A Framework for Change Agents: Fostering Equity-Minded Change within and across STEM Teaching and Learning Contexts

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Abstract

Investments to make the STEM learning environment more diverse, inclusive, and equitable have grown across all levels of the postsecondary STEM enterprise. Yet, despite years of efforts, marginalized and minoritized students continue to experience STEM learning environments as chilly, hostile, and isolating. In this manuscript, we consider the major barriers and opportunities for initiating and sustaining equity-minded change in STEM teaching and learning contexts. We bring together key insights from the organizational change and equity, diversity, and inclusion research and from the literature concerning the history and structure of higher education and the academic profession to create a framework entitled *Equity-Minded Change across and within STEM Teaching and Learning Contexts*. This framework identifies promising opportunities for change as well as systemic barriers that often undermine equity-minded change in STEM teaching and learning, all of which change agents should consider when designing change initiatives. We conclude with specific recommendations tailored to various agents of change, including academic administrators, faculty members, EDI practitioners, and researchers.

Introduction

Years of empirical research has demonstrated that knowledge work, including teaching, learning, and research, is improved when classrooms, labs, and research teams are diverse (McGee, 2020; Plaut, 2010). Accordingly, investments to make the STEM learning environment more diverse and more inclusive,[1] so as to retain diversity gains, have grown across all levels of the postsecondary STEM enterprise (Hrabowski, 2012; National Academies of Science Engineering and Medicine, 2020; 2023). Despite substantial investments, progress remains limited (Basile & Lopez, 2015; Hu & Fernandez, 2023). While diversity, particularly racial diversity, amongst the U.S. college student population grows overall (National Center for Science and Engineering Statistics, 2023), progress in the STEM fields has been slower, and in some fields, progress is non-existent. For example, recent data from the National Science Foundation (National Center for Science and Engineering Statistics, 2023) indicates the percentage of undergraduate degrees completed by Black students in fields such as engineering and physical and earth sciences remained similar from 2011 to 2020. Furthermore, while the percentage of Hispanic/Latinx students in those same fields increased during the same time period, they still remain underrepresented compared to the overall population (National Center for Science and Engineering Statistics, 2023).

Disparities are even more pronounced at the doctoral, faculty, and leadership levels, where white people, especially white men, continue to be overrepresented (National Center for Science and Engineering Statistics, 2023). Black, Latinx, and

[1] Varying umbrella terms like “diversity work,” “DEI work”, or “EDI work” are used, often interchangeably, to refer to efforts to increase diversity, inclusion, and equity. As we discuss below, diversity, inclusion, and equity are distinct goals that demand different scope and effort. In this manuscript, we are interested in equity-minded teaching and situate it as “EDI work,” something we say more about on pp. 7-8.

Indigenous scholars make up under 10% of doctoral holders (National Center for Science and Engineering Statistics, 2023) compared to about 35% of the overall U.S. population. When honing in on certain areas of the STEM academic profession, the picture becomes even worse. Black faculty represent less than 1% of physics faculty and just over 1% of mathematics faculty at top research institutions; Hispanic/Latinx faculty makeup 2.6% and 2.8% in the same fields (Nelson, 2017). Indigenous people, racially minoritized women, and disabled faculty remain particularly underrepresented across all academic fields and institutional types (Ginther & Khan, 2013; National Center for Science and Engineering Statistics, 2023). Given all this, at the current rate of change, researchers project that the **U.S. faculty will never reach parity with the U.S. population** (Matias et al., 2022). And to our earlier point, without demographic diversity, knowledge production within STEM is not as robust nor representative as it could be.

Researchers offer numerous reasons why progress with regard to diversity has continuously fallen short, but one of the recurring concerns is that minoritized students and faculty[2] (Asian, Black, Indigenous, Latinx, disabled, and LGBTQIA+) have historically and consistently experienced STEM contexts, including teaching and learning environments as chilly, hostile, and isolating (Johnson, 2012; Perez et al., 2023; Wilkins-Yel et al., 2022). For instance, because there are so few faculty of color, students of color often feel isolated and without role models, leading them to question their belonging (Griffin et al., 2020a; Reddick & Young, 2012). Moreover, faculty

[2] By minoritized, we refer primarily to racially minoritized groups including Asian, Indigenous, Latinx, Black/African American. However, we understand that gender, ability, sexuality, class are also forms of minoritization and that each of these identity markers is deeply shaped by race and racism. We foreground a racial analysis for reasons discussed in sections two and three.

members, regardless of background, are often not trained as teachers (Austin, 1990), and especially as teachers who incorporate inclusive, culturally responsive, and/or high impact teaching practices (Duncan et al., 2023; Kiyama et al., 2017; Moriarty, 2007; Ramachandran et al., 2023). As a result, studies have documented that faculty, particularly in the context of STEM, employ teaching and mentoring strategies that marginalize minoritized students, causing them to question their ability to succeed in STEM (Fox, 2013; Hurtado et al., 2009). Additionally, aspects of STEM curriculum and STEM research activity can reduce student interest in pursuing STEM degrees. For example, students of color often exit STEM because these fields are presented as apolitical and incompatible with social change or social justice work (Cech et al., 2015; Duncan et al., 2023; Hernandez, 2022; McGee & Bentley, 2017; Seymour, 2019).

Given the persistent gap between investments and results, change agents (e.g., academic administrators, faculty members, diversity practitioners, funders) have become keenly interested in understanding what it takes to change STEM teaching and learning contexts (e.g., classrooms, labs, fields, mentoring/advising) in service of equity, diversity, and inclusion (EDI) (Hrabowski, 2012; Palmer et al. 2013). **This paper offers a research-informed framework for leading, supporting, and sustaining *equity-minded teaching* in STEM teaching contexts.** In brief, **equity-minded teaching requires deep, transformational, or third order change aimed at altering the underlying racialized logics, structures, and cultures present in STEM teaching and learning contexts, such that students from racially minoritized communities not only enter but thrive in science fields.**

To set up this framework, we take readers through several essential bodies of literature.

- In section one, we offer a historical overview of U.S. higher education, the academic profession, and the academic disciplines. This historical section is intended to help readers gain insight into the generally exclusionary conditions that informed the formation of the academic profession and academic disciplines, both of which lend a distinctive autonomy to professors who are central to any efforts to reform teaching.
- In section two, we discuss the organizational change literature, locate EDI change as a particular kind of organizational change, and introduce equity-minded teaching.
- In section three, we present a framework which brings together insights from higher education, organizational change, and EDI literature to shine a light on the potential opportunities and barriers for equity-minded teaching within and across STEM contexts.

Section I: Accounting for the Racialized History of U.S. Higher Education, the Academic Profession, and STEM

The National Academies of Science (2023) recently declared that gaps in racial representation in science fields do not reflect the abilities or interests of individuals but are the result of "systemic and structural issues arising from the legacies of policies and practices designed to disadvantage people from historically minoritized groups along with institutional cultures that, intentionally, or otherwise, create exclusionary and discriminatory environments" based on biased notions of success and prestige," (p. 26) or merit. For this reason, change agents, including activists, scholars, academic leaders, and funders have come to agree that **any effort to create more diverse, inclusive, and equitable change in STEM cannot sidestep the history of U.S. higher education**. In the space below, we offer a brief history of U.S. higher education, the academic profession, and the formation of STEM fields to demonstrate how **colonial and racialized foundations have shaped the underlying logics (e.g., assumptions, mental models), structures (e.g., processes, policies), and culture (e.g., norms, practices) of U.S. colleges and universities** (McNair et al., 2020).

A Brief History

Whereas most popular and even scholarly histories of U.S. higher education frame it as a benevolent institution, it is critical to acknowledge that U.S. higher education was seeded by European colonization and the racial hierarchy which Europeans developed and used to organize every aspect of and relationship within society (Quijano, 2000). Thus, when historians refer to the earliest colleges in the U.S. as colonial colleges; this is not a mere reference to a time period. These colleges were in fact colonial impositions. Upon invading the Americas, Europeans used violent means to displace and expel Native people in order to settle on their land. This expulsion took

many forms: settlers exposed Indigenous people to harmful illnesses that led to death; they disturbed the natural ecosystems and exploited natural food supplies; they used weaponry to murder Native people; and most consistently, they pushed Indigenous communities off their native land to build colonial communities, which frequently involved building colleges (Dunbar-Ortiz, 2023; Wolfe, 2006).

Native people were rarely allowed to remain near colonial settlements, and even more rarely were Natives allowed on college campuses (Dunbar-Ortiz, 2023; Wilder, 2013; Wolfe, 2006). Native people were only allowed access to college grounds when they were used as servants or for the purposes of assimilation. In the latter case, Native men were enrolled as a means of spreading Eurocentric norms, beliefs, and practices (e.g., linguistic, religious, etc.,) to their respective tribes and communities (Harvey, 2020; Rocha Beardall, 2022; Wilder, 2013).

While some Indigenous people were forced to assimilate and then convert other Natives to Eurocentric ways of life, Black people were enslaved. European settlers were simultaneously orchestrating the Atlantic Slave trade and stealing Black people from their homelands (e.g., African countries). These enslaved Africans were dispersed across all of the Americas, including the British colonies and what would eventually become the U.S. Although Black people were often enslaved in white and privately owned estates, many Black people were also forced to labor on colonial college campuses. Indeed, Harris et al., (2019) noted that colleges regularly “rented” enslaved Black people to build and maintain the college facilities and grounds, and Wilder (2013) detailed how college presidents and faculty members who enslaved Black people forced them to work on campus.

