Pedagogy of Healers

STEM+CS Teachers Repairing STEM Identities

Jane W. Kim, Imelda Nava-Landeros, & Michael Shriner

Introduction

A student sketches a woman scientist with short, curly black hair and then writes a description, "I know this person because she is my teacher." Ms. Rayn, who happens to look like the scientist in the drawing, asks the student, "Why did you draw the scientist in this way?" The student responds, "Because I was thinking of you." (Composite narrative, 2022)

Ms. Rayn, a Black woman science teacher, is an inspiration to many of her Black and Latinx students, including the student quoted in the preceding excerpt, who felt inspired to draw a scientist modeled after her. She is one of four teachers with whom we had conversations and whom we observed to learn how abolitionist STEM educators enact their philosophy of education as healers in STEM and computing spaces.

Jane W. Kim and Imelda Nava-Landeros are lecturers in the Graduate School of Education and Information Studies at the University of California Los Angeles. Michael Shriner is a professor in the School of Education at National University, San Diego, California.

For many students with marginalized identities, STEM has been a space that harms, excludes, and is oppressive. Robert "Bob" Moses, a prominent 1960s Black civil rights activist, described the gatekeeping of mathematics, technology, and data literacy as a form of systemic oppression and a civil rights violation for students of color (González, 2010; Moscow, 2020; Moses & Cobb, 2002).

In Gonzalez's (2010) interview, Bob Moses noted that although Black people made substantial gains during the civil rights movement, "what we didn't win was getting Jim Crow out of education." Math, technology, and data literacy are deeply connected to computing disciplines in which underrepresentation of people who are Black, Latinx, girls or women, queer, or with dis/abilities persists (Casper et al., 2022; John & Carnoy, 2019; Ivey et al., 2021; Ladner, 2020; Mattheis et al., 2020; Sax et al., 2017; Wurman et al., 2020).

Despite Bob Moses's call to liberate education, progress has been slow in broadening participation in K–12 computing education for students with marginalized identities, including computing curriculum that involves data science and computational thinking tools in developing technology (CSforALL, 2021; Ivey et al., 2021; Ko, 2021; Sax et al., 2017; Wurman et al., 2020).

Abolitionist dreamers have called for justice-oriented teachers to teach K–12 students with marginalized identities through methods of critical and culturally responsive/sustaining pedagogies (Freire, 1970/2018; Gay, 2018; Ladson-Billings, 1995/2021; Paris & Alim, 2014); acts of love, care, hope, and healing (Ginwright, 2016; Love, 2019); and the humanization of students in STEM spaces (Benjamin, 2019). The dehumanization and silencing of students with marginalized identities in math, science, and computing spaces have resulted in significant harm to their STEM identities (Matthews, 2018; Vakil, 2018; Yeh et al., 2021). Additionally, there is an urgent need for racialized teachers to enact humanizing and inclusive pedagogical practices to reform computing and STEM education (Ivey et al., 2021; Morales-Chicas et al., 2019; Vakil & Ayers, 2019).

However, how teachers enact social justice pedagogies with students with historically marginalized identities in computer science and STEM classrooms requires further examination of how teachers with similar marginalized identities position hope and healing pedagogies to resist ostracism in STEM and computing education (Calabrese Barton & Tan, 2020; Ginwright, 2016; Kokka, 2018, 2019; Love, 2019; Philip, 2011).

How STEM and Computing Education Harms Students

Color-blind racial ideology, characterized by an attempt *not* to see race, culture, or status, is at the root of computing culture's resistance to sociopolitical action contributing to the reproduction of biased and discriminatory technology (Benjamin, 2019; Noble, 2018). Color-blind racial ideology and neutrality are used to justify equal opportunity for all without taking into account the historical, sociopolitical, and economic impacts of racism (DeCuir & Dixson, 2004; Gotanda, 1995; Ladson-Billings & Tate, 1995/2021; Yosso, 2005).

As a result, STEM is socially constructed to be color-blind and neutral, omitting scientific histories, theories, contributions, and ways of being and knowing from non-dominant communities—omissions that enact a form of erasure and epistemic violence (Vakil & Ayers, 2019). Similarly, discussions in computing spaces are devoid of considerations of racism, sexism, and other *isms* when contextualizing abstractions, data analysis, algorithms, and the impact that computing has on real people.

By making a conscious choice not to center social action that addresses issues concerning marginalized communities and by continuing to advance the harmful message that computing is objective and neutral, the default in computing education will continue to be influenced by White supremacy and capitalism with outcomes that affect everything from artificial intelligence (AI) tools in medicine to machine learning in facial recognition software (Benjamin, 2019; Noble, 2018).

Computer science (CS) and STEM teachers also employ color-blind racial ideology when deciding which groups of students participate and thrive in the STEM and computing pipeline (Annamma et al., 2017). Color-blind teachers function as gatekeepers by employing color-blind discourse to dismiss issues of race, culture, gender, and identity when discussing inequities. They often use individualistic and deflective discourses, such as placing blame on students' lack of motivation, lack of home resources, or students' choice to pursue different career paths, rather than acknowledging systematic issues of race (Goode et al., 2020; Goode et al, 2021).

Thus, discussions in computing courses about how AI's privileges and biases are a form of digital structural violence that simulates marginalized communities' social and institutional constraints are absent (Winters et al., 2020). Consequently, color-blind racial ideology makes students feel isolated and invisible in computing spaces (Gretter et al., 2019).

Theories of Humanizing Framework

Broadening participation in computing education and the workplace requires understanding and consideration of social, cultural, and political contexts of systemic oppression's historical and present-day realities. We also recognize that the dehumanization of our students with marginalized identities is a reality in school spaces (Freire, 1970/2018).

Our conceptual framework, centered on pedagogies that (re)humanize students, is situated in critical pedagogy (Freire, 1970/2018; Salazar, 2013), care and healing pedagogy (Ginwright, 2016, 2022; Noddings, 2005), culturally responsive/sustaining pedagogies (Davis et al., 2021; Gay, 2018; Ladson-Billings, 2014; Paris & Alim, 2014), and critical race theory (DeCuir & Dixson, 2004; Ladson-Billings, 1995/2021; Solórzano, 1997; Yosso, 2005).

Using the critical and theoretical construct of humanizing STEM/computing pedagogy, this conceptual framework underpins how we examine identity, positionality, a teacher's philosophy of education, and students' sense of belonging, inclusion, and agency.

Humanizing STEM and Computing Education

Justice-oriented teachers are called to "embrace a humanizing pedagogy that respects the dignity and humanity of all students" (Salazar, 2013, p. 142). One way for teachers to engage in humanizing pedagogy is by adopting a transformative practice of caring for and building hope in students through acts that promote the healing and well-being of our students (Ginwright, 2016, 2022; Noddings, 2005; Sosa-Provencio et al., 2020).

