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# Culturally Relevant and Responsive Education: A Re-Examination of the ISEE Equity & Inclusion Theme

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## Abstract

The lack of diversity in science, technology, engineering, and mathematics (STEM) is a complex problem, and one dimension is the experiences that students from marginalized groups often have in classroom environments. Students cite their struggles to negotiate between their own cultures and STEM's cultures as a reason for why they do not feel a sense of belonging and identity as a person in STEM. To address these challenges, educators and researchers have proposed various frameworks to transform education. In this article, I re-examine the ISEE Equity & Inclusion (E&I) Theme in comparison to culturally relevant pedagogy and culturally responsive teaching models. While these frameworks have many common elements, including their emphasis on students' achievements, building on students' cultural assets, and providing scaffolding for content and practices, they differ in their focus on cultural pride and identities of critical consciousness. Drawing on these differences, I suggest directions for instructors who are familiar with the ISEE E&I Theme on how to make their approach to equity and inclusion more robust.

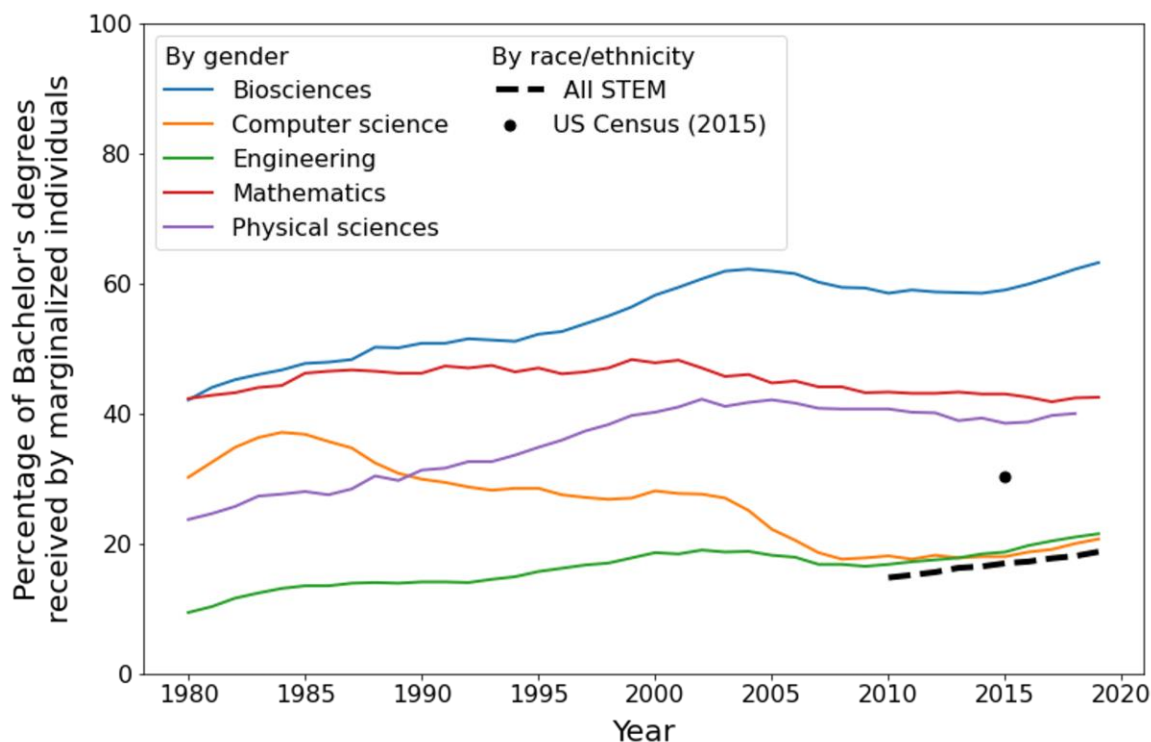
Keywords: culturally relevant, culturally responsive, equity & inclusion, STEM identity

## 1. Introduction

The urgent need to address the lack of diversity in science, technology, engineering, and mathematics (STEM) fields has been an open call for at least the last half century, with innumerable reports stating the discrepancies in demographic statistics (see Figure 1) and more recent literature investigating the systems that maintain these inequities (e.g., Gillette, 1972; National Research Council, 1990; AIP TEAM-UP, 2020; Diele-Viegas et al., 2021).

Research shows that these systemic causes are complex and affect STEM at all levels. For college-level STEM programs, students who leave STEM often cite a lack of belonging as they struggle to navigate between the culture of STEM and their own cultures, including within classroom environments (e.g., Carlone & Johnson, 2007; Seymour & Hunter, 2019).

In response to these studies, many educators and researchers have sought to develop frameworks that transform STEM education into a more inclusive



**Figure 1: STEM fields lack diversity, and the situation has not been significantly improved in recent decades.** The solid colored lines indicate the fraction of bachelor's degrees in various STEM subjects, including biosciences, mathematics, physical sciences, and engineering, that were received by women in the US from 1980 to 2019; the dashed black line indicates the fraction of all STEM bachelor's degrees that were received by African American, Hispanic, American Indian, Alaskan Native, or Pacific Islander students as identified by the National Center for Education Statistics (NCES). I note that these categories are themselves problematic (e.g., NCES treats gender as a binary, and the race/ethnicity categories are limited). For comparison, US Census data from the American Community Survey (ACS) for 2015 is included to show the fraction of the US population that was identified as African American, Hispanic, American Indian, Alaskan Native, or Pacific Islanders in 2015. (Plot generated by author from NCES and ACS data.)

and equitable environment. This article specifically focuses on three such frameworks. The first is from the Institute for Scientist & Engineer Educator (ISEE) Professional Development Program (PDP), which provided training for early-career scientists to improve how they teach STEM content and practices to college-level audiences. The PDP included an Equity & Inclusion Theme (Seagroves, et al., 2022) for attending to those topics within their curricular activity model.