That Black and Indigenous people (and later other People of Color) were viewed in such limited ways was an extension of the racial hierarchy that European settlers had constructed. In this hierarchy, Europeans made themselves superior—deserving of love, respect, education, health, and limitless possibility—while Black and Indigenous people were cast as less than human and thus undeserving of a full life (Dunbar-Ortiz, 2021; Quijano, 2000; Wilder, 2013; Wolfe, 2006). **This racial hierarchy provided a foundational logic or assumption about what kind of people were capable of learning and whose knowledges and ways of knowing were legitimate and worthy of shaping society and being included in higher education** (González-Stokas, 2023). To this point, critical scholars trace the colonial and racist history of higher education to the exclusionary nature of contemporary academia, especially when it comes to epistemic matters (e.g., what constitutes legitimate knowledge, whose/what knowledge is curriculum worthy). In the next section we describe the formation of the academic profession and the disciplines to provide readers further insight into the foundational apparatus of academia.

The Academic Profession and the Disciplines

Most colonial college teachers (sometimes referred to as tutors) were white men, who had religious training and familiarity with England's model of higher learning. In line with the colonial mission, these tutors implemented a highly religious and Eurocentric curriculum consisting of languages (e.g., Greek, Latin) and the liberal arts (e.g., grammar, logic, arithmetic, geometry, music, etc.,) (Rudolph, 2021). However, in the late 1700s, some of these teachers became interested in Europe's Enlightenment movement, which introduced the basic tenets of western science and other secular philosophies (Chalmers, 2013). As Enlightenment ideas spread to university instructors

in the Americas/colonies, historians estimate that hundreds of intrigued colonial college teachers traveled overseas to Europe to learn more about this emerging movement and its translation into institutions of higher learning.

While abroad, visiting teachers were exposed to two novelties: 1) specialized inquiry and 2) the unrestricted pursuit of knowledge. Although colonial faculty had typically taught according to the interests of their college leadership and the church, upon their return from Europe to the colonies, they set out to secure structures for specialized inquiry and intellectual freedom (Knorr Cetina, 1999). One of the first steps that these scholars took was to draw boundaries around themselves and those that were interested in similar subject matter. In drawing such boundaries, these faculty initiated “academic territories” (Becher & Trowler, 2001), which are now called academic disciplines. Within these boundaries, as scholars with similar interests interacted, they developed preferences for ways of framing, knowing, and studying the subject matter within their territory (Abbott, 1988; Cetina, 1999; Gonzales, 2013; Traweek, 1993).

Thus, the foundation of higher education was in and of itself colonial; then, the ideas that early scholars used to build out their academic territory were drawn from European conventions. Of course, not all people were invited into the creation of the academic disciplines, meaning only some people’s ideas and some ways of knowing set this educational foundation. For example, the first international meeting of sociologists, wherein the disciplinary association was formed, only included European men; according to Go (2020), organizers explicitly excluded Black and Indigenous thinkers who had much to offer on social matters. Furthermore, the American Association for the Advancement of Science (AAAS) as well as numerous other scientific and medical associations excluded People of Color from intellectual endeavors and also played a

critical role in advancing eugenics (Farber, 2008; Graves et al., 2022). Eugenical research propagated the racist and now scientifically debunked notion that white people were genetically and biologically superior to all other races and that the human race could be perfected by selectively breeding white people only (Farber, 2008; Graves et al., 2022). **The exclusion of People of Color and their ideas meant that the disciplines were formed with partial and particular views of the world, all of which served as the basis for research that led to racial harm** (e.g., forced sterilization, discriminatory immigration policies) (Graves et al., 2022). These are but a few of the numerous examples of the ways that the academic disciplines and some disciplinary societies perpetuated both racial and epistemic exclusion in ways that continue to haunt some of the disciplines today (Cech et al., 2017; Go, 2020, Gonzales et al., 2024b; Hernandez, 2021; Kerr, 2014; Settles et al., 2021; Wilder, 2014).

In tandem with the development of the disciplines, faculty members started to understand themselves as experts and subsequently made calls for freedom of intellectual inquiry - or what is now known as academic freedom. Many of the faculty observed that, relative to Germany, college leaders heavily guided, or directed, curricular and intellectual work (Tiede, 2015). Subsequently, faculty wanted more control over their work and a larger role in any decision-making that would shape the conditions of their work (i.e., shared governance) (Tiede, 2015).

Relatedly, faculty members began to observe that they needed protections in order to pursue research and teach on topics free from external influence. In the late 1800s and early 1900s, there were numerous cases wherein university leaders terminated faculty members who advanced ideas contrary to the interests of university stakeholders (e.g., donors, politicians). Among these, perhaps the best known is the

case of Edward Ross, a Stanford sociologist who was fired after criticizing the business decisions of Leland Stanford, the founder of the university at which he was employed (Tiede, 2015). Ross' termination is often thought of as one of the catalysts for both the founding of the American Association of University Professors and the introduction of the tenure system, both of which were aimed at preserving academic freedom and faculty professional autonomy—values onto which academics hold tightly (Gonzales et al., 2024b; Tiede, 2015). However, historians and scholars have noted that Ross, also considered to be among one the leading proponents of eugenics in sociology, grounded his critique of Stanford's business practices in racist and xenophobic assumptions about Chinese immigrants (Leonard, 2003). Indeed, many of the faculty involved with academic labor organizing and advocacy for the tenure system during the progressive era were leaders in, or associated with, the eugenics movement (Leonard, 2003). To that end, some scholars argue that the tenure system, viewed as one the foundational structures on which the professoriate is built, and faculty autonomy is maintained (Tiede, 2015), was in fact founded to, at least in part, perpetuate scientific racism (Graves et al., 2022; Leonard, 2003; Tucker, 1994).

Legacies of Exclusion in Contemporary STEM Teaching and Learning

The legacies of colonialism and racism remain relevant today, generally, in the academic disciplines, specifically, and therefore in teaching and learning spaces (Go, 2018, 2020; Gonzales et al., 2024a, 2024b; Gonzalez-Stokas, 2023; Hernandez, 2021; Shahjahan et al., 2022; Tuhiwai Smith, 2012). STEM is no exception. **Researchers have observed that in most STEM classrooms, Eurocentric assumptions and the western scientific method is taught not only as the dominant form of knowledge production, but as the only form of acceptable knowledge** (Brayboy, 2005; Tuhiwai

Smith, 2012). Moreover, students in STEM majors are typically forced to choose, and usually early on in their studies, a single disciplinary field on which they will focus (Tripp et al., 2020). Many have critiqued that such choices not only constrain scientific innovation but undermine epistemologies or ways of knowing, which do not conform with academia's disciplinary boundaries (O'Neill et al., 2023; Tuhiwai Smith, 2012). In Table 1, we show how the exclusionary histories of academia and the STEM disciplines manifest in the way that STEM students and scholars teach, learn, and are otherwise socialized to behave as scientists.

Table 1.
Legacies of Colonialism & Racism in STEM Teaching and Learning Contexts

Contexts	Examples from the Literature
How to interact in teaching & learning settings (e.g., classrooms, research talks)	● Confrontational, disruptive, physical/jockeying interactions in learning spaces (Blair Loy et al., 2017; Fox, 2013; Sallee, 2011). ● Unidirectional delivery of course content; positioning faculty/instructors only as experts (O'Neill et al., 2023) ● Faculty presented as objective, neutral knowers (Lalujan & Pranjol, 2024; Leyva et al., 2022)
How to formulate and approach research problems	● Privileging western scientific methods (Hernandez, 2021; Page-Reeves et al., 2019; Tuhiwai Smith, 2012) ● Identifying research problem based on prior research rather than from community concerns (Anderson & Cidro, 2019; Hernandez, 2021; O'Neill et al. 2023; Tuhiwai Smith, 2012) ● Isolating research problems from their local context (Anthony-Stevens & Matsaw, 2020; McGinty & Bang, 2016; Medin & Bang 2014) ● Deploying extractive, rather than collaborative, research methods (Anthony-Stevens & Matsaw, 2020; McGinty & Bang, 2016; Medin & Bang 2014; Tuhiwai Smith, 2012)
How to approach subject matter	● Framing subject matter as race neutral (Gildersleeve et al., 2011; Haynes & Patton, 2019) ● Prioritizing disciplinary methods and norms over interdisciplinary approaches (Gonzales et al., 2023, Holley, 2009; O'Meara et al., 2023; Settles et al., 2021)
How to assess student learning and achievement	● Using singular ways of demonstrating knowledge and/or assessing student knowledge (e.g., closed-book, time-limited exams) (Lalujan & Pranjol, 2024) ● Conceptualizing success in highly individualized ways (Brayboy, 2005; Lopez, 2021)
Who/what is represented as canon/foundational knowledge	● Presenting only white, western thinkers in syllabi (Gonzales et al., 2023; Grant, 2021) ● Relying on western histories and narratives around how knowledge has been/should be created (Álvarez & Coolsaet, 2018; McGinty & Bang, 2016; Medin & Bang, 2014)

In summary, in this section we have argued that as colonial era faculty built the academy—creating territories for their specialized inquiry, establishing themselves as experts, and designing conventions to support their professional autonomy in research and teaching— they perpetuated colonialism and racism. Said plainly, the academic profession was ceded in exclusion rather than inclusion. Any effort to make STEM more diverse, inclusive, and equitable particularly in connection with racial justice will have to grapple with the logics, structures, and cultures that govern faculty life and prescribe normative approaches to knowledge work, including teaching and learning. Thus, as readers move through the next section, which addresses organizational change, the above history should be kept in mind. We bring both bodies of work together in section three.

Section II:
Organizational Change and Equity, Diversity, & Inclusion Change Work

Our goals for this section are to describe various kinds of organizational change followed by a more targeted discussion of equity, diversity, and inclusion (EDI) change work. Both discussions might be considered scaffolding to properly introduce **equity-mindedness and equity-minded teaching**, which are at the heart of our framework.

A Primer on Organizational Change

Whether change is incited by external conditions, as happened with the COVID-19 pandemic (Culpepper & Kilmer, 2022), or through the entrance of a new leader, organizational change is consistent (Kezar, 2018). Some change efforts are top-down, or leader initiated (Gonzales & Pacheco, 2012). Other change efforts come from the grass-roots, meaning they come from staff, students, or employees (Kezar et al., 2011). While some change efforts are big and broad, such as when a university's leadership aims to shift an entity's identity, other change proposals are smaller in scope, such as when a department decides to offer an online section of an in-person class.