Furthermore, a humanizing pedagogy looks beyond teaching strategies to a more respectful and loving inclusion of students' realities, history, and perspectives (Ladson-Billings, 1995). Deficit thinking, discriminatory practices, and racist ideology have continued to harm students of color, those living in poverty, and other marginalized students in the hegemonic institution of education (Freire, 1970/2018; Salazar, 2013).

If schools engage in violent acts that dehumanize, make invisible, or employ deficit thinking about students with marginalized identities and cultures, then an uprising against institutional oppression requires teachers to love and know those students' cultures, languages, and identities (Freire, 1970/2018). For too long, CS and computing have centered on hegemonic cultural values, and teachers have reproduced the same in their classrooms.

Critical and humanizing pedagogy seeks to move away from the practice of having students divest from their culture and assimilate to survive in schools (Salazar, 2013) and computing spaces. Teachers can transform schools and serve to liberate students through acts of love and care, the intentional humanization of students, and the development of social agency toward cultural, social, political, and institutional action for justice.

Critical Race Theory in STEM and Computing Education

Love and care for students and their whole persons, including their languages, cultures, families, and communities, are prerequisites for liberating students. However, how teachers humanize students and participate in the liberation of marginalized people is achieved through their pedagogical teaching paradigms (Ladson-Billings, 1995). Broadening the participation of students in computing requires a broadening of computing culture to include and normalize the identities of marginalized students and their communities in those spaces.

The authors of the CS framework by the Kapor Center add,

> Culturally responsive-sustaining computer science pedagogy ensures that students' interests, identities, and cultures are embraced and validated, students develop knowledge of computing content and its utility in the world, strong CS identities are developed, and students engage in larger socio-political critiques about technology's purpose, potential, and impact. (Davis et al., 2021, p. 5)

Appreciating cultural differences is not enough to challenge the hegemonic schooling that students endure. What has surfaced in STEM and computing spaces is a need for counter-storytelling and critical discourse, such as discussions situated in critical race theory, disability critical studies (DisCrit), LGBTQ+

studies (QueerCrit), Latinx critical studies (LatCrit), feminist critical theories (FemCrit), and the use of abolitionist tools to dismantle the persistent color-blind ideology present in computing education and workplaces (Benjamin, 2019; Goode et al., 2020; Ivey et al., 2021; Jones & Melo, 2020; Ko et al., 2022; see also Ladson-Billings, 2021; Solórzano & Yosso, 2002).

There is enormous evidence of historical and existing structural and institutional oppression in STEM and the computing spaces of Black, Latinx, and LGBTQ+ students who encounter heteronormative, hegemonic, and color-blind policies and cultures (Benjamin, 2019; Goode et al., 2020; Mayson, 2019; Noble, 2018). Critical race theory provides a lens to understand how computers and algorithms represent our social conditions and how, for example, the "neutral" and "objective" decision-making tools employed in Google's search engine replicate the sexualization of Black women in its search returns of the keyword phrase *Black girls* (Noble, 2018, p. 1).

White supremacy, color-blind racial ideology, and their historical impact on people resonate in the algorithms humans encode today (Benjamin, 2019). Without a critical framing of education, pedagogies and practices become nothing more than gimmicks with little impact on increasing marginalized students' joy, healing, and academic achievement (Ginwright, 2016; Ladson-Billings, 1995/2021; Love, 2019).

Methodological Approach

Mainstream research has generally ignored that challenges sustained in urban STEM education are deeply rooted in the enduring struggle for racial, ethnic, gender, class, and cultural equity (Calabrese Barton, 2001; Nygreen, 2006). A critical and decolonizing ethnographic methodology of a case study orients toward positive social change when studying the nature that social and institutional structure, power, culture, and agency have when describing, refining, and reconceptualizing an inquiry for social and educational transformation in urban schools and communities (Beach & Vigo-Arrazola, 2021; Calabrese Barton, 2001; Carspecken, 1996, 2005; Darder, 2015; Nygreen, 2006).

From a critical, decolonizing, and transformative research perspective, we view the participating STEM educators and researchers as humans who actively produce meaning influenced by a social, political, and cultural environment (Bhattacharya, 2021; Darder, 2015; Esposito & Evans-Winters, 2022; Thambinathan & Kinsella, 2021).

Data Stories and Ethnographic Analysis

During the study, three collaborating teachers were resident teachers completing their master's degree in education, and the fourth was an alumna of the program. The federally funded teacher education program aimed to recruit and credential CS teachers in equity and social justice.

This work occurred in urban Title I schools serving predominantly Black and Brown students in historically low-income communities in southern California. The highly qualified and racialized urban secondary STEM teachers held single-subject credentials in math or science and micro-credentials in CS. Consequently, we label the collaborating teachers as STEM+CS teachers in their dual roles as STEM and computing educators.

Between fall 2021 and spring 2022, we engaged in participant observations and conversations. These engagements were essential to co-constructing people's stories through firsthand experiences in a contextual setting (Carspecken, 1996; Merriam & Tisdell, 2016). Although we had a long-standing relationship with the school sites and the collaborating teachers were our former students, for this study, we visited each school site a minimum of five times and observed more than 30 class periods, averaging 3–5 hours each visit.

The observation and interview guides were based primarily on norms and recommendations by Carspecken (1996) and Merriam and Tisdell (2016). During each observational field visit, we engaged in conversational interviews before or after each observation to generate context and pedagogical discussion.

In addition to the three to five unstructured conversational interviews, the participants engaged in two semi-structured interviews, each lasting 1.5 to 2 hours. Before concluding, we gathered documents from 2020 to 2022, including the collaborating teachers' writings and formal papers for their graduate school coursework, teacher lesson plans, student handouts, and students' work.

We articulated and portrayed authentic stories of our collaborating teachers from an insider positioning stance and a decolonial perspective through co-construction, sociopolitical action, and voice (Smith, 2012). We situated a reflexive and critical approach to community and research celebratory practices, representation, and restorative practices and emphasized the return rather than the claiming of resources (Smith, 2012).

This study contributes to understanding the STEM+CS teacher's role in resisting deeply rooted beliefs that color-blind racial ideology, including heteronormativity, hegemony, and ableism, in STEM and computing education are neutral, objective, and without potential harm (Benjamin, 2019; Goode et al., 2020; Ko, 2021; Mattheis et al., 2020; Mayson, 2019; Noble, 2018). Specifically, we explored how STEM and computing spaces can be healing, inclusive, and transformative for historically marginalized K–12 students.

