urban elementary schools. *Human Development*, 55(5-6), 319-339. https://doi.org/10.1159/000345324
- Williams, J., & Tolbert, S. (2021). "They have a lot more freedom than they know": Science education as a space for radical openness. *Cultural Studies of Science Education*, 16(1), 71–84. https://doi.org/10.1007/s11422-020-10016-6
- Winn, M. T. (2018). Justice on both sides: Transforming education through restorative justice. Harvard Education Press.

How to cite this article: Burgess, T., & Patterson Williams, A. (2022). Utilizing theory to elucidate the work of creating equity for transformation within the science classroom. *Science Education*, 1–13. https://doi.org/10.1002/sce.21721