Given the various aims and scopes of change work, organizational theorists have developed numerous schemas to differentiate organizational change efforts (Bartunek & Moch, 1987; Kania et al., 2018; Kezar, 2018). Such schemas can be helpful to those who must design, communicate, and support change work. In Table 2, just below, we also offer a schema organized around three kinds of change: first order, second order, and third order change. As explained in the second column of the table, the variation in these change efforts are related to their scope (i.e., depth, magnitude). The third column provides an example of each type of change.

Table 2.

Types of Change, informed by Bartunek & Moch (1987) & Kania et al., (2018)

Type of Change	Scope (i.e., depth, magnitude)	Example
First Order Change	**First order change targets, or is meant to be compatible with, existing structures, and thus does not seek to change those structures, or their foundations.** Some scholars suggest that this type of change is shallow because it does not challenge the foundations or core of the organization.	Implementing a recruitment effort to diversify the STEM faculty and student body on a campus (see Hrabowski, 2012; Palmer et al. 2013)
Second Order Change	**Second order change often targets relationships, practices, and norms in phases or in ways that are otherwise contained.** Some scholars describe this change as semi-explicit and/or relational. These changes are often more significant than first order change, but also do not address the core or foundations of an organization.	Implementing affinity groups wherein minoritized and marginalized students can build community, share strategies for navigating their disciplines and departments (see Villa et al., 2013)
Third Order Change	Third order change is often described as deep, transformative, and implicit. **It targets the deepest foundations of the organization, or its core, including mental models.** Third-order change involves or assumes first and second order change and demands adjustments at the individual, sub-organization, and whole organization level.	Ongoing conversations to design educational and policy initiatives to enhance faculty members' understanding of the entrenched and exclusionary foundations of their institutions, disciplines, etc., (see Liera, 2024)

Although it is ubiquitous, organizational change, especially third order transformational change is difficult, slow, non-linear, and more often than not, it fails (Ashkenas, 2015; Kezar, 2018; Thomas, 2020; Weiner, 2009). The literature indicates a fairly common set of change barriers. For one, change leaders often overestimate organizational members' willingness to change, even when the change may benefit them (Olson et al., 2022). Conversely, leaders often underestimate resistance (Kezar, 2018). Somewhat relatedly, change leaders often fail to account for communication related challenges, including the fact that change proposals must move through multiple channels and organizational units (e.g., departments, offices) and will therefore be (re)interpreted multiple times (Weiner, 2009). Leaders rarely invest in the capacity (technical, human, etc.) required to enable the proposed change (Kezar, 2013).

In a study showcasing all of these challenges, Gonzales (2013) studied one university that aimed to position itself as “national research university.” Through surveys and interviews with faculty, it became apparent that leadership sorely underestimated the research infrastructure typical of a nationally competitive university. Faculty were, therefore, confused and frustrated by the proposed change, assumed that leadership had failed to do the proverbial homework, and thus publicly and privately subverted the effort.

Such challenges are present across all types of organizations, but are particularly salient in large bureaucratic organizations, like colleges and universities (Bastedo, 2012; Kezar, 2018; Thomas, 2020). Most colleges and universities are organized into loosely coupled or siloed entities (e.g., departments, centers, offices, programs, etc.,), meaning different entities that should regularly share information rarely do. Additionally, researchers have found that accountability protocols are fairly loose or ineffective, so that an office might only performatively adopt a change effort (Frieband et al., 2022). Relatedly, universities are composed of faculty, staff, students, and administrators who often have competing priorities (Vican et al., 2020) and nuanced authority, autonomy, and power. As a result, these stakeholders can and do come into conflict about what, why, and how change should occur. For instance, although student stakeholders might express dissatisfaction with a department’s curriculum, the faculty—on the basis of their professional expertise and authority—can counter and refuse to make substantive changes. Finally, and related to the siloed nature of colleges and universities as well as the professional autonomy held by faculty and other professionals (e.g., academic deans), many colleges and universities are highly decentralized, meaning that departments and colleges retain power and resource autonomy to ignore or subvert

centralized mandates (Austin, 1990; Tagg, 2012). For all these reasons, most change efforts in higher education are viewed with deep skepticism and arouse some level of resistance; some change work incites more skepticism and resistance than others, as is the case with equity, diversity, and inclusion (EDI) efforts.

Equity, Diversity, and Inclusion Change Work

Given the deep imprint of colonialism and racism on higher education, equity, diversity, and inclusion (EDI) represent particularly disruptive organizational change. For this reason, it is important to offer a focused and careful discussion of EDI change work. Our goal in this subsection is to sketch out EDI change work, broadly and delineate how equity, diversity, and inclusion represent different goals and different scopes of work as visualized in Figure 1 below and described in Table 2 above. We conclude this subsection by introducing equity-mindedness and equity-minded change for teaching.

Diversity Work

Diversity efforts typically address the composition of a particular entity (e.g., a department, a student body, a community). In STEM, there is concern that the academic community is largely dominated by white people despite a student body and a society that is not. Thus, diversity efforts in STEM are often focused on increasing the representation of racially minoritized individuals (e.g., Black, Indigenous, Latinx) (Griffin, 2020a). **Most diversity efforts are what organizational theorists would deem first-order changes** (Bartunek & Moch, 1987; Kania et al., 2018), **which focus on change that can be quickly adopted—by doing "more" of what an organization does rather than fundamentally altering conditions within the organization** (see Table 1)**.** The most classic examples of diversity efforts in STEM are those which focus on

increasing the “pipeline” of students interested in pursuing STEM degrees, including enhanced recruitment efforts or funding/scholarships dedicated towards scholars from historically minoritized backgrounds (Byrd & Mason, 2021; Culpepper et al., 2021). Such diversity efforts can make headway in increasing the overall number of racially minoritized students in STEM classrooms. The challenge with these first-order, diversity-focused initiatives is that they pay little attention to the experiences of students within those classrooms, nor to the ways in which classroom structures and culture may undercut student success. Moreover, first-order changes can disappear quickly, for example, if leaders are no longer interested or funding shrinks.

Inclusion Work

Inclusion refers to the extent to which individuals feel welcomed and/or a sense of belonging within a given organizational context (Griffin, 2020a). I**nclusion efforts tend to fall under second order changes, as they focus on small and rather contained alterations to pre-existing practices and relationships** (Bartunek & Moch, 1987; Kania et al., 2018). For instance, inclusion might mean changing syllabi to ensure that racially diverse authors are represented (Fuentes et al., 2021); the line of thinking is that minoritized and marginalized students may benefit when they realize that some of the scholarship that they are reading has been produced by someone who looks like them (i.e., possibility models, Fries-Britt & White-Lewis, 2021). Another example of inclusion work is a faculty member altering their teaching practices such that students are empowered to co-create knowledge alongside the instructor (Killam et al., 2023). Such efforts can (and do) change the experience of individual students within discrete domains (e.g., a specific classroom, a specific department).

Inclusion efforts are typically the result of efforts at the individual (e.g., an instructor's individual decision to revise a syllabus) or programmatic level (e.g., a department deciding to create an affinity group for Black and Latinx students), rather than broader systemic led change. Similar to diversity efforts described above, this means that change can be short-lived and isolated, for example, if the instructor moves to another institution or the sponsor for the Black and Latinx graduate group retires. Additionally, when change is not aligned with the underlying organizational structures and culture (Hora, 2012), it is likely to be marginalized, or to be thought of as "extra-curricular" rather than as part of the organization's core (Kezar, 2018). For example, if an instructor introduces a course to highlight Indigenous thought in their discipline, but the department faculty refuses to adopt the course as a requirement, the inclusion effort remains contained and isolated because the material has not been deemed worthy as "core." Resultantly, students may be less likely to enroll due to time, financial, and other pressures.

Equity Work

Equity work focuses on changing the underlying logics, structures, and culture that maintain inequity and thus qualifies as third order or transformational change (Kezar, 2018; McNair et al., 2020; see Table 2). To be frank, most EDI work has focused on diversity and inclusion (e.g., recruitment efforts, affinity groups, scholar showcases) (Griffin, 2020a, 2020; Liera & Desir, 2023) with fewer efforts anchored in an equity orientation (McNair et al., 2020). This is, we and others suggest, because **equity work demands the deepest and most difficult kind of change. It is the approach that requires new or revised policies and practices, long-term reallocation of resources, and ongoing learning and reflection to shift mental models, or logics**

about how departments, colleges, universities, and/or the profession should work. In this way, equity requires a deep interrogation of the "implicit conditions that hold [inequity] problems in place," (Kania et al., 2018, p. 3) and fundamental recalibrations about what is or what should be normative (Kania et al., 2018; Kezar, 2018).

If we return to the example of the instructor making changes to a course syllabus, equity demands that we consider the logics that underline STEM teaching and learning (e.g., the expectation that scientists are objectively removed from social issues, the understanding that STEM content is neutral rather than connected to political or personal concerns) as well as the rewards structures and processes that incentivize (or de-incentivize) an instructor to make their course syllabus more inclusive. In other words, fostering equity requires change not only at the individual level, but to all the systems that surround those striving for inclusion, such as the professor who modifies syllabi or implements high-impact, culturally responsive teaching methods.

Building on insights in Table 2, the figure below illustrates the variability of EDI efforts, showing that equity focused change must be preceded and/or supported by efforts at other organizational levels.