Collaborating Teachers' Narratives

The research question addressed in this study was, *What aspects of social justice pedagogy do STEM teachers center on when teaching in STEM and computing disciplines?* Although several themes emerged from the research question, in this article, we focus on the following theme: STEM+CS teachers used pedagogical practices of belonging (culturally responsive pedagogy), counter-storytelling (critical race theory), and dialogical engagement (Freirean critical pedagogy) to heal students and their negative and traumatic experiences in STEM+CS educational spaces.

We present the findings using an adaptation of constructed composite narratives. Traditionally, composite narratives are constructed from interview transcripts from multiple interviewees (Johnston et al., 2021; Willis, 2019). We construct composite narratives from multiple data sources from a single participant.

Each participant's story is individual, constructed from interview transcripts, observation notes, researcher notes, and documents. Our purpose in using composite narratives is to center participants' words and perspectives when presenting the research findings (Johnston et al., 2021) and to allow for the complexities of the participants' motivation and position in the storytelling (Willis, 2019).

Additionally, we present the findings in the present tense as a practice of storytelling employed in autoethnography,

an evocative way to write about people's lives (Bhattacharya, 2018; Bochner & Ellis, 2016; Gregersen, 2022). As educators and researchers, we engaged in reflexivity and attended to our own power dynamics while co-constructing relational trust to uncover the stories that reflect the realities and perspectives of the collaborating teachers (Esposito & Evans-Winters, 2022; Wa-Mbaleka, 2020).

Collaborating Teachers and School Context

Rayn, Firehouse Middle School and Academy High School:

> I center students from marginalized backgrounds, so Black and Brown students, queer students, and young women. There's an absence of visibility in the education of Black and Brown folks. I feel like it's not really addressed. Women, because when growing up, I hadn't seen a lot of women in science, but I had a lot of women educators, which I think is a reason why I have such a strong identity as a woman because my first educators were Black women. (Interview, 2022; see Figure 1)

Daniel Gomez and Beach City High School:

> The part about me being gay has definitely shaped the way that I want to participate in school. One of the first things I tried to do was seek out the GSA [Gender and Sexuality Alliance Club] and say, "Hey, how can I help?" and connect with those students. (Interview, 2021; see Figure 2)

Figure 1

Participant Identity
A 26-year-old Black woman from a working-class family
Poet/artist
STEM
Teacher activist
Credentialed in biology and computer science

Participant Positionality
Black women's health due to her mother's history of health disparities
The education of Black folks
Dehumanization of her father (learning difficulties, drug use)
Black queer and trans folks
Success in STEM

Philosophy of Education
Inclusion of Black and Brown students in STEM
Inclusive and sustaining pedagogy
Principles of Black Student Achievement (BSAP)
Racial literacy
STEM literacy
Anti-oppressive and emancipatory pedagogy
Care pedagogy

Curriculum Discussed or Observed
Science 8
Force & Energy and and Space Science withPhenomenon—STEM Challenge, does a rocket move?
Urban Heat Island

Anatomy/Physiology
Endocrine Lab
Phenomenon—Understanding feedback mechanisms, prenatal care, and women's health
STEM Identity

School Context
Firehouse MS (7–8)
85% of students are Hispanic/Latinx and 14.2% are Black/African American
98.3% of students are socioeconomically disadvantaged, 18.2% are students with disabilities, and 18.7% are English learners (CA School Dashboard, 2021)
1A Science 8 is a sheltered class for emergent bilingual students
3A Science 8 is full inclusion, predominantly students with IEPs or 504 plans or emergent bilingual students

Academy HS (9–12)
86% of students are Hispanic/Latinx, 8.8% are Black/African American, and 2.4% are Asian/Pacific Islander
82.1% of students are socioeconomically disadvantaged, 13.5% are students with disabilities, and 21.9% are English learners (CA School Dashboard, 2021)

Figure 2

Participant Identity
A 27-year-old gay man
Mexican American
Biomedical scientist
Inclusion teacher
Credentialed in biology and computer science

Participant Positionality
Socioeconomic classes (family history of poverty and middle-class experiences)
Catholic schooling in K–12, closeted gay K–12 student

Philosophy of Education
Inclusion of LGBTQ+ students and students with dis/abilities
Bicultural and bilingualism
STEM literacy
Racial literacy
Critical media literacy
Community asset-based pedagogy
Care pedagogy

Curriculum Discussed or Observed
Biology
Photosynthesis and Cellular Respiration Unit
Urban Green Space Parks Project Phenomena
Closed system terrarium

Genetics Unit
Viruses and Vaccines Project
Phenomena—What makes us who we are?

School Context
Beach City HS (9–12)
59.9% of students are Hispanic/Latinx, 15.3% are Black/African American, 14.4% are White, 7.8% are Asian/Pacific Islander, and 2.3% are two or more races
68.8% of students are socioeconomically disadvantaged, 14.4% are students with disabilities, and 5.5% are English learners (CA SchoolDashboard, 2021)
Daniel's biology full inclusion classes consisted of more Black students and fewer White and Asian American students compared to the school demographic, 31% of students having an IEP or 504 plan

Mila Erchul and Chavez Academy High School:

> Ableism is so normalized in society, especially in education, that I just assumed that my inability to keep up was my own fault due to my own laziness and lack of discipline. With that perspective, I know that my own high school students may not even recognize how ableism has an impact on their lives. Being queer and closeted until adulthood, I can relate to and provide a supportive space for queer students, whether they are out or not. I think we all have certain aspects of our identity that make us uniquely capable of supporting our students in different ways. (Positionality paper, 2020; see Figure 3)

Jessica Garcia and TA Middle School Magnet:

> I think the biggest thing for me is to remember that my students are people with experiences that can impact their learning, how they engage, and what they can contribute, and what becomes meaningful to them. Especially with math because I feel like math can be seen as, "Oh, it's just math, like you learn it, it's neutral," but you know, kids have experiences that connect to math, and those experiences impact the way that they're coming into the classroom and engaging or not with the subject. (Interview, 2022; see Figure 4)

Repairing STEM Identity as a Philosophy of Education

The four collaborating teachers had personally experienced discrimination, alienation, and microaggression that harmed their STEM identities. Although the four collaborating teachers had education and STEM imprints of negative experiences, they resisted marginalization. They successfully navigated the STEM pipeline to earn their math and science degrees and

Figure 3

Participant Identity
A 27-year-old White woman
Queer identity
Physicist
Computer scientist
Mental & physical disability/health issues
Credentialed in physics & computer science

Participant Positionality
Chronic pain due to multiple sclerosis (MS)
Depression and mental health (bipolar disorder)
Ableism
Socioeconomic class
Queer inclusion in STEM

Philosophy of Education
DisCrit
QueerCrit
Inclusion of LGBTQ+ students and students with dis/abilities
Dismantling heteronormative schooling and culture