In this article, I re-examine this framework and compare it with two other frameworks for equitable and inclusive education: culturally relevant pedagogy (Ladson-Billings, 1995a, 1995b) and

culturally responsive teaching (Gay, 2010). Both of these frameworks were developed for K–12 educators in the US to better attend to teaching and learning for all their students. By mapping concepts from the ISEE E&I Theme onto culturally responsive and culturally relevant models, I identify differences that can be leveraged to make the ISEE E&I framework more robust and offer more opportunities for participating learners to identify with STEM.

In §2, I summarize the three different frameworks and how they approach creating an equitable and inclusive classroom. §3 introduces my mapping between the three frameworks, highlighting both

common elements (§3.2) and differences (§3.3) following a brief discussion about the different intended audiences and purposes of the three frameworks (§3.1). Finally, in the discussion in §4, I offer some directions for how an instructor who is already familiar with the ISEE E&I Theme can adopt additional themes from culturally relevant and responsive education, along with considerations for professional development targeted at early-career STEM professionals like the ISEE PDP.

### 1.1 Author positionality statement

Before moving on to the analysis, I would be remiss to not mention my own positionalities that affect my lived experiences and therefore the writing of this article (e.g., D’Ambrosio et al., 2011; Secules et al., 2021). Professionally, I’m an astronomer who moved into discipline-based education research (DBER); I have since left academia and work as a program manager at the American Physical Society (APS). Personally, I am a cis-gender woman who is White-passing (though not White-identifying) and a member of the LGBT+ community. My identities influenced my experiences and motivations in STEM, including my choices to participate in the PDP and research projects. While working in DBER, I focused on developing inclusive and culturally responsive astronomy curricular materials for both high school and college students. For some of these materials, I led professional development sessions for instructors, and I have also assessed these materials for research publications.

### 1.2 Definitions

Finally, I wish to share the definitions of terms like “equity” and “inclusion” that guide my own work (adapted from Rodriguez & Morrison, 2019):

- **Diversity** is the representation of visible and invisible physical and social characteristics (e.g., gender, race, ethnicity, ability).
- **Equity** requires allocating resources such that everyone has access to the same outcomes and opportunities.

- **Inclusion** is having an environment that celebrates diversity as a source of strength.
- **Justice** is the process of dismantling systems that maintain oppression and bias.

Additionally, in *How People Learn II*, **culture** is defined as “the learned behavior of a group of people that generally reflects the tradition of that people and is socially transmitted from generation to generation through social learning; it is also shaped to fit circumstances and goals” (NASEM, 2018). Culture is a complex and intersectional construct that incorporates many personal aspects, including race, ethnicity, gender, sexual orientation, ability, and more; in education settings, culture impacts what people learn, how they learn, and how they present and share what they have learned.

## 2. Literature review

Below I will briefly summarize the frameworks being compared in this analysis. However, a brief note on terminology: ISEE uses the term “learners” to broadly refer to participants in inquiry activities, whereas the culturally relevant and responsive models use the term “students”, especially since they were developed for the K–12 classroom environment. In this article, I will generally try to use the terms as appropriate (e.g., “learners” when specifically writing about the ISEE theme). However, I do not draw a distinction between “learners” and “students”.

### 2.1 ISEE Equity & Inclusion Theme

ISEE motivates their Equity & Inclusion (E&I) Theme (Seagroves et al., 2022) with a social justice argument from a 2003 speech by Shirley Tilghman (then president of Princeton University):

“... it is simply unjust for a profession to organize itself, intentionally or unintentionally, in such a way as to exclude a significant proportion of the population. This is an argument based on fairness and justice.” (Tilghman, 2003).

STEM fields are generally not diverse, with White able-bodied men overrepresented among people who engage with STEM (Figure 1). The causes for why individuals from gender, racial/ethnic, and other groups are minoritized in STEM are complex, and attrition happens at all levels of STEM. Since ISEE PDP’s inquiry activities target college-level audiences, the ISEE E&I Theme is grounded in research at the college-level, which shows that a significantly lower fraction of Latino/a, Black, and Native American<sup>1</sup> students who enter college aspiring to STEM degrees graduate with STEM degrees than students from White and Asian American groups (Hurtado et al., 2010). Recent research has reinforced these results. For example, Riegle-Crumb et al. (2019) compared students who identified as White, Black, and Latino/a<sup>2</sup>, and they found that students from these groups enter college with similar levels of interest in STEM majors. However, a much lower fraction of Black and Latino/a students persist to graduate with STEM degrees; instead, these students switch to non-STEM majors or leave college without completing a degree.

These findings demonstrate that college STEM environments fail to retain (or even potentially push out) individuals from marginalized groups, which is one of the many factors causing STEM fields to lack diversity. Transforming college STEM environments to be more equitable and inclusive is one step to addressing these problems. One aspect within the college STEM environment is the classroom environment, including what topics are being taught and how they are being taught.

The ISEE E&I Theme aims to address this particular aspect through four focus areas:

1. “Multiple ways to productively participate;
2. Learners’ goals, interests, and values;
3. Beliefs and biases about learning, achievement, and teaching; and
4. Developing an identity as a person in STEM” (Seagroves et al., 2022).

Below, I describe these focus areas in more detail (§2.1.1–2.1.4). In §2.1.5, I also briefly describe the ISEE Inquiry Theme (Metevier et al., 2022), as it intersects with some of the concepts in the other frameworks analyzed in this article.

### **2.1.1 Multiple ways to productively participate**

Because each learner carries with them their own unique lived experiences, the way learners access and engage with ideas, approach new content, communicate with their peers and instructors, and demonstrate success will vary. Instructors can support learners by building in multiple opportunities for learners to express their understanding and by clearly communicating expectations (e.g., by a rubric). Additionally, by acknowledging and managing group work (e.g., by having learners assign and rotate roles), instructors can also support learners in developing teamwork skills (Seagroves et al., 2022).