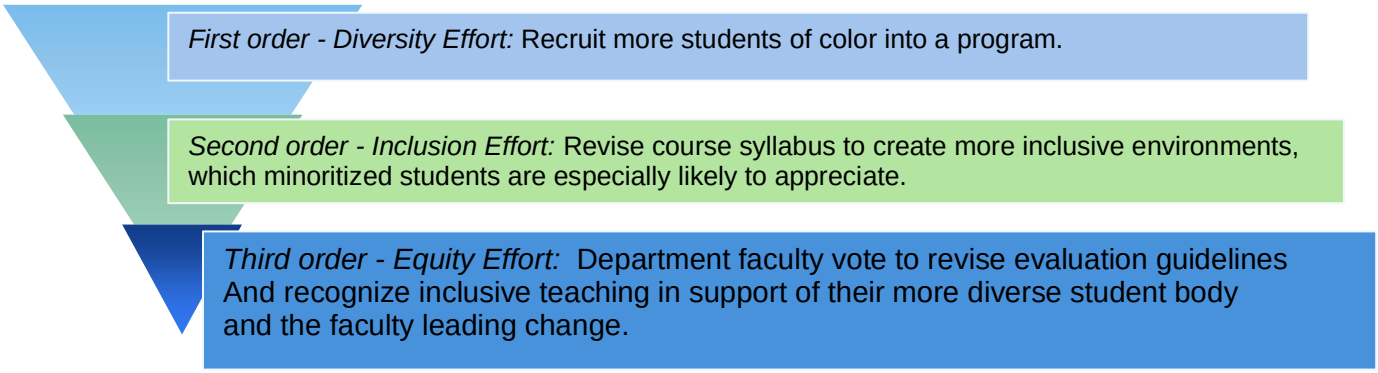

Figure 1.

Mapping EDI Efforts onto First, Second, Third Order Change

Having laid out the array of change work that exists under the EDI umbrella, we now introduce equity-minded change, which foregrounds racial equity.

Equity-Mindedness and Equity-Minded Change

As we have previously laid out, because of the United States', including higher education's connections to colonialism, slavery, and other forms of racial disenfranchisement, focusing on racial equity is an imperative (McNair et al., 2020). Estela Bensimon (2007, 2018) coined the term **equity-mindedness to describe a way of thinking that centers, brings attention to, and seeks to resolve persistent patterns of racial inequity in higher education**. This does not mean, however, that other forms of inequity do not matter; instead, it is a way of understanding that all inequities are racialized— touched by racial hierarchy and racism (Bensimon, 2007; 2018; Ching, 2023; Dowd & Liera, 2018; Griffin, 2020b; Liera, 2020; Kezar et al., 2021; McNair et al., 2020; Rall, 2021; Whitcomb et al., 2021). For example, white women and women of color both report sexism in the workplace, but how they experience sexism varies (Spates et al., 2020). Similarly, in a society that privileges able-bodied people, a disabled white person and a disabled Black person both experience ableism, but in radically different ways (Stephens-Peace, 2021). **In line with these observations, our framework centers racial equity in STEM teaching and learning contexts, as such aims will inevitably improve teaching and learning for all students, including other marginalized communities** (e.g., trans students, disabled students, economically vulnerable students) (National Academies of Sciences, Engineering, and Medicine, 2022).

There are four characteristics commonly associated with equity-mindedness. First, **equity-mindedness is unapologetically race-conscious**, **aware of and knowledgeable about race, racism, and racial equity** (Bensimon, 2018; McNair et al., 2020). Second, **equity-mindedness requires an awareness and recognition of the ways in which racially exclusionary practices are embedded into the everyday logic as well as the structures of higher education organizations** (Bensimon, 2018; McNair et al., 2020). Third, **equity-mindedness calls attention to the importance of using data, and specifically disaggregated racial data, in identifying and therefore addressing inequities** (Bensimon, 2018; McNair et al., 2020). Finally, **equity-mindedness is characterized by a sense of shared responsibility and accountability for advancing racial equity in policies, practices, and norms, meaning racial equity is everyone's responsibility** (Bensimon, 2018; McNair et al., 2020).

Equity-mindedness can be viewed as an ethos, as a kind of practice, and as outcomes. As an ethos, it can inform both individual practice and organizational change. For example, individual faculty members might learn about and use equity-mindedness to guide their instructional strategies (McNair et al., 2020). However, equity–mindedness can also be used as an ethos for diagnosing, motivating, and implementing change across organizational entities (e.g., colleges, universities). In the latter case, equity-minded change agents learn how racism is shaping inequities in order to dismantle "organizational structures, policies, and practices" that perpetuate white privilege and supremacy throughout higher education (Liera & Desir, 2023, p. 3). As outcomes, equity mindedness aims to see that racially minoritized community members are experiencing marked improvements (e.g., graduation outcomes, funding awards,

sense of belonging and ownership of the organizational space) (Liera & Desir, 2023; McCambly & Colyvas, 2023). Equity-mindedness, as alluded to, can be applied at multiple levels, and to various areas of an organization; below, we describe how it has been applied to STEM teaching and learning.

Equity-Minded Teaching and Learning

An equity-minded analysis of STEM teaching and learning reveals many barriers that frequently undermine marginalized and racially minoritized learners in STEM. For instance, in Table 1, above, we highlighted evidence that STEM teaching and learning environments can be confrontational and hostile to racially minoritized and other marginalized community members (Duncan et al., 2023; Ives et al., 2023; Sathy & Hogan, 2022). Additionally, we highlighted that many traditional classroom practices used in higher education, generally, and by STEM instructors, especially, have been shown to decrease student self-efficacy and empowerment; undermine psychological safety; and restrict the development of science identity among racially minoritized students (Duncan et al., 2023; Ives et al., 2023). Aspects of classroom structure, from the syllabus design, to the physical configuration of the classroom, to the ways in which faculty articulate expectations to students, likewise hinder student success and learning (Duncan et al., 2023). Finally, the literature shows that STEM faculty often frame STEM subject matter as disconnected, or removed from applied, personal, or community-based interests, which can dissuade marginalized and racially minoritized students from pursuing STEM degrees (Garibay, 2015; Hernandez, 2021; McGee & Bentley, 2017).

Given the exclusionary nature of conventional STEM teaching and learning environments and pedagogies and their negative impact on racially minoritized community members, change agents increasingly encourage equity-minded

teaching, (Castillo-Montoya, 2020; Hogan & Sathy, 2022; Tuitt et al., 2018; Wofford & Blaney, 2021). **Informed by equity-mindedness, equity-minded teaching brings attention to the ways that teaching and learning practices, policies, and other conditions may serve to perpetuate, rather than dismantle, racial hierarchy and exclusion in STEM** (Ives et al., 2023).

It is helpful to note that equity-minded teaching shares some conceptual and practical overlap with other recent teaching and learning innovations, such as high-impact, inclusive, or culturally responsive teaching. For example, these approaches generally challenge conventional modes of instruction, wherein the professor is viewed as the only holder of knowledge. All these innovations also challenge the notion that disciplinary subject matter is universally meaningful and thus universally understood (Lalujan & Pranjol, 2024; Leyva et al., 2022). Despite some shared similarities, there are also significant differences across these approaches. For example, high-impact teaching practices, such as first-year seminars, experiential learning, undergraduate research, and internships, etc., are concerned with meaningful student experiences and success (Kuh, 2008), but do not necessarily apply a racial analysis for understanding experiences or outcomes. Indeed, multiple studies show that racially minoritized students are less likely to participate in high impact practices compared to white students, indicating systemic access issues (e.g., gateway courses, financial barriers) (Finley & McNair, 2023; Minichiello et al., 2021). Other studies show evidence that programs designed to bring high impact practices to racially minoritized students are often not tailored to their specific needs and contexts (Stewart & Nicolazzo, 2018). With regard to inclusive or culturally responsive teaching, these approaches stress relationality, culturally grounded or experiential knowledge (Jaeger et al., 2024; Sathy &

Hogan, 2022), but do not always stress or attend to racial disparities (Carducci et al., 2024). In fact, some argue that culturally responsive frameworks (e.g., funds of knowledge) have been over-extended in ways that deemphasize their roots in race-consciousness (Gonzalez et al., 2006; Kiyama et al., 2017).

Equity-minded teaching, however, always centers race and the potential racialized impacts of course design, delivery, assessment, and student outcomes (Ives et al., 2023; Tuitt et al., 2018)**.** For example, Bauer and colleagues (2020) described the results of an equity-minded intervention in introductory biology courses. Instructors introduced two new pedagogical practices: active learning and growth mindset messaging. They found that the introduction of these practices "completely eliminated the academic performance gap between Black and white students" (Bauer et al., 2020, p. 19). In another study, Bhattacharya et al. (2020) described efforts to redesign a college algebra course at the University of California Santa Cruz, a Hispanic Serving Institution, including changing course delivery methods and providing academic advising support for students in the course. They found that students' academic performance improved after the redesign and that racial/ethnic gaps in course grades were no longer statistically significant. And finally, Wofford et al. (2023) recently published an equity-minded mentoring toolkit, with evidence-based exercises that faculty and students can use to enhance their mentoring relationship. Table 3, below, provides examples of equity-minded teaching (see Duncan et al., 2023 for a recent meta-analysis).