School Context
Chavez Academy HS (9–12)
99.5% of students are Hispanic/Latinx, 97% of students are socioeconomically disadvantaged, 15.6% are English learners, and 18.5% are students with disabilities (California School Dashboard, 2021)

Curriculum Discussed or Observed
Exploring Computer Science
Web Design
Computing Practice and Programming
Inquiry-Based Pair Programming
AI Bias

Physics
Forces in motion, Phenomenon—Rockets
Momentum, Phenomenon—Car Collisions
Energy, Phenomenon—Rollercoaster
Waves, Phenomenon—Breaking Glass with Voice
Earthquake and Waves Community Center Project

Figure 4

Participant Identity
A 27-year-old Mexican American woman
Eldest sibling
Math
Computer science
Engineering
Credentialed in math and computer science

Participant Positionality
Socioeconomic class (working-class family)
Prestigious boarding school
Latina in STEM

Philosophy of Education
Inclusion of Latina girls in STEM
Rightful presence
Sense making

Curriculum Discussed or Observed
CTE Computer Science 6th
Theme Park Design
College Research Project
Minecraft Landmark Project Design

Math 8th
Unit 3: Proportional and Linear Relationships
Unit 4: Linear Equations and Linear Systems
Unit 5: Functions
Transformation Art "What Moves You?" Project

MESA 6–8th
MESA Engineering Design Competition
Artificial Intelligence and Social Media

School Context
TA MS Magnet (6–8)
96.2% of students are Hispanic/Latinx and 1.7% are Black/African American
93.1% of students are socioeconomically disadvantaged, 13.3% are students with disabilities, and 13.6% are English learners (California School Dashboard, 2021)

credentials. Consequently, these experiences inform how they implement social justice pedagogies with students choosing to focus on inclusive and collective healing practices. The teachers were motivated to create authentic learning experiences based on diversity and inclusion, sustaining students' sense of belonging, and developing positive STEM identities (Singer et al., 2020).

Rayn described that as a young fourth-grade student, teachers disciplined and shamed her in front of her classmates. These experiences negatively impacted her academic and STEM identity:

> I will never want any of my students to feel humiliated or ashamed within my classroom space. I would never want a student to leave my classroom with only memories of how they were disciplined. I want them to leave my classroom working towards a positive STEM identity, confidence, and agency. My fourth-grade experience is the reason why I work hard toward implementing social justice education. [I want] education that is liberating, education that is humanizing, education that stimulates creativity, education that cultivates agency, education that provokes critical thinking, education that is inclusive. As a social justice educator, it is always important to remember that our students are humans with lives outside of school that have an impact on their interactions within our class and how they are able to connect to their educators. (Capstone Project, 2022)

Mila relates her negative experience of feeling a lack of belonging in STEM, which harmed her overall relationship with STEM. Because of these feelings, Mila expressed her desire to center inclusivity and a sense of belonging in STEM for her students while also reflecting on ways to repair her own damaged relationship with STEM:

> I always felt like I was hiding a huge part of my STEM identity: all of the times I felt like I didn't belong, like I wasn't smart or dedicated enough to succeed, like no matter how many times I caught up, I would just fall behind again. How could I inspire my students to find joy and fascination in a field that seemed to hold only painful memories for me? How could I expect my students to be excited about science when I wasn't even excited about it? I've been trying to repair my relationship with STEM by allowing myself to reconnect with physics and computer science through a mature lens.
>
> As I reflect on my past and how it impacts my ideas of teaching for social justice, I wonder how systemic barriers impact access to STEM education and have even shaped my own experiences. I am working on being kinder to myself and more critical of the institutions through which my students and I must navigate in order to succeed in academia. The ecology of many STEM fields is ingrained with racism, sexism, homophobia, and ableism, among other oppressive ideological structures. It is not a coincidence that queer people, for example, are not well represented in these fields. And yet, I still have a hard time acknowledging that many of the challenges that I faced in school were bigger than my individual experience. (Capstone Project, 2022)

Jessica shared similar feelings of harm and a need for healing. She attended a small private college as an engineering major and enjoyed her CS programming classes. Nevertheless, after two years in the engineering program, despite finding fulfillment in her CS classes, she felt discouraged by the exclusionary culture of the engineering program and discrimination from her White male professors as a Latina:

> I've always really enjoyed CS. I just didn't think it was a field that had any possibility for me. I was miserable with my program, not so much because of the content but because of the professors and the lack of support and community that I wasn't feeling, which is a very common experience for women in STEM and women of color in STEM. (Interview, 2022)

Jessica reflected on a high school experience when her teacher invited her to join a coding club of all boys. She declined the invitation, which she regrets to this day:

> If I could go back and change anything in high school, it would be to have joined the club. But knowing that, and knowing that feeling of "I don't want to join this because I'm going to be the only girl or the only person that looks like me," I really try to encourage my students to see themselves as computer scientists and see themselves as mathematicians, even if that's not a career that they will eventually pursue, just so they know that it is a possibility for them. It's not our goal to make them into math, computer science, and math-adjacent majors. I don't think that's the goal, but I think the goal is to make them feel like that was a real option for them.
>
> As an educator, I want to make sure that I'm not silencing my kids, whether they get the math or not. That means having them speak up but that also means me speaking up and getting that voice back again, in class, but also outside of class, too—reclaiming my voice and reclaiming the time and space that was taken from me in college and also in other parts of life in general. (Composite interviews, 2022)

Healing Students' STEM Identity as an Act of Resistance

The collaborating teachers felt the need not only to repair their own STEM identities but also to engage in healing practices to repair and empower their students' STEM identities and create a sense of belonging and inclusion. The four teachers centered students' voices by including their diverse identities, cultural ways of knowing, and sociopolitical values instead of sustaining the established hegemonic power and positionality of the dominant culture in STEM and CS (Garibay, 2018; Goode et al., 2020; Mattheis et al., 2020; McGee, 2020; McGee & Bentley, 2017; Ryoo, 2019; Vakil, 2020).

Because they had experienced painful moments when they felt othered, excluded, or oppressed in their own school spaces, they viewed repairing their STEM identity as an act of resistance against patriarchy, hegemonic bias, ableism, and heteronormativity. The collaborating teachers also felt a strong responsibility to provide an inclusive space for their students to feel validated for who they are and what they bring to the classroom. Through collective and community action the classroom became a healing space for students and teachers alike.