### **2.1.2 Learners’ goals, interests, and values**

As in the first focus area, due to learners’ varied lived experiences, they will each come into a classroom with their own interests, values, and motivations. By designing an activity so that learners have a choice about aspects like questions, investigation paths, etc., instructors can create multiple opportunities for learners to express their own interests and find ways to connect their personal motivations with the activity content. Furthermore, by clearly

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<sup>1</sup> These are the demographic categories from Hurtado et al. (2010).

<sup>2</sup> These are the demographic categories as reported in Riegle-Crumb et al. (2019).

sharing the value of the learning goals and learners' efficacy, instructors can increase learners' motivation and agency in an activity (Seagroves et al., 2022).

### **2.1.3 Beliefs and biases about learning, achievement, and teaching**

The third focus area in ISEE E&I Theme is explicitly addressing and managing beliefs about learning and teaching, including fixed versus growth mindsets (e.g., Dweck, 2008, 2014), stereotype threat (e.g., Steele & Aronson, 1995; Totonchi et al., 2021), and unconscious bias (e.g., Moss-Racusin et al., 2018; Begeny et al., 2020). An instructor should ensure an activity reinforces a growth mindset and positive beliefs about learners' abilities, and they should also watch for instances where stereotypical pitfalls may happen (e.g., during group work in activities). Providing opportunities for self-reflection and self-assessment can also help to build learners' metacognition and cultivate a growth mindset (Seagroves et al., 2022).

### **2.1.4 Developing an identity as a person in STEM**

The final focus area in ISEE's E&I Theme is around guiding learners so that they see themselves as "people in STEM". Having this "identity" thus means that someone feels both (1) a sense of belonging in STEM and (2) a sense that STEM is an important part of who they are. ISEE adopted a framework for developing a STEM identity that combines competence, performance, and recognition (Carlone & Johnson, 2007). Thus, activities should make science practices explicit and provide a means for learners to monitor their own progress on these skills to grow their competence in STEM. Furthermore, activities can include opportunities for learners to practice communicating their work in a variety of relevant settings (e.g., to other experts in the field, or to audiences of other students or friends/family). Finally, activities embed opportunities for students to receive recognition from meaningful others, including instructors, peers, and other individuals (Seagroves et al., 2022).

### **2.1.5 ISEE Inquiry Theme**

While this article focuses on the ISEE E&I Theme, some of the concepts are intertwined with the ISEE Inquiry Theme, which describes the approach to STEM learning used by ISEE. This framework has six key elements (Metevier et al., 2022):

1. Learners will engage in cognitive STEM practices to gain proficiency with core practices and how it applies in different contexts.
2. Learners will gain an understanding of the challenging and assessable aspects of a core STEM concept and how it may be applied to different contexts.
3. Learners will investigate intertwined STEM content and practices, including raising questions about content, engaging with STEM practices to come to their own understanding of that content, and explaining their findings or solutions.
4. The inquiry activity will mirror authentic STEM research and design, including having learners investigate their own questions and/or design their own solutions to problems they defined; contribute, explain, and justify their ideas to their peers; and be assessed as they explain findings in a way that is similar to authentic STEM reporting.
5. Learners will have ownership over their own learning by having choices, such as in developing questions, deciding how to investigate questions, deciding which reasoning pathway is used to explain their findings, etc.
6. When answering their questions and/or designing solutions, learners will define what counts as evidence and/or generate their own evidence, and they will use their evidence to support an explanation of their new understandings.

## 2.2 Culturally Relevant Pedagogy

Gloria Ladson-Billings (1995a) studied “excellent teachers” of African American students in K–12 schools. She interviewed eight teachers (five African American women and three White women) in a small (<3,000 students) elementary school district in Northern California that served predominantly African American and low-income communities (Ladson-Billings, 1995b). She sought to understand these teachers’ strategies and approaches that supported their students in achieving larger learning gains (e.g., as measured on standardized tests) than students in their colleagues’ classrooms. She summarized her findings in a framework of “culturally relevant pedagogy”, which she notes shares many practices with teaching strategies that are part of good teaching. This framework is a “pedagogy of opposition” that is committed to collective, and not merely individual, empowerment (Ladson-Billings, 1995a, 1995b).

Ladson-Billings’s culturally relevant pedagogy framework rests on three criteria:

1. “Students must experience academic success;
2. Students must develop and/or maintain cultural competence; and
3. Students must develop a critical consciousness through which they challenge the status quo of the current social order” (Ladson-Billings, 1995a, p. 160).

These strategies are described in more detail below (§2.2.1–2.2.3) as well as a brief discussion of how teachers implemented culturally relevant pedagogy (§2.2.4).

### 2.2.1 Academic success

Ladson-Billings (1995a) notes that the skills taught in a classroom, such as literacy, numeracy, and technological and social skills, are necessary for

students to become active participants in a democracy. Culturally relevant teachers demanded and reinforced these skills in their students to attend to the students’ academic needs. The “trick” was in getting students to “choose” academic excellence. For example, Ladson-Billings (1995a) described an example from one teacher who guided students with “social power” in the classroom to take on academic leadership, channeling these students’ skills and abilities so that they would influence their peers to also develop academic excellence (p. 160).

### 2.2.2 Cultural competence

The next criterion is that students should be able to maintain cultural integrity while growing their academic excellence. For example, Ladson-Billings (1995) references the phenomenon of African American students “acting White” to avoid being ostracized by their peers as described by Fordham & Ogbu (1986)<sup>3</sup>. School is a hostile place where certain students — especially those identifying with marginalized groups — cannot “be themselves” (Ladson-Billings, 1995a, pp. 161–162).