Table 3.
Examples of Equity-Minded Teaching Approaches in STEM

Examples of Equity-Minded Teaching	
Intentional Data Use	Change “gateway” courses to enhance access and learning for Latinx students (Bhattacharya et al., 2020) • Review student progress and outcomes through a race-conscious lens to surface, inquire, and address gaps (Kerr et al., 2022) • Gauge student interests and aspirations related to courses and/or STEM to design responsive and affirming courses (Rincon & Rodriquez, 2021)
Course Design and Structure	Center racially diverse authors in course syllabi (Tuitt et al., 2018) • Redesign a core course to center Indigenous Knowledge Systems and outcomes, like giving back to one’s community (Anthony Stevens & Matsaw, 2020) • Acknowledge the ways that racism or racial exclusion might have shaped disciplinary content (Grant, 2021) • Enable flexibility/choice and opportunities for self-authorship in student learning assessments (Tuitt et al., 2018)
Classroom and Instructional Practices	Forge authentic, transparent relationships with students (Tuitt et al., 2018; Williams, 2016) • Make connections between lived experiences, cultural knowledge, and lessons (Bhattacharya et al., 2020; Kiyama et al., 2017; O’Neill et al., 2023; Tuitt et al., 2018) • Invite student’s cultural knowledge or practices into the course to make connections (Kiyama et al., 2017)
Cultural Responsiveness and Racial Literacy	Build instructors’ critical consciousness of the ways that race and racial identity shape instructor and student relationships and experiences (Tuitt et al., 2018) • Equip faculty to interrupt racial biases and microaggressions when they occur in the classroom (Duncan et al., 2023) • Create teachable moments around race/racism (Tuitt et al., 2018)

Mentoring and Advising	Set mutual expectations for mentoring relationships (Wofford & Blaney, 2021) • Create mentoring roadmaps for how the relationship between mentor and mentee will unfold (Griffin, 2020b) • Gauge student interests (past, present, future) and acknowledge in mentoring and advising conversations (Burt & Johnson, 2018; Rincon & Rodriquez, 2021)
Out-of-classroom experiences	Invest in resources (e.g., scholarships) to facilitate participation (Ives et al., 2023) • Approach out-of-classroom experiences as opportunity to (re)connect students with their communities, or a community with whom they want to be connected for cultural, personal reasons (Lopez, 2020) • Build reciprocal and meaningful relationships with communities before designing out-of-classroom experiences, be guided and support students in being guided by cultural and community protocols (Anderson & Cidro, 2019; Cidro & Anderson, 2020)

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Notice that the examples in Table 3 could be carried out at the individual and/or broader organizational level (e.g., by an entire department). However, to engender transformative, or what we call third order change, **equity-minded teaching must be fostered not only by individuals, but supported by the systems and conditions that surround individuals and their efforts.**

In summary, in this section, we shared that there are various kinds of organizational change (e.g., first, second, and third order change). Change agents must be cognizant of the kind of change they are mobilizing as each entails different scope and strategy. We also noted that EDI work is a unique kind of change work with its own variances, all of which can be mapped onto the first, second, and third order change schema. Readers may want to revisit Table 2 and figure 1 to review this element of our argument. Finally, in this section, we introduced and defined equity minded change, noting that while it is a promising pathway to supporting racially minoritized students and faculty who are interested in EDI work, it is also the most difficult given its scale and given the emotional and cognitive demands associated with such work. With this in mind, in the next and final section, we offer a framework that change agents can use to design, introduce, and foster equity-minded change in STEM teaching and learning contexts. We account not only for the history of higher education and its highly professionalized conventions but for challenges that often arise when EDI change is introduced.

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Section III: Synthesizing the Research: A framework for Equity-Minded Change across and within STEM's Teaching and Learning Contexts

One might wonder why, given the broad interest, creating STEM spaces where minoritized and marginalized students can succeed has proven so difficult—especially in light of the many examples and positive evidence for teaching innovations, including equity-minded teaching. As we shared above, equity-minded teaching, which brings attention and seeks to remediate the ways that teaching and learning practices, policies, and other conditions perpetuate racial hierarchy and exclusion in STEM (Ives et al., 2023) has grown in popularity and proven to be effective by many measures. Successful efforts include those that focus on enhancing faculty awareness of racial equity gaps in the classroom (Thoman et al., 2021); to infusing Indigenous knowledge and research methods into course content (Anthony-Stevens & Matsaw, 2020; Bhattacharya et al., 2020); to enhance clarity and expectations for graduate student performance in culturally and race conscious ways (Fisher et al., 2019).

Here, we propose a framework for designing, delivering, and sustaining equity-minded change in STEM teaching and learning contexts (see figure 2 below). This framework is derived from the literatures reviewed above: organizational, and specifically, systemic change (Kania et al., 2018), equity-minded organizational change (McNair et al., 2020; Kezar, 2018; Liera & Desir, 2023), as well as literature on the history of higher education, the academic profession, and the disciplines (Austin, 1990; Culpepper et al., forthcoming; Bastedo, 2012). These literatures reminded us that **there are many kinds of change** (e.g., first order, second order, and third order) and **many levels at which change can be fostered.** Indeed, our framework shows (see Figure 2 below) that equity-minded change requires work—often simultaneously— across

multiple nested contexts: 1) the individual, 2) the department, 3) the college/university campus, and 4) the profession—all of which are shaped by the histories outlined earlier.

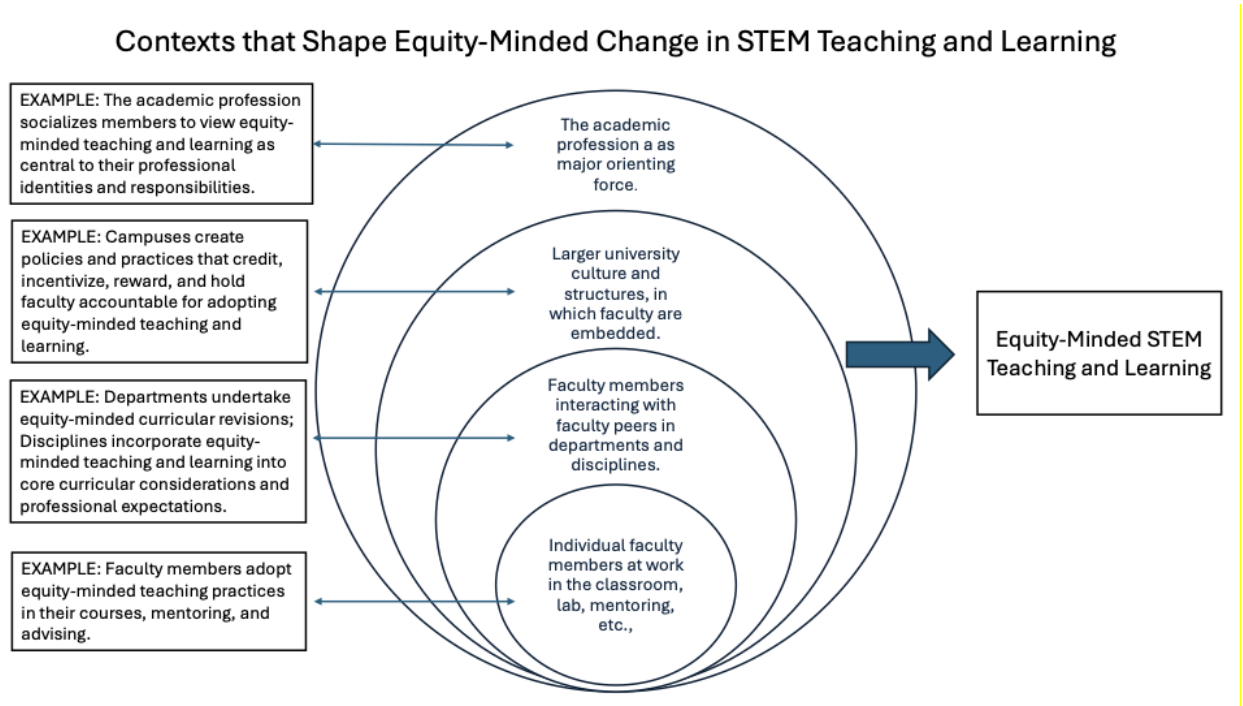

Figure 2.
Contexts to account for in Equity-Minded Change in STEM Teaching and Learning

For example, a faculty member might be ready and willing to adopt equity-minded teaching practices, but sustaining and scaling such practices requires work all around that individual faculty member. For the change to take hold and transcend one faculty member's classroom, department and college colleagues, including academic administrators, must be supportive. Of course, such supportive work would involve policy reform and resource allocation, but it would also demand a willingness to consider how logics underlining STEM subject matter, teaching, and learning have contributed to racial exclusion and marginalization. In this way, organizational members must be willing to grapple with the legacies of colonialism and racism that informed and continue to shape higher education, including how many contemporary academics go

about, are rewarded for, and reward others for their work. In what follows, we leverage our framework to consider the barriers and the possible facilitators of equity-minded change at various levels: the individual, the department/disciplinary, the campus, and the profession.

Individual

In our framework, the individual level is conceptualized as a faculty member. Organizational change and equity-minded literature suggest multiple factors can shape the willingness, capacity, and effectiveness of individuals to change. Drawing from the general organizational literature, organizational members need to be aware of organizational problems, committed or motivated to take action, and have a sense that change can be achieved (i.e., efficacy) (Kezar, 2018; Weiner, 2009). For example, studies show that often organizational members need to be persuaded, through leader behavior, organizational communication, and change champions, that the organization has a concrete, viable plan for change before they will become committed to the process (Kezar & Eckel, 2002).

Potential Barriers

The literature suggests many barriers that may stifle, impede, or otherwise undermine individual faculty engagement in change, particularly change that entails racial redress. Specifically, researchers have come to understand that racial equity work requires more than awareness and commitment. As was foregrounded in the equity-minded change section, **numerous studies show that individuals involved in racial equity work need to have developed a critical, race consciousness regarding race, its role in higher education, and their own positionalities within those**

systems (Bensimon, 2007; McNair et al., 2020; Ueda et al., 2022)[3]. Such research shows that in order to embark on this kind of change, faculty members must have deep fluency in racial equity issues and the ability to talk about these issues across multiple stakeholder groups (James-Gallaway & Wilson, 2023; Liera, 2023; Peña, 2012; Ueda et al., 2022). Unfortunately, King et al., (2023) interviewed 39 STEM instructors and found that a majority refused to acknowledge racist events that had unfolded in their classrooms, and often exacerbated the event due to their non-reactions.

Relatedly, **several studies reveal discussions of race and racial equity are often highly emotional experiences, ones that bring up feelings of discomfort, guilt, and shame for white people and anger and resentment for People of Color** (Gonzales et al., 2021; Liera, 2023; Sue, 2016; Vigil et al., 2023). Indeed, Gonzales and colleagues found that, even in the explicit context of EDI interventions, both white and minoritized faculty members are highly uncomfortable about naming racism and acknowledging its manifestation in localized contexts (e.g., one's department). Moreover, studies show that when faculty do undertake equity-minded teaching they often find it to be cognitively, emotionally, and culturally taxing (Liera, 2023; Padilla, 1994). In sum, individuals that set out to employ equity-minded change must be prepared to deal with emotions involved in the work (Sue, 2016; Vigil et al., 2023). Such new learning and unlearning demands extensive labor, time, and energy intensive, and if faculty assume their efforts will go unrecognized, they may temper their engagement or opt out altogether.