Rayn described how these experiences shaped her philosophy of education while helping her to heal her students' STEM identity. Like David, Jessica, and Mila, Rayn employs a healing practice of empathy by providing space for students to express themselves, including anger and resentment, from having been made invisible by society and school:

As a teacher, I need to work towards seeing my students holistically by working towards understanding the neighborhoods they are growing up in, getting to know their families, and getting to know what they have experienced inside and outside of school. I need to see my students holistically because I never know what they may be going through at home, but I know I can provide a space to heal within my classroom—a healing space that works to amplify youth voices, a platform where my students can share their ideas and for those ideas to actually be listened to, considered, and cherished, a healing space that cultivates vulnerability even if we may not always be comfortable, and that's okay. Students will come as they are and work towards ways to cope with the adversities they are experiencing. My students will know that they bring their own identity and knowledge to the space. No judgment. No hatred. No harm. A space where communication is used to work through conflict because we may not always agree, but we will work towards an understanding and acceptance of the variability in the classroom. (Capstone Project, 2022)

Jessica offered another example of how to address healing for students in STEM by validating students' feelings in their lived experiences. She mentioned that healing her students' math identities begins with how she creates an inclusive environment at the start of the school year using "I Am From" poems and "Dear Math" letters. Not only does Jessica share her "I Am From" poem with her students on the first days of the school year, but she also has them write poems. Figure 5 is an example of a student's poem.

Additionally, Jessica asks students to write a "Dear Math" letter (see Figure 6). Students reflect on their past experiences with math and how they relate to it now. In the first letter, a student wrote about his antagonistic relationship with math, hopeful that the past experiences that left him crying would be different in this math classroom. In the second letter, a student wrote about her struggles with math and hopes that math will be kind to her as she tries to learn the concepts.

Figure 5
Student "I am From" Poem

I am from nopales
from caldo and frijoles

I am from the corner house
A house that looks small yet big
I am from the pink/purple trees in the front
The red roses in the yard

I am from Quinceanera's and Bautismos
from primos and primas
I am from waking up on Sundays to go to Church and running from the chancla and
From putting Vaporub when you are sick

I am from No se dice que se dice Mande and ponte las pilas
and sana sana colita de rana
I am from playing a family soccer game on Christmas
I am from Torrance and Mexico
From tamales and tacos

I am from my cousin getting hurt on a log
Everyone was laughing with him
From many boxes in the attic of family pictures
Some in Los Angeles and Guadalajara

Healing as Agency and Cultural Assets

CS and STEM teachers, as gatekeepers, tend to employ color-blind racial ideology when deciding which groups of students participate and thrive in STEM and CS education (Annamma et al., 2017; Sparks & Pole, 2019). The lack of inclusion and belonging our students with marginalized identities experience is a result of the erasure of their identities in the hegemonic and color-blind culture of CS and STEM education (Goode et al., 2020; McGee, 2020; McGee & Bentley, 2017; Rodriguez et al., 2020). In contrast,

Figure 6
Student Artifacts of "Dear Math" Letter

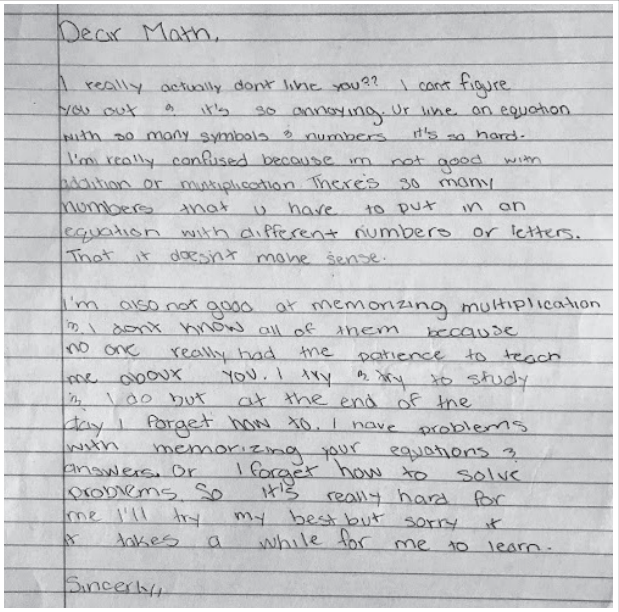
Dear Math,

I've never liked you and to be honest I don't think those feelings will ever change. Since I was little you've never been my ally but more like you've been my enemy for eternity. It's like I'm in a video game and you're the final boss and I can never figure out your weakness to defeat you. Every time when I think I've figured you out, you just end up hitting me with another problem like 560x600÷25x235x437x10000x4758. Sometimes I get a problem right and I think I finally understand you but then you hit me with these crazy problems fullingly knowing that I don't understand and that I have trouble with them.

I've had the worst experience with you math like back in the fifth grade. YEA i bet you remember math when i studied so hard for a test just to take it the next day and not remember or understand anything anymore. Sometimes i got along with you math because sometimes you were kind and nice but that was just a disguise to hide your true identity. You would always show yourself with a kind and mannered way but when no one was paying attention you would show your true colors and hit me with pure nonsense on a paper. I know you enjoyed looking at me suffer almost making me cry when i was just a kid.

When i was a kid i was still bad at you math and you were the reason i would cry when i was little. You made my parents help me and I always tried my best but as you know i wasnt the best at math. When my parents helped me and I would get one wrong they would get mad at me of course and i didn't like when that happened so it always made me cry. Hopefully in the near future I'll finally be able to understand you and be able to work with you. This was a tough journey but i think i'll get through it because i have to cause i feel like this journey is just beginning.

Sincerely,


Dear Math,

I really actually dont like you?? I cant figure you out & it's so annoying. Ur like an equation with so many symbols & numbers it's so hard. I'm really confused because im not good with addition or multiplication theres so many numbers that u have to put in an equation with different numbers or letters. That it doesnt make sense.

I'm also not good at memorizing multiplication bc I dont know all of them because no one really had the patience to teach me about you. I try & try to study it, I do but at the end of the day I forget how to. I have problems with memorizing your equations & answers. Or I forget how to solve problems, so it's really hard for me I'll try my best but sorry it takes a while for me to learn.

Sincerely,

the collaborating teachers created an empathetic, welcoming, and inclusive classroom ecology.