Culturally relevant teachers instead invite students to bring their culture into the classroom. For example, one teacher connected poetry to the students’ own love of rap music, encouraging students to bring in non-offensive lyrics to perform and analyze for technical aspects such as rhyme scheme and alliteration. Another teacher invited parents to serve as an “artist or craftsperson-in-residence” where they would come into the classroom for 1–2 hours for 2–4 days and teach a “seminar” (e.g., on baking sweet potato pies, or on being a carpenter). Students were then required to conduct additional research on some aspect of the seminar, such as creating and testing new products, developing marketing plans for selling products, or learning what steps are required for that type of career path. These exercises increased students’ knowledge and value of their

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<sup>3</sup> Other authors have critiqued the deficit mindset of the Fordham & Ogbu (1986) article (e.g., Spencer et al., 2001). That said, the reality of students from marginalized groups engaging in “code-switching” to follow the norms of dominant (White) students is well-documented in the literature (e.g., see Stanton et al., 2022).

own backgrounds and gave them practice with important skills for their future success (Ladson-Billings, 1995a).

### 2.2.3 Critical consciousness

The third criterion in Ladson-Billings's (1995a) framework is guiding students to grow a critical consciousness. The first two criteria — academic success and cultural competence — can be achieved as individual achievements. However, as mentioned in §2.2.1, if a goal of education is to empower students to be active citizens in a democracy, then students need broader, collective achievements as well. Under this criterion, students must be able to critique the cultural norms, mores, values, and institutions that exist in society and that maintain inequities (cf. Freire, 1970). For example, when students in several of the classrooms studied by Ladson-Billings learned they had received older, out-of-date textbooks, whereas a middle-class school received newer textbooks, they practiced critiquing the knowledge represented in the texts and the inequities in funding systems that led to this problem. The students wrote letters to the editors of local newspapers that informed the community of the situation (Ladson-Billings, 1995a).

### 2.2.4 Implementing culturally relevant pedagogy

The teachers that Ladson-Billings studied each used markedly different approaches to implement culturally relevant pedagogy. For example, some teachers were more structured or rigid than others in their pedagogies. However, Ladson-Billings also identified common beliefs and ideologies among the eight teachers. All of the teachers held similar conceptions of themselves and others, believing that all students were capable of academic success, treating pedagogy as a process of “becoming” and thus always evolving, seeing themselves as members of their community, and viewing teaching as a way to “give back” to their community. They also guided students to form a peer community of learners, and they promoted the development of equitable and reciprocal teacher-student relationships. Finally, their

conceptions of knowledge were that it is dynamic, required critical reflection, and that teachers must scaffold learning and provide multiple forms of excellence in assessments (Ladson-Billings 1995b).

## 2.3 Culturally Responsive Teaching

A second influential framework in inclusive and equitable education is Geneva Gay's culturally responsive teaching (Gay, 2010). Gay drew on her work with pre-service K–12 teachers to develop a framework that encompasses behaviors and instructional moves, such as demonstrating dispositions of caring; promoting communication between students and teachers as well as among students; implementing culturally diverse curricula; and focusing on instructional processes.

Gay (2010) describes six descriptive characteristics or dimensions of her model:

1. “Culturally responsive teaching is validating and affirming” of cultural heritages;
2. “Culturally responsive teaching is comprehensive”;
3. “Culturally responsive teaching is multidimensional”;
4. “Culturally responsive teaching [empowers]” students to become “better human beings and more successful learners”;
5. “Culturally responsive teaching is transformative” of both educational practices and social inequities; and
6. “Culturally responsive teaching is emancipatory” (Gay, 2010, pp. 31–38).

Below, each dimension is described in more detail (§2.3.1–2.3.6).

### 2.3.1 Validation and affirmation of cultural heritages

Culturally responsive instructors teach “*to and through*” the assets and strengths of students (Gay, 2010, p. 31). Cultural responsiveness acknowledges the cultural heritages of different groups as



legitimate legacies that affect students (e.g., in terms of students' attitudes or approaches to learning), and these cultural heritages are crucial content to include in formal curriculum. Instructors also should build bridges between students' home and school experiences. By connecting academic abstractions (e.g., mathematical calculations or literary genres) with lived sociocultural experiences, instructors can reinforce that students' own personal experiences are valid.

Furthermore, culturally responsive approaches guide students to understand and praise both their own as well as other students' cultural heritages. Incorporating multicultural information and resources in all subjects and skills affirms the role of culture in academic content. Finally, instructors should use a wide variety of instructional strategies to respond to different learning approaches of students with different lived experiences and heritages. Gay (2010) noted that increased pride in cultural identities is interactional with improved academic achievement, and that the knowledge and skills to challenge existing social orders and power structures are desirable outcomes for education.

### **2.3.2 Comprehensiveness**

Culturally responsive instructors "teach the whole child", developing "intellectual, social, emotional, and political learning by using cultural resources to teach knowledge, skills, values, and attitudes" (Gay, 2010, p. 32). Especially for students of color, this demands a commitment to helping students maintain identity and connections with their heritages and communities. Culturally responsive teaching weaves expectations and skills throughout all curricular content and classroom practices. As a result, to be truly culturally responsive, cultural diversity needs to be embraced throughout the entire educational enterprise, including personnel such as teachers, counselors, staff, and administrators; formal policies and programs; and informal extracurricular activities and community relations.

As with Ladson-Billings (1995a), the comprehensiveness of culturally responsive teaching means that students are guided to form a community of learning where each student is accountable not only for their own success but one another's success as well. This promotes caring relationships among students and fosters a sense of belonging (Gay, 2010).

### **2.3.3 Multidimensionality**

Culturally responsive teaching also encompasses all aspects of the classroom environment, such as curricular content, classroom climate, instructional techniques, student-teacher relationships, and assessments, as well as building connections across many content areas that are sometimes "siloeed" in education. For example, Gay (2010) described an example of teaching the concept of protest, which could incorporate instruction in language arts, social studies, arts, and music. Students could explore how protest (e.g., against racial discrimination) is expressed in different media, including poetry and political actions, and during different time periods. By comparing across the approaches, students can compare the major arguments in each form of expression and investigate whether consensus and collaboration are possible. Beyond the subject material, students could also have a role in determining how they will be assessed on the unit, e.g., through written tests, performances, or other means. This kind of teaching requires both students and teachers to tap into a broad range of cultural knowledge, experiences, and perspectives, which can help students clarify cultural values and better understand different cultural heritages.