[3] Researchers sometimes use terms like racial consciousness (Ueda et al., 2022) and racial literacy (Douglass Horsford, 2014), among others. For our purposes, we consider all of this to be part of equity-mindedness in the spirit of Bensimon (2007).

Additional barriers are related to faculty members' status as experts and professionals. For example, academics built and continue to solidify their status as experts through disciplinary informed routines (e.g., peer review), which as we discussed earlier, are anchored in Eurocentric values, such as objectivity and neutrality. These values shape how STEM faculty have been socialized to understand not only STEM subject matter, but how STEM faculty have been encouraged to frame STEM work, more generally (McGee, 2020; Perez et al., 2023). **When STEM faculty do not see equity, diversity, or inclusion as related to their scientific expertise, or when they believe it is inappropriate to consider how contemporary STEM contexts are tied to racial inequities, either through exclusion in the classroom or broader phenomena like environmental racism, they are likely to mobilize disciplinary logics and refuse to legitimize peers who do seek to advance EDI considerations** (Gonzales et al 2024b; Liera & Hernandez, 2021; O'Meara et al., 2023). Moreover and relatedly, when STEM scholars do not see EDI as part of their professional responsibilities, they may develop problematic mental models (Kania et al., 2018) that prevent them from considering how they contribute to racial exclusion. In fact, faculty members often cite the lack of diversity in STEM as a pipeline problem rooted in the K-12 schools (Griffin, 2020a). Said otherwise, STEM faculty refuse to acknowledge that they have a hand in preparing STEM educators and also that their admissions processes or course conventions (e.g., gateway courses) undermine racial equity.

Potential Opportunities

Despite the numerous and varied barriers, change agents have managed to support individuals—both willing and hesitant— through well-designed, well-resourced educational interventions. While most colleges and universities now offer workshops on

inclusive pedagogy or disrupting classroom microaggressions (Castillo-Montoya et al., 2023; Sathy & Hogan, 2022), the literature suggests that single trainings or workshops often do not move the needle and can actually be more harmful than helpful (Dobbin & Kalev, 2016, 2018). Instead, **evidence suggests that long-term professional development (e.g., over a semester or year) is needed and ensures more likelihood of success** (Bifulco & Drue, 2023; Castillo-Montoya et al., 2023; Kerr & Handelsman, 2021; Hakkola et al., 2021). For example, Hakkola et al. (2021) examined the impact of a semester-long faculty community of practice aimed at enhancing equity-minded teaching. They observed that the community of practice helped faculty develop an understanding of pedagogical practices that promote equity while also increasing their motivation to change and engage in the work beyond the classroom (Hakkola et al., 2021).

Furthermore, there is evidence to suggest that the introduction of such teaching practices can serve as a kind of gateway for developing greater equity-mindedness in faculty, overall (Castillo-Montoya et al., 2023). For example, multiple studies show that although faculty members may initiate equity-minded reforms to their courses with the goal of addressing/meeting the needs of their students, faculty members are simultaneously engaging in a process of deep learning and unlearning about new paradigms and epistemologies that they had likely not been exposed to previously (Anthony-Stevens & Matsaw, 2020; Lopez, 2021). Such results suggest that engagement with and in equity-minded teaching practice has the potential to contribute to larger shifts in the way that STEM knowledge is produced overall, or what some might describe as enhanced epistemic inclusion (see Gonzales et al., 2024b; Settles et al., 2021).

In sum, while there is ample evidence that faculty members as individuals can and do engage in equity-minded teaching, there is less evidence about the ways in which these new approaches to teaching are received and facilitated within their organizational contexts, which we tackle next.

Departments

Departments are important spaces; they serve as the building block for faculty careers (Austin, 1990). Students, especially advanced majors and graduate students, also spend extensive time in the department space (Golde, 2005). Departments, which are constituted by faculty members, play a critical role in evaluating and thus in advancing individual faculty members. As discussed earlier in sections one and two, in most university contexts, department faculty hold great autonomy in terms of identifying priorities, resourcing those priorities, and in designing and delivering curriculum. Thus, in designing change, it is important to understand departments as sub-organizations — with their own governing logics, structures, and cultures.

Potential Barriers

On college and university campuses, academic departments are the organizational manifestations of the disciplines. Unfortunately, as already alluded to, disciplinary norms can serve as barriers to adopting equity-minded teaching in STEM fields. As we have already discussed, many STEM fields are rigid in their view that European, or western, modes of knowledge production are superior. There is often high consensus within these fields about the ways that research and therefore knowledge can be demonstrated (Braxton et al., 1996, 1998; Shadle et al., 2017). **Studies show that faculty members in such high consensus fields are often less likely to be invested in improving their teaching in general (Braxton et al., 1996, 1998),**

nevermind adopt equity-minded teaching approaches. As such, many STEM faculty members would not likely prioritize or make the connection between science and, for example, culturally responsive or equity-minded teaching.

A department's curriculum may likewise reflect such discipline rigidity. In many STEM fields, there are expectations that students will develop a common set of competencies by taking certain required courses that use predetermined assessment strategies in a specific sequence (Yother et al., 2022), which undermines the extent to which even the most equity-minded instructors can make deviations from the curriculum. **To be clear, the point here is not that disciplinary expertise should not be used to develop the curriculum or inform teaching practices. Rather, when norms that underlie curricular decision-making are harmful yet perpetuated without critical equity-minded interrogation, inequities are held in place** (Posselt et al., 2020). As such, any equity-minded change initiative needs to account for the ways in which disciplinary norms shape the willingness of department faculty to engage in change and the extent to which change is incentivized and/or accepted within disciplinary informed departmental policies and processes, such as hiring, tenure, and promotion. For example, Gonzales et al. (2024b) reviewed the literature on academic hiring and found that across **all** disciplines, hiring practices and patterns tended to be more similar than different. All fields, regardless of demographic diversity, demonstrated a propensity for "prestige seeking" or "prestige maximization," leading committees to rely on disciplinary logics and metrics that perpetuated racial inequalities. As such, change agents need to be prepared to hear out disciplinary-driven narratives of resistance and also point out how such narratives maintain exclusion.

Related to the desire for prestige maximization, barriers reflecting risk aversion and fear of change might also surface at the department level. For example, faculty members may worry that if their department adopts curricula or teaching methods that do not align with disciplinary norms and expectations, their program's reputation, and perhaps prestige, may suffer (O'Meara et al., 2023). Indeed, higher education is known for being risk evasive, and the STEM disciplines are no exception (O'Meara et al., 2023). For instance, there is significant evidence of the Mathew effect in many STEM fields, the phenomenon wherein researchers who have already received grant-funding are more likely to subsequently receive more (Katchanov et al., 2023; Qiu, 2023). In part, the Mathew effect is an outcome of risk-averse decision-making: grant-makers view veteran grantees who have an established track record of success as much safer compared to grantees that have no such track record. Unfortunately, risk aversion often undercuts opportunities to diversify faculty and knowledge production.

In the context of a department, faculty may be hesitant to amplify and support any reforms that seem to diverge from disciplinary norms. For instance, although there are numerous calls for interdisciplinarity, the research has repeatedly found departments lack the frameworks for understanding and appreciating such scholarship and often end up marginalizing faculty and students that do interdisciplinary work (Holley, 2015; Mäkinen et al., 2024; Settles et al., 2021). That is, disciplinary norms shape the extent to which some faculty's members ' scholarship is viewed as too "risky" or "edgy," which can then shape how they are evaluated with departmental (e.g., hiring, tenure and promotion, rewards) (Besson, 2021; Gonzales et al., 2024b; O'Meara et al., 2023) and other disciplinary contexts (e.g., grants, disciplinary awards). Because some have found that marginalized scholars often (though not always) hone interdisciplinary

interests, given that they are often navigating western epistemic dominance from a marginal position and thus bring different ways of knowing and thinking together as they analyze the world, such resistance to interdisciplinarity is an equity concern with racialized and gendered implications (Collins, 1986; Gonzales, 2018; Hernandez, 2022; Rhoten & Phirman, 2007).

Potential Opportunities

There are a few examples of equity-focused change interventions at the department and/or disciplinary level. One study conducted in the two-year college setting found that department-based communities of practice focused on inequities in geosciences were able to completely close or significantly reduce racial gaps in student outcomes (Ormand et al., 2022). Leydens and Lucena (2017) likewise described the efforts of multiple engineering departments to integrate equity-minded teaching and learning into their curricula. Specifically, these engineering departments leveraged universal design and created multidisciplinary courses that made clear the connections between engineering and social justice. These departments, working as a collective, implicitly operated as a learning community and thus provided a safe context in which they could co-learn from similar minded colleagues — task risks, ask questions, and make errors without significant failure or risk. In fact, some suggest that in higher education, learning communities, networks, or alliances can serve as a buffer for prestige pressures (e.g., disciplinary influences, Matthew effects) (Teeter al., 2011).

Similar departmental efforts have been observed in fields like chemistry (Muñiz et al., 2021), mathematics (Bhattacharya et al., 2020), and biology (Bauer et al., 2020), among many others (Johnson & Elliot, 2020). These departmental successes, which foreground collective engagement and investment offer a bit of a roadmap for change in

other departments, in particular, for changing the departmental norms and expectations about how faculty members engage in teaching and mentoring.