They cultivated their students' voices and agency to create a sense of belonging and *rightful presence* in STEM education (Calabrese Barton & Tan, 2020). The collaborating teachers framed their teaching based on critical theories while engaging in humanizing and care pedagogy practices. They took the time to build the relational trust needed to engage in STEM while also making space for students to bring their cultural and linguistic wealth and their selves as assets into the classroom. In doing so, both the students and teachers are on a healing journey that repairs and affirms their STEM identities:

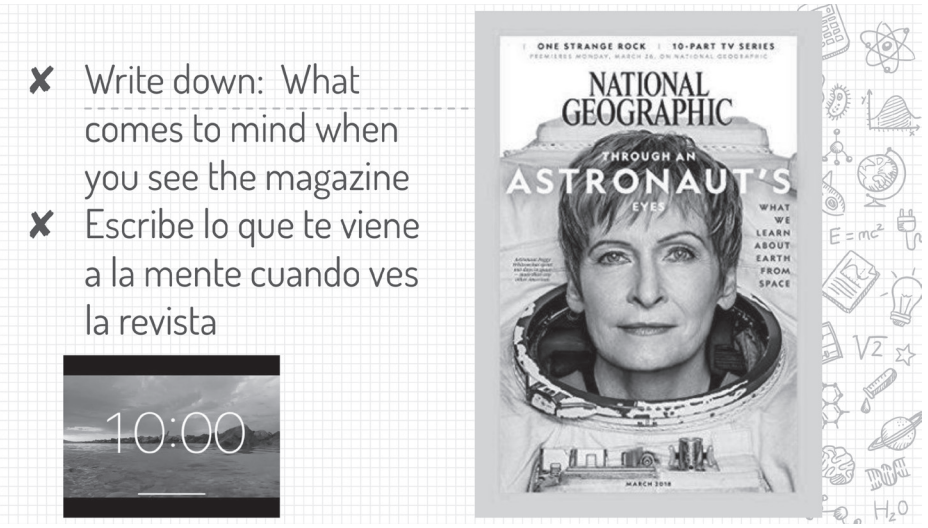
> Ms. Rayn projects a magazine cover of the astronaut Peggy Whitson [see Figure 7] and asks the students, "Through an astronaut's eyes, who does this advantage? [Who does this] disadvantage?" After a brief discussion, a student offers Ellen Ochoa, a Latina astronaut, as a more appropriate representation for the students at the school. A student counters that Ellen Ochoa is not a good representation because "she has fair skin and hair." Another student with a darker complexion adds, "She doesn't look like me." Ms. Rayn emphatically agrees with the students and affirms that intersectionality matters, "Representation isn't about having a woman astronaut on the cover, but a woman with darker skin color too." (Composite narrative, 2022)

Daniel centers belonging in his classroom by responding to students' mental and emotional well-being. Like the other collaborating teachers, he begins each class with a community-building activity and poses a question of the day. Daniel takes the opportunity to speak about love as an act of inclusion and belonging and to celebrate Black History Month through brotherly love:

> Monday, February 14, 2022, Period 4, Biology, 9–10th Grade
>
> Mr. Gomez plays Alicia Keys' "If I Ain't Got You" as ninth- and 10th-grade biology students enter the classroom during an opening check-in activity [see Figure 8].
>
> Students have a lively discussion, sharing fun facts while munching on candies and chocolates. Mr. Gomez then shares his fun fact, "When we talk about loving friends, family, whatever, we can use the word 'love,' but in Greek culture, there are seven different kinds of words for love." Students are confused and stop fidgeting as a few students ask for clarification. Mr. Gomez elaborates, "They have different words. They all mean different types of love. They have brotherly love, like love for your fellow person, romantic love, of course, love for your family, love of self, unconditional love, flirtatious love, and the love of your friends." A student with autism wonders, "What's unconditional love?" Several students share that they only know love as romantic love. Another ponders about the love of self. Mr. Gomez pivots the discussion with a message about brotherly love, embracing each other's differences, and uplifting one another as peers, resulting in another lively conversation.
>
> Mr. Gomez then offers to share another fun fact about Valentine's Day as he transitions the slide forward. "How many of you know who Frederick Douglass is? He was an African American writer and abolitionist. Do you know what an abolitionist is? It is someone who's trying to get rid of slavery in the US, and he worked in politics." Mr. Gomez continues, "His mother used to call him her 'Little Valentine,' and so he chose his birthday as Valentine's Day, February 14th." Mr. Gomez explains how Frederick Douglass's chosen birthday and President Lincoln's birthday in February led to this month's dedication as Black History Month. As students attentively listen,

Figure 7

Teaching Slides of National Geographic Cover and STEM Identity Activity



a few heads nod in agreement. Mr. Gomez ends the morning check-in with, "So that's why we have Black History Month in February, partially because of Frederick Douglass's birthday on Valentine's Day." (Composite narrative, 2022)

Frequently, the question of the day is related to the lesson and is a way for Daniel to provide inclusion and an entry point to the biology curriculum. He also creates an opportunity to learn about his students' interests, what is on their minds, and how they are feeling. The core of the community-building activity is to recognize students' linguistic and cultural values and create a sense of belonging. Daniel explains:

> Students have brought up their autism and other disabilities in class. We talked about it once again when we were talking about genetics and mutations because one of the most familiar chromosomal disorders is Down syndrome, trisomy 21.
>
> I have a student who can barely speak. He has a very, very severe speech impediment. He has autism. He has Down syndrome. He has a lot of developmental disabilities, but he's one of my top students, and that was even brought up during his IEP, too. They categorized him with three different things, and they're like, "But despite all of this, you overcame all of these challenges." Students are starting to realize that, and I think being around other students like this also helps them realize, "Oh, just because they're different doesn't mean they're not capable." (Interview, 2022)

Daniel also shared an incident about a closeted student who decided to come out to his classmates during a class discussion:

> I asked the kids, "What are the issues that you have in school?" Three out of the five classes talked about LGBTQ bullying. One of the kids took a long pause in the middle of the discussion. My co-teacher and I looked at each other with the same thought: *Is he going to come out right now?* And sure enough, he did. He said that the issue of bullying mattered to him "Because I'm bisexual. I have a boyfriend now." He's wearing pink jewelry and he has a little stuffed pink rabbit that he wears now. He's really coming out. He is really feeling he can express himself more, which is cool. (Interview, 2022)

Figure 8
Teaching Slides of Opening Community Buiding Activity and Frederick Douglass

Dialogical Engagement Through Counter-storytelling

One tenet of CRT is counter-storytelling, which uncovers and critiques normalized narratives that perpetuate racial stereotypes while giving voice to those who are othered or marginalized in privileged discourses (DeCuir & Dixson, 2004). The four STEM teachers used counternarratives and storytelling to address and counter biases and discrimination in STEM and computing spaces.

Additionally, the teachers practiced dialogical engagement that considered sociopolitical and socioscientific issues. They centered culturally responsive pedagogy to challenge their student's ability to problem-solve complex open-ended issues by cultivating student agency, encouraging them to use their lived history as a counter-story to the hegemony of STEM and computing.

As racialized teachers, they actively oriented students to social injustices and viewed education as a political process committed to social transformation for people of color (Burciaga & Kohli, 2018; Jackson & Knight-Manuel, 2019). They challenged the dominant and hegemonic culture of schooling and made curricular and pedagogical decisions to foster critical thinking toward social change (Jackson & Knight-Manuel, 2019).