### **2.3.4 Empowerment**

Culturally responsive teaching empowers students to become "better human beings and more successful learners", encompassing "academic competence, personal confidence, courage, and the will to act" (Gay, 2010, p. 34). Guiding students to empowerment requires teachers to be aware of the risks and pitfalls on the way to mastery. Culturally responsive teachers must scaffold content, create

intermediate opportunities for success, bolster morale, provide resources and assistance (both in terms of the student-teacher relationship as well as peer relationships), and celebrate both individual and collective accomplishments so that students will persevere.

### 2.3.5 Transformation of educational practices

Culturally responsive teaching defies “traditional” educational practices by explicitly respecting cultural experiences as strengths and accomplishments that enhance instructional processes. Students’ cultural norms, such as preferences for group work or practices like storytelling, are formally included in curriculum and assessment strategies. Academic success is clearly communicated as a nonnegotiable mandate and an accessible goal, and it is achieved simultaneously with cultural consciousness. The transformative nature of culturally responsive teaching is “double-focused”: the first direction confronts and transforms the cultural hegemony in traditional educational environments, and the other direction guides students to develop “social consciousness, intellectual critique, and political and personal efficacy [...] so that they can combat prejudices, racism, and other forms of oppression and exploitation” (Gay, 2010, pp. 36–37).

### 2.3.6 Emancipatory and liberating education

By validating and affirming students’ cultural heritages, the pride culturally responsive teachers generate is liberating, freeing students to focus more closely on academic learning tasks, leading to a variety of achievements: insightful thinking; more caring interpersonal skills; a better understanding of interconnections among individual, local, cultural, global, and other identities; and acceptance of knowledge as something to be shared, critiqued, revised, and renewed. By reclaiming psychoemotional energy that students may have had to use to “cover up” or “contain” their cultural heritages, students can channel their efforts into academic achievement and intellectual attentiveness.

Furthermore, community, cooperation, and connectedness are central features of culturally responsive teaching. By emphasizing collective achievement, rather than individualistic competitiveness leading to “some winning and others losing”, culturally responsive teachers can draw on community patterns and norms to incorporate students’ own cultural and communication styles into the classroom (Gay, 2010, p. 38).

Finally, culturally responsive teaching “lifts the veil of presumed absolute authority” from content taught in schools (Gay, 2010, p. 38). Students learn how to apply new knowledge generated by scholars — including scholars from marginalized groups — to analyze histories, problematize issues, and describe experiences. Students are encouraged to find their own voices and become active participants in their learning.

## 2.4 Additional frameworks

While beyond the scope of this analysis, many other authors have offered their own frameworks for inclusive and equitable education. For example, Paris (2012) proposed a framework of *culturally sustaining education*, which offered an alternative to culturally relevant and responsive approaches. Culturally sustaining education explicitly seeks to perpetuate and foster (i.e., sustain) linguistic, cultural, and literate pluralism. Paris noted that in many educational settings in the US, students’ existing cultural norms and practices might be used as bridges to learn dominant norms (e.g., the dominant dialect of English in the US), but the outcome would be that the dominant norms were prioritized *above* students’ own cultural norms. As a result, these settings promoted a monoculture, rather than sustaining cultural pluralism. Paris offered the concept of culturally sustaining education as a “needed step” against these systems (Paris, 2012, p. 96).

Finally, other authors have offered synthesis frameworks. For example, Aronson & Laughter (2016) noted the overlap between culturally relevant pedagogy and culturally responsive teaching as defined

by Ladson-Billings (1995a, 1995b) and Gay (2010), respectively. Drawing on these similarities, they combined the two frameworks into a single culturally relevant education (CRE) model with markers of academic empowerment; multidimensionality; cultural validation; social, political, and emotional comprehensiveness; school and social transformation; and liberation or emancipation from oppressive educational practices.

### 3. Mapping between ISEE E&I, cultural relevance, and cultural responsiveness

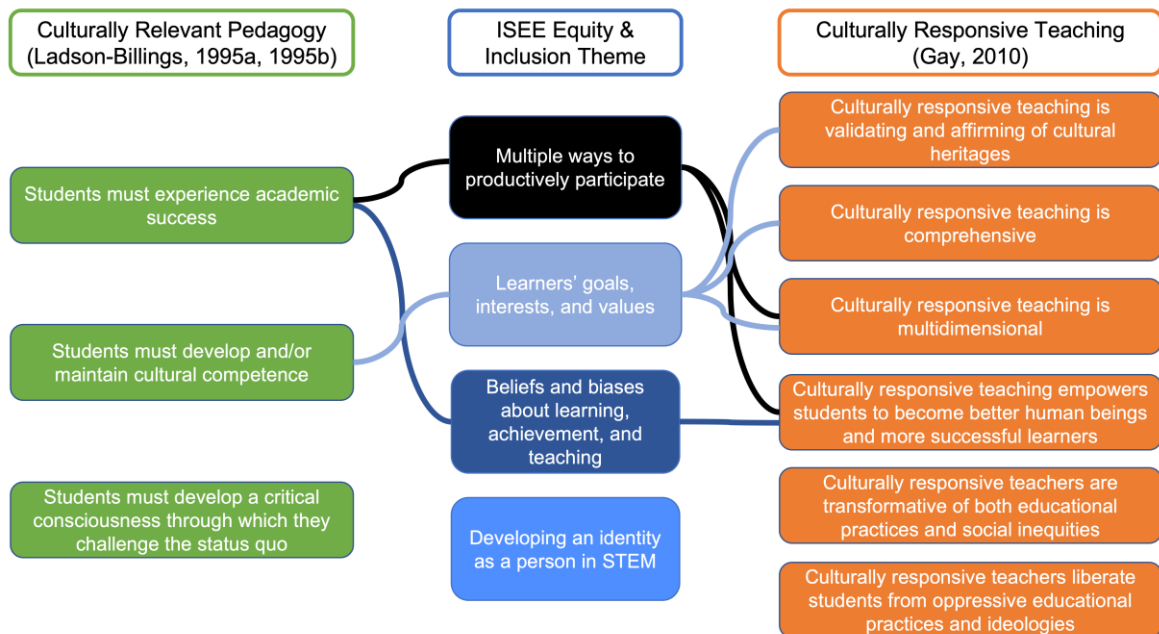
In Figure 2, I present a mapping between the four focus areas of the ISEE E&I Theme (§2.1) with culturally relevant pedagogy (§2.2; Ladson-Billings, 1995a, 1995b) and culturally responsive teaching (§2.3; Gay, 2010). This figure is intended to be demonstrative of the similarities and differences between the three frameworks. It is not necessarily a