At the same time, many equity-minded teachers (including those working in collectives) and scholars argue that the effort associated with this work is often not recognized in departmental workload and rewards (Castillo-Montoya, 2020; Padilla, 1994; Park, 1996), which limits the extent to which such changes might be institutionalized. For that reason, we suggest that equity minded efforts, including those in support of teaching, must be complemented by equity-minded evaluative practices and policies. Thus, we highlight one particularly effective intervention that targeted department workload (O'Meara et al., 2018, 2021). In this intervention, researchers worked with STEM departments in a range of institutional types (research universities, regional comprehensives, baccalaureate colleges, and Historically Black Colleges and Universities) to help department members a) review data on the distribution of faculty workload, including the distribution/intensity associated with different kinds of teaching and b) put in place equity-minded workload policies (O'Meara et al., 2021). Policies included those that gave credit to department faculty who were engaged in intensive, EDI and teaching-focused work (O'Meara et al., 2021). **Cumulatively, these department-focused efforts show that changes in teaching practices are possible, but ultimately need to be reflected in faculty workload and evaluation policies if the goal is to transform rather than support isolated initiatives.**

In this regard, chairs or units heads can also serve as a critical lever for change at the department level. Chairs play a key role in many decisions that shape the environment for teaching and learning in a department, including but not limited to making course assignments, proposing new majors/minors, allocating departmental

resources, hiring faculty, stewarding faculty evaluation processes and procedures, preparing for accreditation, among others (Collins & Olesik, 2021; Dowd & Liera, 2018). Although there is some evidence about the impact of department chair training related to gender equity in STEM (Gardner & Ward, 2018; Greene et al., 2011), less attention has been paid to the role that department chairs can play in, for example, making disaggregated student outcome data available to faculty members to help assess places where their teaching could be improved, ushering systematic reviews of the curriculum, among other equity-minded teaching practices (Collins & Olesik, 2021). Focusing on professional development for chairs offers much promise in enhancing equity in STEM teaching and learning but remains largely unexplored in research.

Finally, change agents should pay attention to the role of disciplinary and other professional associations in spurring and supporting equity-minded teaching and learning. Although we noted above that disciplinary norms and expectations can underpin faculty resistance, disciplinary association and disciplinary-based efforts can also fuel change. Several recent grant-funded initiatives focus on building networks among equity-minded educators in specific disciplines (e.g., geosciences; mathematics, chemistry, biology) with the explicit goal of enhancing faculty members' awareness of racial equity gaps in STEM undergraduate education and capacity to meaningfully change their teaching practices (e.g., Leibnitz et al., 2021; Holm, 2016; Sachmpazidi & Henderson, 2023). For instance, the Inclusive Environments and Metrics in Biology Education and Research (iEMBER) is a national network of biology educators that has convened communities of practice and developed resources with the explicit focusing of transformation biology education (Tennial et al., 2019). These efforts aim to leverage the socializing power of disciplinary communities to shift teaching norms and

expectations among members. Although disciplinary-driven efforts seem promising, little evidence exists about their presence, impact, and to our knowledge, no research has explored the extent to which departments actually draw on such disciplinary-driven efforts.

College or University Campus

Faculty and departments do not operate in a vacuum, but in campus contexts. These campus contexts vary in many ways— by size, academic mission, location, and of course, institutional type. Thus, there are some specific barriers to and opportunities for equity-minded teaching related to campus context, as discussed below.

Potential Barriers

Overall, it is necessary to remember that colleges and universities are generally large highly bureaucratic organizations. In this way, barriers that surface in relation to change in any bureaucratic organization tend to hold in the higher education context as well. As discussed earlier, change leaders must be prepared to communicate about intended change efforts repeatedly and with consistent language for a long period of time. And yet, at the same time, change leaders should also anticipate that the change effort will need to be reframed or interpreted in nuanced ways for different contexts. For example, an equity-minded initiative would likely need to be framed differently in a STEM college versus a College of Education (Liera, 2020). Moreover, change leaders must be aware of local political contexts, especially when it comes to fostering change in service equity, diversity, and inclusion. In recent years, legislators, often imbued in white racial resentment (Taylor et al., 2019), have sought to punish campuses for pursuing diversity related work, both by making such work illegal and/or defunding higher education (Abrica & Oliver Andrew, 2024; Taylor et al., 2019). These contexts

clearly impact if and how campuses engage in EDI work, as well as the extent to which that work affects meaningful change. Altogether, change leaders must be aware of the usual inertia and also attuned to local racialized politics and hostilities.

In terms of higher education specific barriers, campus-level faculty evaluation policies and processes can stymie change. In most research-intensive institutions (Griffin et al., 2013; Park, 1996), as well as institutions that wish to move up in the research rankings (Gonzales, 2015), tenure-system faculty members are not incentivized to invest much effort in improving their teaching at all (Braxton et al., 1996), and especially in equity-minded ways that may involve more emotional labor (Castillo-Montoya, 2020). In comprehensive university contexts, non-tenure-track faculty members (who are more likely to be racially minoritized faculty) are doing the bulk of instructional and other student-facing work (Baldwin & Wawrzynski, 2011; Boss et al., 2019), including equity-related teaching and service. These faculty are often devalued (Boss et al., 2019) and do not have the same autonomy nor power that tenure-track counterparts hold. Given this, if institutions do not have in place intentional language, metrics, and processes for appreciating equity minded teaching, faculty members who make equity-minded changes to their courses are not given credit or recognition for their effort, and faculty members who advocate for wide scale, equity-minded curricular change may be viewed with skepticism or considered to be wasting their time.

In other institutional types, different challenges emerge. Although most colleges and universities are under financial strain (Mitchell et al., 2019), community colleges, regional colleges and universities, tribal colleges, and many Historically Black Colleges and Universities (HBCUs) - institutions that enroll significant numbers of racially minoritized students in STEM - are chronically underfunded (Orphan, 2018; Palmer et

al., 2013; Varty, 2022). This means that faculty members in these contexts often have limited access to professional development resources, data, or other institutional supports that can encourage the uptake of equity-minded teaching practices (Toldson, 2019; Varty, 2022) or support their ongoing implementation (Ward et al., 2014). Similarly, faculty at these institutions often have intensive teaching loads, and therefore less time to engage in such opportunities even if they are available (Varty, 2022). It is also worth noting that some universities try to compensate for lack of resources by pursuing greater research productivity (Gonzales, 2015; Orphan, 2018; Warsaw et al., 2020). In doing so, these institutions may reallocate resources in ways that undermine racial diversity of the overall student body (Warsaw et al., 2020) and incentivize faculty to invest more time in research than teaching and mentoring (Gonzales, 2015).

Institutional context may also shape the efficacy of common equity-minded practices. While a community-based field experience that highlights the power of Indigenous methodologies for understanding climate change (Anthony-Stevens & Matsaw, 2020) may be appropriate for traditionally-aged college students who are interested in field based research, similar intensive opportunities are likely not possible or relevant to community college students, who are more likely to be older students, caregivers with familial responsibilities, and working full or part-time (Varty, 2022). Thus, community college faculty would have to consider how best to respond to their students. Similarly, researchers have observed that just because an institution enrolls a demographically diverse student body, it is not inherently equity-minded nor poised for equity-minded teaching. For example, Black students in STEM fields who attend HSIs have reported unique forms of classroom and out-of-classroom discrimination (Brooms,

2021; Choi et al., 2023). Indeed, it is for such reasons that equity-minded change stresses race conscious data collection and analysis. Change agents need to be keenly aware of the ways in which context will shape the way equity-minded teaching is received as well as the way equity-minded teaching and learning needs to be tailored.

Potential Opportunities

While campus contexts may feel particularly unwieldy, it is helpful to note that institutional types are still uniquely promising spaces for equity-minded work. For example, although Minority Serving Institutions are a highly diverse population of colleges and universities, **there does appear to be great momentum amongst this sector of higher education to ensure that they are in fact, serving, rather than simply enrolling racially minoritized communities** (Garcia, 2019; Mitchneck et al., 2020). **Such campaigns to serve rather than enroll are decades old by now, but MSIs are recognizing that presence of diversity is not sufficient and that culture matters more than a designation.** Thus, it may be surprising to know that some efforts to improve EDI within MSIs often mirror efforts in other institutional types. For instance, we previously described efforts by Bhattarcharya and colleagues (2020) to redesign mathematical education at the University of California Santa Cruz (UCSC) to be more culturally responsive. The authors note that efforts resulted in increased academic success for racially minoritized students. However, Bhattarcharya and colleagues explicitly stated that UCSC's status as a Hispanic-serving institution (HSI) not only animated the change, but was one of the key ways that they, as change agents, were able to appeal to other faculty that change was needed. Said another way, aligning equity-minded change with institutional values and mission can be a particularly effective change strategy.

Because Historically Black Colleges and Universities and Tribal Colleges and Universities were founded with the express purpose of advancing Black and Native learners, there is much to be learned from some of these institutions. Researchers argue that the overall environment for teaching and learning at some HBCUs centers Black student success, from the way that faculty and students interact, to the asset-based curriculum, to the relationships built between universities and their community (Palmer et al., 2013; Williams & Taylor, 2022). Palmer et al. (2010) observed that many STEM degree programs at HBCUs are fundamentally grounded in student development and retention theories (e.g., involvement theory; identity development), which is a significant departure from the disciplinary-driven approach in most predominantly or historically white institutions (HWIs or PWIs). Similarly, tribal colleges have always honed culturally informed and place-based STEM curriculum models, including undergraduate research (Ward et al., 2014) and course redesign (Caughman, 2022). Similar to findings from HBCUs, research in this area suggests that tribal colleges contribute not only to Native student success, but are sites of epistemic inclusion, meaning there are efforts to expand who counts as a knower and what kinds of knowledge are welcome within a curriculum. For instance, Talahongva (2018) described how some tribal colleges welcome tribal elders as key knowledge holders, integrating their wisdom into all teaching and learning spaces.