When teachers contemplated ways to confront students' unconscious biases in STEM, they leaned toward lessons that drew on counter-stories, such as the activity "Draw a Scientist," discussions of women in science, humanizing STEM/computing practices, and STEM identity formation. They aspired for

their students to feel they have the power and the right to use STEM tools to better their community, knowing they have experienced marginalization in scientific research, medicine, technology, data science, and AI design.

Daniel and Rayn mentioned how the lesson "Draw a Scientist" provided a good example of challenging biases and discrimination in STEM by using computational thinking and critically reflective practices. Additionally, Rayn uses herself as a counter-story to the image of Einstein:

> Thursday, February 10, 2022, Period 3 Anatomy/Physiology, 11–12th Grade
>
> Ms. Rayn engages students in a community-building activity celebrating youth culture and joy. She then transitions to the next slide [see Figure 9], "Today, we're gonna talk about STEM identity. Please write what your definition of identity is. What do you think 'identity' means? What are some examples of identity?"
>
> As students type onto Peardeck, Ms. Rayn reads the anonymous responses aloud:
>
> "So, identity to me is what presents you."
>
> "What makes you, you."
>
> "I can describe it as clay molds us into the sculpture that we are in the present."
>
> "I think that identity is how a person acts and how they express themselves."
>
> "I think identity is how someone wants to be viewed as."
>
> "Identity is what a person makes about themselves."
>
> "I am a softball person. I'm happy. I am a happy person on the outside."
>
> "It's a thing that represents you, how they express themselves, characteristics."
>
> Ms. Rayn points to a table in one of the slides to explain a person's developing identity. She then asks students to take out a paper. "Okay, so I want us to journal. I want us to pick one thing that influences our identity, and I want you to write about how it has influenced your identity. So, we all have different pieces, right? So, for example, culture, we all have different cultural backgrounds, you just pick one."
>
> Ms. Rayn calls for volunteers to share their journal entries. Students are eager to share their identities and the experiences that impacted who they are. One student discusses her ethnicity, another shares about their sexuality and confidence, and another describes interactions with neighbors in terms of their identity when it comes to trust and friendship. Classmates clap for each student to acknowledge the deeply personal stories they shared. A fourth student shares, "I believe something that represents my identity is as a woman advocate." The student continues to describe how her "home country was politically oppressive, and now, as an immigrant in the United States," she feels the need to "exercise my political activism by speaking at board meetings and advocating for classmates in the classroom."
>
> Ms. Rayn introduces the final activity, "Draw a STEM Scientist" [see Figure 10]. Students are given time to draw a scientist. Most students draw a White male with glasses or goggles, a white lab coat, and big hair [see Figure 11]. As Ms. Rayn walks around the classroom, she quietly acknowledges the few female students who drew a woman scientist.
>
> Ms. Rayn shows a slide of the front page of a Google search for the phrase *cartoon scientist* for discussion and comparison with the students' drawings and their identities [see Figure 12]. She explains to the students that STEM scientists could represent a more diverse group, such as a queer scientist or a scientist who is stylish and sexy [see Figure 13]. Ms. Rayn then advances the slide to

Figure 9
Teaching Slides of "What Shapes Your Identity?"

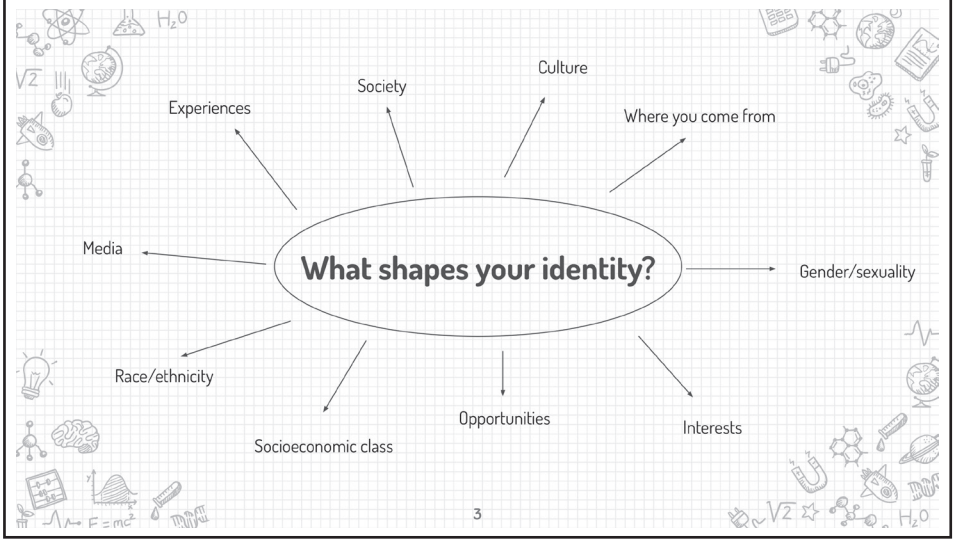
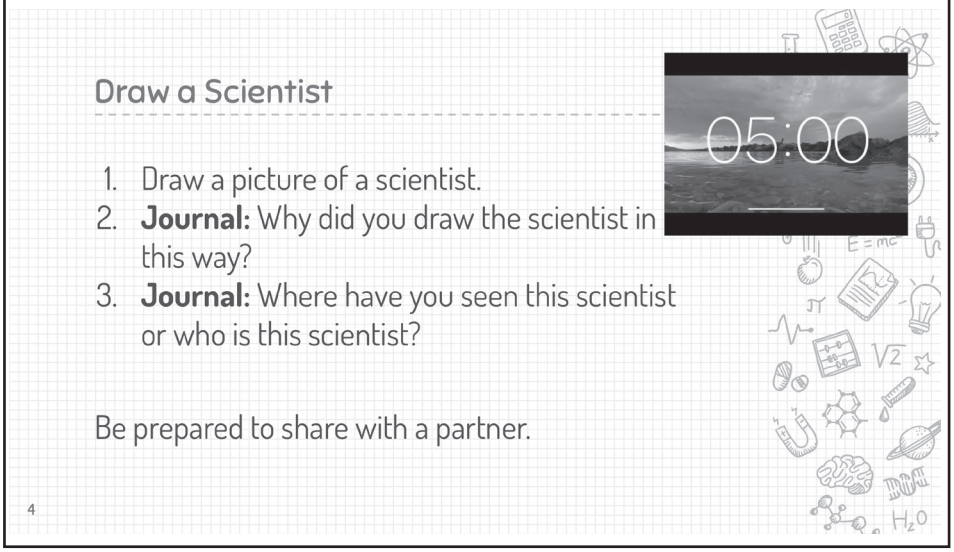