one-to-one mapping, and another instructor may interpret some of the elements to have more or less overlap than is indicated on the map. That said, I intend that the figure can be a helpful guide for an interested reader to consider the similarities and differences between the approaches.

Below, I describe the common elements in more detail (§3.2), and I also explore the differences and how they can be leveraged to transform STEM education to be more equitable and inclusive (§3.3). However, to set the groundwork for discussing these elements, I first discuss the target audiences and intended purposes of these frameworks (§3.1), which influences the commonalities and differences.

#### 3.1 Target audiences and intended purposes

An underlying tension in this analysis is that the three frameworks have different intended target audiences and purposes. ISEE wrote the E&I Theme



**Figure 2. Mapping concepts from the ISEE Equity & Inclusion Theme with culturally relevant pedagogy (Ladson-Billings, 1995a, 1995b) and culturally responsive teaching (Gay, 2010).** This figure is intended as a general guide for similarities and differences between the frameworks. Not all mappings are one-to-one (e.g., “cultural competency” in Ladson-Billing’s (1995a) framework is more complex than just attending to learners’ goals, interests, and values).

for their Professional Development Program (PDP), a limited professional development series with early-career scientists to create short standalone STEM inquiry activities with a college-level audience. In this context, ISEE sought to introduce participants to concepts in equity and inclusion, although they were constrained to maintain a narrow focus on aspects that the participants could reasonably implement and practice in their inquiry activities.

On the other hand, both cultural relevance (Ladson-Billings, 1995a, 1995b) and cultural responsiveness (Gay, 2010) were written for K–12 teachers. At the K–12 level, teachers are often responsible for multiple subjects, and they are also responsible to different standards (e.g., state-level education standards, which may include cultural standards<sup>4</sup>). Additionally, the students served by K–12 teachers are (often significantly) younger than those served by ISEE PDP participants, and teachers also have more time with their students (e.g., multiple hours per day over the course of a whole academic year, rather than only a few hours in a single activity or lab). K–12 teachers also often have more training in pedagogy, either as part of their certification or through required annual professional development activities, than early-career STEM professionals.

Beyond the differences in the audiences for the frameworks, there are some nuances in how instructors at the college level (such as ISEE PDP participants) engage with students' cultures as compared with K–12 classes. Sometimes, the cultural connections to advanced college STEM content is not as "obvious" as the content taught in K–12 classrooms. However, since STEM fields have their own cultures, any activity within STEM is impacted by cultural values, and therefore is culturally relevant (e.g., in terms of STEM practices, how the STEM knowledge can be applied, which STEM research questions are pursued and prioritized, etc.). College-level STEM instructors also often work with

students who come from much broader cultural and geographic backgrounds than K–12 teachers whose students come from the local community. That said, the added complexity should not prevent college-level STEM instructors from modeling cultural relevance and responsiveness and/or creating spaces in their classroom that welcome and affirm students' own backgrounds.

In the remainder of this section, I focus on comparing the characteristics of the three frameworks to identify existing synergies and opportunities for expanding what an inclusive, relevant, and responsive STEM education framework might look like. While a college course instructor could likely take advantage of these expansion opportunities, it may not be reasonable to expect the same for a program like the ISEE PDP because of its narrower scope. In the discussion (§4), I will return to these implementation considerations.

### **3.2 Common elements between all three frameworks**

These subsections highlight commonalities between the three approaches in terms of their underlying motivations and themes (§3.2.1), approach to students' academic learning and achievement (§3.2.2), and awareness of students' cultures (§3.2.3).

#### **3.2.1 Underlying motivations and themes**

While not explicitly shown in Figure 2, all three frameworks were created to address the same issue: the current educational system is deeply impacted by inequities, making the systems themselves and their outcomes socially unjust. While the ISEE E&I Theme is targeted to college STEM education, and STEM certainly has its own unique challenges and cultural biases that impact diversity, equity, and inclusion, the basic problem is not unique to STEM. As Ladson-Billings (1995a) noted, many of the aspects of culturally relevant (and responsive)

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<sup>4</sup> For example, Alaska has a robust set of cultural standards for K–12 education, which can be used to review school and/or district-level goals, policies, and practices: <https://education.alaska.gov/standards/cultural>

education are part of “just good teaching” and thus are not unique to any specific subject. All three frameworks also emphasize a growth mindset (Dweck, 2008) and believe that all students can accomplish high levels of academic achievement (for more, see §3.2.2 below).

Another common element is the way these frameworks view students: as whole human beings with their own cultural beliefs, knowledge, values, and more. They also recognize these elements are assets that can and should be incorporated into the classroom environment. This approach addresses the shortcomings of what Freire (1970)<sup>5</sup> calls the “banking model” of education, which is also addressed in many other pedagogical frameworks, including both *How People Learn I* and *II* (NRC, 1999; NASEM, 2018). In the banking model, an instructor treats a student as an empty vessel to fill with knowledge, ignoring the existence of the strengths that each student has built up from their lived experiences. In E&I, cultural relevance, and cultural responsiveness, instructors instead invite students to contribute their strengths and form connections with academic practices and knowledge.