Change agents in predominantly white institutions (and in some MSIs) need to be concerned with decentering whiteness in the organizational culture (Ray, 2019) to one that is foundationally and unapologetically equity-minded (Liera & Desir, 2023). Researchers, scholars, and change agents have spent significant time identifying the strategies or levers for changing organizational culture (e.g., Kezar & Bernstein-Serra,

2020; Laursen & Austin, 2020). Although the models for such change are numerous, the research suggests a few common suggestions (e.g., Kezar & Holcombe, 206; Miller & Fairweather, 2016; Santangelo et al., 2021). For example, when possible, an institution should leverage leadership at multiple contexts (e.g., multi-layered leadership) (Kezar & Holcombe, 2016). Campus leadership should also identify champions who can translate change agendas in context-meaningful ways, thus increasing coalitional energy and support for the effort (Miller & Fairweather, 2016). Ueda et al., (2023) stresses the importance of investing in learning and unlearning for all relevant stakeholders.

All this to say, campus level conditions and the coordination of interventions matter in equity minded change. For example, equity minded change stresses the use of data; thus, institutions must invest in, or fine tune, their data infrastructure such that faculty, departments, and colleges are regularly provided with disaggregated racial data on student learning and success outcomes (Meraz, 2022). To this point, Meraz (2022) described an effort in the California community college system wherein faculty were given access to an equity dashboard that allowed faculty to view the academic performance of their students based on gender, race, and ethnicity. These data, along with targeted professional development resources and communities of practice, allowed faculty to diagnose issues in their teaching and make improvements (Carlson, 2022; Meraz, 2022).

Indeed, **we suggest that equity minded change, generally and more specifically in support of teaching, is most likely to take hold when institutions simultaneously invest in first, second, and third order change.** For instance, an institution might invest in the recruitment of racially minoritized students (e.g., first order change), allocate resources to curriculum reform efforts through, for example, the

creation of teaching and learning centers that focus on equity-minded teaching (e.g., second order change), and reform faculty evaluation in ways that will support equity-minded teaching (e.g., third order change) (Marbach-Ad et al., 2016; Miller & Fairweather, 2016). However, **we emphasize that without changes to campus-level faculty evaluation policies, including workload, annual and merit review, and promotion policies, it will be difficult to move equity minded teaching into the core of an institution.** Some campuses have changed faculty evaluation policies to emphasize and legitimize the scholarship of teaching and learning and make available resources that encourage departments to hire faculty who do disciplinary-based teaching and learning research and scholarship (Dolan et al., National Academies of Science Engineering and Medicine, 2020; Molinaro et al., 2020). Similarly, some scholars have advocated for multiple pathways to tenure and promotion, including creating specific pathways for scholars who engaged in equity-minded teaching and learning (Francisco-Menchavez et al., 2022; Gibau et al., 2022; O'Meara et al., 2021). All of these reforms send the signal that at an institutional level, equity-minded teaching and learning, and the faculty who engage in it, are valued, which can act as both a catalyst and a lagging indicator of change.

A final important note about change concerns not only resource investments, but how campus leadership frames change efforts. In the context of EDI, and specifically equity minded teaching, campus leadership must be able articulate the difference between diversity, inclusion, and equity and must be able to share why each is an important goal and part of an overall strategy to make higher education a more inclusive space that is capable of fostering data-driven, equity minded change.

Profession

The final context that we account for is the academic profession. The academic profession, writ large, is an institution, like “the church” or “the law.” Faculty members’ status as professionals underlines, or anchors, not only their academic freedom but their discretion to accept or reject certain ideas, practices, values, or agendas, including the relevance of EDI.

Potential Barriers

As we introduced above, the academic profession and STEM academics in particular are guided by norms grounded in Eurocentric ideas and racial hierarchy. These norms are role modeled by faculty members to students in their classroom and mentoring practices; reflected in institutional logics and rules; and grounded in the overall culture of STEM. One of the most prevailing norms that serves as a barrier to equity-minded change in STEM teaching and learning is the myth of meritocracy. Professors assume that because they have worked hard and have been successful, the system must be fair, only rewarding the best and the brightest (Blair-Loy & Cech, 2022; Grindstaff & Mascarenhas, 2019; Liera & Hernandez, 2021). For example, Blair-Loy and Cech (2022) interviewed 500 STEM faculty members and found that faculty members across disciplines, races, and genders—even those who had experienced identity-based exclusion—were steadfast in their belief that the peer-based system of evaluation in science created the most innovative, excellent, and objective forms of knowledge possible. Because this norm is so deeply entrenched, critiques of the academic profession—including its ties to colonialism, its racialized history, the ways knowledge is produced, and the way teaching is conducted (Liera & Hernandez, 2021; Ray, 2019)—are viewed as attempts to discredit and undermine the very system that granted faculty members their autonomy and power.

Stemming from the myth of meritocracy, many faculty members, particularly in STEM, do not view equity, diversity, and inclusion— in any form or context—as relevant to their work. This, too, emerges from norms within the profession. Multiple studies show that many STEM faculty pursue their science in devotional, nearly, monastic manner (Blair-Loy & Cech, 2022). While seemingly neutral, this monastic "removed" devotion to science is likewise grounded in western conceptions of what it means to live a meaningful life. In the context of STEM and academia, studies have shown that some scientists cannot untie themselves from work and thus place great weight into their professional standing (Blair-Loy & Cech, 2022; Davies & Frink, 2014; Tuhiwai Smith, 2012). As such, especially for faculty in disciplines where the connections between their disciplinary-based work and equity issues are less clear, EDI work, including equity-minded teaching, is often viewed as at best a distraction and at worst, a waste of time (McGee, 2020; Perez et al., 2023).

Potential Opportunities

In many ways, change across the academic profession is an outcome of the systemic and equity-minded change that needs to occur among individual faculty members, within departments and disciplines, and on campuses, as we discussed above. Researchers have observed that norms that exist within professions tend to change when individuals observe others in their social group exhibiting different behaviors (i.e., individual-level change); when they view these behavior changes being adopted collectively (i.e., departmental & disciplinary change), and when they receive institutional rewards that validate and legitimize the change (i.e., college, university change) (Tankard & Paluck, 2016). Given the multiple levels of change that are required to affect norms at such an institutional level, this kind of change is often slowest. To

date, there is not extensive work on the academic profession, probably because it is such a massive institution with such variance, it is difficult to study. However, researchers might consider the presence and prevalence of EDI efforts across academia's many professional bodies (e.g., disciplinary) or professional associations (e.g., *American Association of University Professors*). As discussed earlier, professional bodies send signals to faculty, graduate students, and campuses about what is acceptable; when these bodies adopt certain language or change efforts, it is important to examine how well academic administrators, academics, and other stakeholders take note.

Concluding Summary

In sum, to address the lagging diversity, chilly climates, and uneven student outcomes in STEM, we have made the case for equity-minded teaching. In line with its original conceptualization, **we position equity-minded teaching and learning as necessary for addressing the historical legacies of colonialism and racial hierarchy which have yielded racial exclusion in higher education generally and STEM specifically.** This does not mean that other forms of inequities do not matter, but in foregrounding a racial analysis, change agents account for the fact that all inequities are touched by race and racism. A white trans* student will experience transmisogyny and a trans* student of color will experience a racialized version of transmisogyny. Both forms of exclusion matter and have no place in higher education contexts, and yet they are qualitatively different. Thus, as we argued earlier, centering race allows for a more nuanced analysis of all kinds of exclusion, overall.

Mindful of the difficulties in making and sustaining change, especially third order change like normalizing equity minded teaching, we argued that **change agents need**

to consider the layered and historically informed contexts through which equity-minded change must pass. In each context (faculty member; individual; department and discipline; college or university; and profession) we identified potential barriers that change agents should be aware of, but also pointed to potential opportunities (e.g., models, examples, frameworks) that could be maximized or leveraged. Although there are many lessons, we highlight a few takeaways that may be especially important for steering institution wide equity minded efforts:

- Individuals must have explicit and ongoing opportunities for learning, unlearning, reflection, and they must be prepared for the emotional load that comes with EDI work, generally, and equity work most specifically—particularly when one must consider how their professional socialization and status is imbued in colonialism and racial exclusion. Individuals deserve to feel assured that their efforts will not go unseen, meaning they will look to their departments, disciplines, and campuses for support.
- At the department level, research suggests that collective work is critical. Departments, like higher education overall, are often risk averse, but working in collectives can provide a safe haven for learning, trying out new ideas and practices, and buffering the powerful influence of the disciplines. When departments are able to collectively develop race conscious, equity minded practices, they should immediately look for ways to value such work in their evaluative and reward policies.
- At the campus level, change agents must identify champions to carry and translate the change message in context-relevant ways. In line with equity-mindedness, data should drive the analysis and messaging but data must be

melded into a story that will resonate with different campus communities. Coordinating complementary efforts at each level of the campus is critical, so that first, second and third order change can move in tandem at the individual, department, and campus wide level.

- Like other institutions, the academic profession is knowable without being touchable. In this sense, it is a powerful force that was built through faculty efforts to assert expertise and claim control over several domains of work (e.g., teaching, research, and service). Historically speaking, the academic profession has not articulated EDI as part of faculty work roles or responsibilities. As campuses, departments, and individuals engage in change, it is a matter of research to explore if and how the profession also responds and provides positive (or otherwise) reinforcement.

Although change seems daunting, it is important to point out that the literature suggests that faculty engagement in equity-minded teaching may prime them to become more attuned to the big and small ways that racial exclusion is perpetuated in STEM **and** to the possibility that they can be a part of, and are in fact, responsible for fostering change. We believe that equity-minded teaching and learning, with its emphasis on cultural responsiveness, its openness to interdisciplinarity and connection to communities and problem-solving is a critical strategy not only for recruiting, retaining, and supporting minoritized students and faculty, but it is also a lever for producing more robust, inclusive, and creative knowledge work. Change agents interested in fostering racial equity in STEM teaching and learning should consider equity-minded teaching. It will demand work across multiple levels and contexts. It will also require a commitment to learning, and unlearning, and perhaps most importantly, a

willingness to unsettle the logics, structures, and cultures that have kept racial inequity in place.

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