### **3.2.2 Academic achievement and learning**

As mentioned above in §3.2.1, all three frameworks include academic learning, success, and achievement as key outcomes. They also recognize that many of the skills, knowledge, etc. teachers wish to impart on students can be difficult, and so they emphasize techniques such as scaffolded learning and celebrating successes along the way. Furthermore, as students have a diverse set of lived experiences, and therefore a diverse set of learning styles and abilities, instructors should provide multiple pathways for students to achieve learning and to express that learning during assessments. Instructors should also adopt and express a growth mindset with their students to boost morale and personal confidence in students’ abilities to succeed.

However, a key difference between the ISEE E&I Theme and cultural relevance/responsiveness is the role of *culture* in academic achievement. Specifically, both cultural relevance and responsiveness demand that academic achievement is done simultaneously to cultural achievement, which is part of what Gay (2010) describes as empowering students to be “better human beings” who are able to problematize and address social inequities in their communities. On the other hand, ISEE E&I does not explicitly require the two to be in lockstep. This difference is explored further in §3.3.2 below.

### **3.2.3 Building with students’ cultures as assets**

Finally, all three frameworks prioritize inviting students to express their own beliefs, goals, values, etc. and making those assets a formal part of curriculum, instructional practices, and assessments. Beyond valuing and affirming students’ lived experiences, these strategies ensure that education is comprehensive of the whole student and is multidimensional by making space for students to connect to other topics and practices. §3.3.2 will further explore how the three frameworks approach the roles that students’ cultures have in learning to identify nuanced differences.

## **3.3 Differences between the frameworks**

Below, I describe three key differences between ISEE E&I with cultural relevance/responsiveness in terms of the explicit roles of cooperation, community, and connectedness (§3.3.1); students’ cultures (§3.3.2); and intended identity development (§3.3.3).

### **3.3.1 Cooperation, community, and connectedness**

One of the elements emphasized in both culturally relevant and responsive education is the role of guiding students to build a community of learning

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<sup>5</sup> Freire (1970) is explicitly cited by both Ladson-Billings (1995a, 1995b) and Gay (2010). ISEE does not specifically cite Freire, but the concepts in the ISEE themes (especially the Inquiry Theme, see §2.1.5) parallel these arguments.

in the classroom such that achievement is a collective goal, rather than an individualistic endeavor (Ladson-Billings, 1995a, 1995b; Gay, 2010).

The ISEE E&I Theme does not explicitly call on this kind of cooperation and connectedness in the same way. Inquiry activities were designed to be done by learners working in groups, and the E&I Theme noted that instructors should be aware of group dynamics. The E&I Theme also emphasized the importance of learners receiving recognition from meaningful others for their accomplishments, but arguably these points were made in the effort of learners *individually* developing their STEM identities.

That said, the ideas of cooperation, community, and connectedness do not contradict the goals of the ISEE E&I Theme, and so they could be directions of growth beyond the current E&I Theme. In fact, adding this emphasis would be consistent with other themes in the ISEE PDP, such as the Inquiry Theme that includes mirroring authentic research and design. The theme focuses on aspects of STEM, such as designing questions and developing solutions. Another aspect of authentic STEM research and design is that much of it is done by collaborations, and sometimes those collaborations are very large (e.g., the discovery paper for gravitational waves was a collaboration of over 1,000 authors; Abbott et al., 2020). These collaborations succeed when the group works together collectively, and so addressing cooperation, community, and connectedness would prepare students for engaging in this type of STEM research and design.

### 3.3.2 Maintaining students' cultures

Another difference between the frameworks is in the way they approach students' cultures and the assets, values, etc. that they bring into the classroom. In all three themes, instructors are encouraged to build bridges between students' own cultures and

the academic content (§3.2.3 above). However, cultural relevance and responsiveness take this concept further by demanding that instructors *maintain* or even *grow* students' cultural pride, competence, and consciousness in their own and their peers' cultures (Ladson-Billings, 1995a, 1995b; Gay, 2010). Other frameworks, such as Paris's (2012) culturally sustaining education (§2.4) further emphasize and prioritize these goals.

However, the ISEE E&I Theme does not explicitly consider students' culture in this regard; as mentioned in §3.2.1, cultural achievements are not required to be in lockstep with academic ones in the ISEE E&I framework. That said, as with cooperation, community, and connectedness (§3.3.1 above), placing a greater emphasis on maintaining culture would be consistent with the existing E&I framework and could enhance its existing goals, such as by providing additional avenues for a learner to grow their identity as a person in STEM through fostering a sense of belonging in a STEM-focused community.

### 3.3.3 Intended identity development for participating students/learners

The most significant difference between the frameworks is the intended identity development for participants (in Figure 2, the "row" of unconnected boxes towards the bottom of the map): who do we want our students/learners to view themselves as, and what will they be capable and willing to do after engaging with us?

Both cultural relevance and responsiveness contend that students should be empowered and liberated. They should be able to use their critical consciousness to assess and problematize social inequities, oppression, and exploitation and to develop solutions to transform the systems that maintain these situations.<sup>6</sup> Broadly speaking, these frameworks guide instructors to introduce content and apply

<sup>6</sup> Arguably, there are nuanced differences between the approaches to identity development in cultural responsiveness and cultural relevance, but for the purposes of this article, their general goals for students' identity development are complementary and can be synthesized to compare with the ISEE E&I Theme.

pedagogy so that students can become change agents in service of their communities (Ladson-Billings, 1995a, 1995b; Gay, 2010).

On the other hand, while the ISEE E&I Theme also seeks to empower students, it takes a much narrower focus on developing learners' STEM identity. In part, this reflects the audience for ISEE's materials: early-career scientists who will be in positions to teach those who will hopefully be the next generation of scientists. Developing a STEM identity still requires that learners develop beliefs around their competency, agency, and sense of belonging, and these are the aspects that the ISEE E&I Theme focuses on.

As with the other differences identified in §3.3.1–3.3.2, expanding the STEM identity construct from the ISEE E&I Theme to also encompass critical consciousness would enhance the potential for equitable and inclusive science education. Other literature has developed frameworks for what it would look like for students to develop a combined critical consciousness and STEM identity. For example, Ashcraft & Eger (2017) discussed the formation of a *techno-social change agent* identity in girls of color participating in a computer science program that had them engage in both computer science content (e.g., exploring a virtual world) and discussions about social inequities (e.g., the limited avatar options in a virtual world platform). The participants were empowered to seek social change using their newfound technical skills, such as critiquing local news coverage of the program, which had edited out parts of participant interviews that mentioned the program's focus on girls of color.

Another example is the framework of *transformative intellectuals* as described in Morales-Doyle (2017). In this article, Morales-Doyle described a high school AP Chemistry class he taught where

students engaged with assignments, projects, etc. that connected the content to local issues. For example, his students investigated the impact of a recently closed coal power plant by measuring the concentrations of lead and mercury in neighborhood soil samples. They also organized a family science night to present their findings to parents, teachers, other students, and community members. Through these activities, Morales-Doyle described his students as transformative intellectuals who demonstrated complex thinking about science and social justice, with a commitment to their communities. The students became local youth leaders with both the knowledge and ability to advocate for social transformation.

A final example is the *critical science agency* framework (Basu & Barton, 2009; Basu et al., 2009).<sup>7</sup> Under this framework, Basu et al. described a framework where students in a physics course were empowered to take ownership and leadership over their learning. Specifically, through vignettes, Basu et al. share the stories of students who created and led course sessions for their peers on topics they were interested in. Before this course, these students did not identify with science, and both were from marginalized groups. One student wanted to be a lawyer and led a class debate on black holes; the other became a robotics expert and competed in local competitions. Both of them talked about how they enjoyed engaging with science in a different and authentic way that connected with their existing interests, and they both appreciated the recognition from their peers of becoming experts on their topics.

These three examples show that guiding students to develop a transformative critical consciousness and to develop an identity as a person in STEM can be done in sync. Including these approaches can offer

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<sup>7</sup> Coincidentally, the ISEE E&I Theme does cite Basu & Barton (2009). In the focus area on learners' goals, interests, and values, the authors cite the article in the statement that agency in STEM "equips learners to apply their knowledge to make a difference", and in the focus area on STEM identity, they use the reference to support the argument that agency is one of the many components "inextricably linked to identity". However, the E&I Theme did not explore the identity construct of Basu & Barton (2009) in further detail.

more pathways for a learner to develop both of those identities. It also advances conversations around how to transform STEM fields to be more equitable and inclusive by empowering more individuals to be capable and active change agents.

#### 4. Discussion and next steps

All three frameworks considered in this article were designed to empower students to be active participants in teaching and learning. These frameworks transform typical classroom practices by explicitly validating and incorporating students' cultural heritages and assets, emphasizing that all students can be high-achieving, and providing the support and scaffolding students need to accomplish those results.

However, there are also differences in how these frameworks emphasize community, as well as whether they focus on incorporating and/or sustaining students' cultures. Most importantly, the frameworks offer different conceptions for students' identity development. The ISEE E&I Theme defines this goal narrowly: learners should develop a STEM identity so that they feel a sense of belonging in STEM and that STEM is an important part of their lives (Seagroves et al., 2022). On the other hand, culturally relevant and responsive approaches demand that students achieve cultural pride in sync with academic success; prioritize cooperation and community-building; and guide students to develop a critical consciousness so that they feel able and are willing to use to address inequities in their communities (Ladson-Billings, 1995a, 1995b; Gay, 2010).

These differences offer instructors who are familiar with the ISEE E&I Theme directions for how to make their approach to equitable and inclusive education more robust. Instructors can work with their students to identify course topics (referring broadly to both STEM content and practices) that intersect with students' own experiences, which in turn can elucidate opportunities to promote simultaneous

cultural and academic achievement. Instructors can also bolster their use of group activities as a pathway for students to receive recognition from meaningful others (cf. Carlone & Johnson, 2007) in order to form a stronger community of learners in their classrooms. This social practice mirrors the authentic STEM research and design practices of collaboration, and so it will better prepare students for future careers in STEM (and beyond).

Furthermore, using the examples of frameworks that blend STEM identity with critical consciousness, such as techno-social change agents (Ashcraft & Eger, 2017), transformative intellectuals (Morales-Doyle, 2017), and/or critical science agency (Basu & Barton, 2009; Basu et al., 2009), instructors can provide additional pathways for students to see a STEM identity as being congruent with their own identities and experiences.

Finally, as mentioned in §3.1, this analysis also raises the question of what should be prioritized in ISEE PDP-style professional development workshops for early-career STEM professionals. These types of events need to have a narrower focus than a framework that is targeted towards instructors of year-long K–12 classrooms. Considering the differences highlighted in the analysis, how can early-career STEM professional development events be more effective at addressing equity and inclusion? The ISEE E&I Theme offers one option by focusing on a few areas that align closely with concepts that participants might already be familiar with, like STEM identity. However, another perspective would be to consider Audre Lorde's provocative admonishment, "The master's tools will never dismantle the master's house" (Lorde, 2003). By centering concepts that are already part of the existing systems that were created by and for those from dominant groups in STEM, a framework like the ISEE E&I Theme may be hampering their own efforts to promote equity and inclusion. Instead, centering concepts of critical consciousness and identities might be an approach to build a new system with new tools for our students.



Whether someone is designing a STEM professional development workshop, teaching in a K–12 classroom, or teaching a college-level course, determining an approach to equity and inclusion requires continuous critical self-reflection (e.g., Civitillo et al., 2019), especially for instructors from non-marginalized groups (e.g., Spanierman & Smith, 2017; Smith et al., 2017). What do we want to empower our students to do? Are we achieving those goals? How are we still sustaining bias, and how can we better center marginalized voices? As STEM as a whole continues to grapple with its cultures and systems that maintain inequities, addressing these questions in educational contexts can help to advance STEM to be more inclusive and equitable for all of its participants.

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