Figure 10
Teaching Slide of "Draw a Scientist" Activity



show a picture of Dr. Mae Jemison, the first Black woman to travel to space [see Figure 13]. "She was an engineer. She was a physician and an astronaut. She is also the woman who inspired me to study science. When I was a kid, I had seen her in a science textbook, and I was like, 'Oh!' Literally, she looked like me. So, then I started reading about science. Then I studied science, and here I am a science teacher." Ms. Rayn then instructs students to redraw their scientists in relation to who they are [see Figure 14]. (Observation notes and audio, 2022)

This activity allowed Daniel and Rayn to address students' unconscious biases regarding their perceptions of people who are in math, science, engineering, and CS as being only White and male. Mila facilitated her exploring computer science students (Exploring Computer Science, 2018) in a dialogical engagement on color-blind racism and the injustice reproduced and amplified through technology. Although Mila is a White woman, her students, who are Latinx, felt safe and empowered to bring their cultural and familial assets and stories into her physics and CS classroom. The relational trust and sense of belonging Mila had fostered between students and herself created an opportunity for a student to share his negative encounters with the police:

> March 18, 2022, D Track, Exploring Computer Science
>
> Students are seated around large lab-like tables in groups of three and four with computer laptops. A large Progress Pride Flag occupies a section of the classroom's front-facing wall. Additionally, eight posters of women scientists with diverse identities are all around the classroom [see Figure 15]. A large poster of "We the Future: Power to the Polls" is next to a student "2022 Vision" wall in the back of the classroom.

It is the beginning of class, and Teacher Mila has a journal prompt projected, "What does injustice mean to you? How might technology play a role in injustice?" [see Figure 16]. Students eagerly write in their notebooks while having quiet conversations within their group. Teacher Mila then engages in a class discussion, needing to provide little prompting as students freely share. Students had already seen the documentary movie *Coded Bias* [Kantayya, 2020] and had explored activities about biases in computing throughout the year.

Teacher Mila introduces the short film *Please Hold* [Dàvila, 2020]. She presents the slides while asking students to think about questions to to consider after viewing the short film. "This movie is actually made by somebody from here and a Mexican American woman. So, I feel like a lot of you could relate more to this perspective. Just keep that in mind when you're watching. And see if you can make connections between who she is and the film, like what choices she made, like who the characters are. What did she choose to have happen based on who she is? And see if you can relate better to this movie than the other one we watched."

Teacher Mila also has students consider the questions, "1) What are some moments of injustice in the film? 2) How might this film relate to ideas that we have explored in our class?" [see Figure 17]. Then she turns off the lights to show the film. Students are attentive and take notes while watching the film. The film ends with a cliffhanger. As soon as the credits begin to roll, the students erupt into conversation with each other while Teacher Mila turns on the light. A student suggests that the main character, Mateo Torres, has a common Hispanic name and that "they probably just got him confused with someone else." Teacher Mila acknowledges the comment and redirects students with a question to discuss with their table groups, "What do you think happened?" Teacher Mila walks around while students are having

Figure 11
Student Artifacts of Scientists

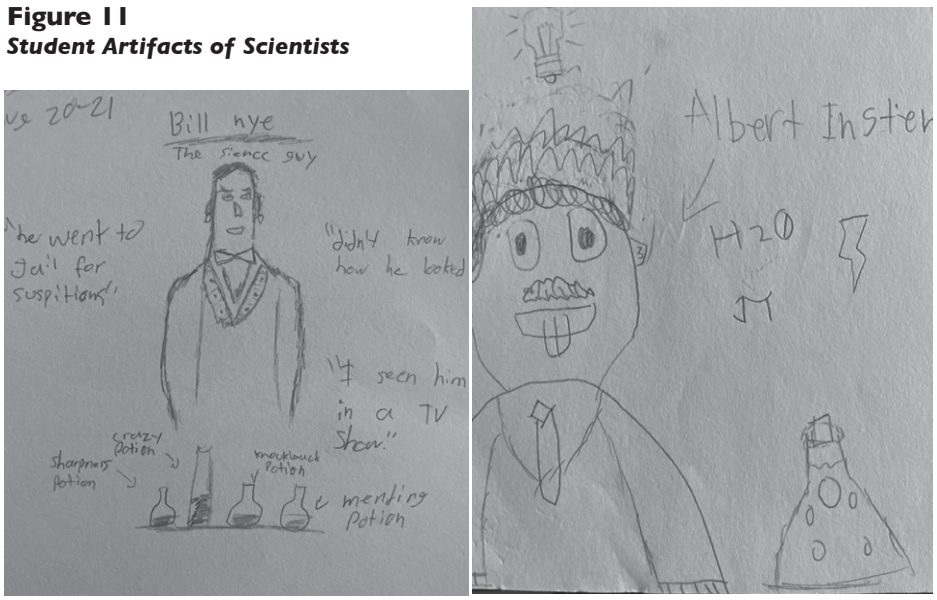
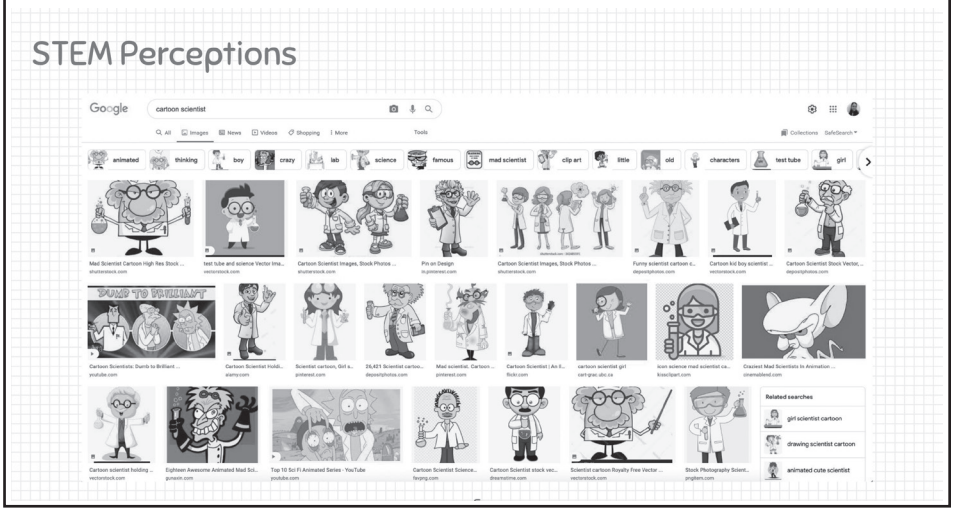


Figure 12
Google Search of "Cartoon Scientist"



a heated discussion about the film's outcome and then returns to the front to engage in a whole-class discussion, "What do we know about Mateo's identity?" Students respond:

"He's Mexican because of his name."

"He works at a restaurant because of his clothes."

"He's not educated because he didn't know a lot about the law."

"He's not super-rich. They drain his bank account because he makes an outgoing call."

"Yeah, he only had $300 in his bank account."

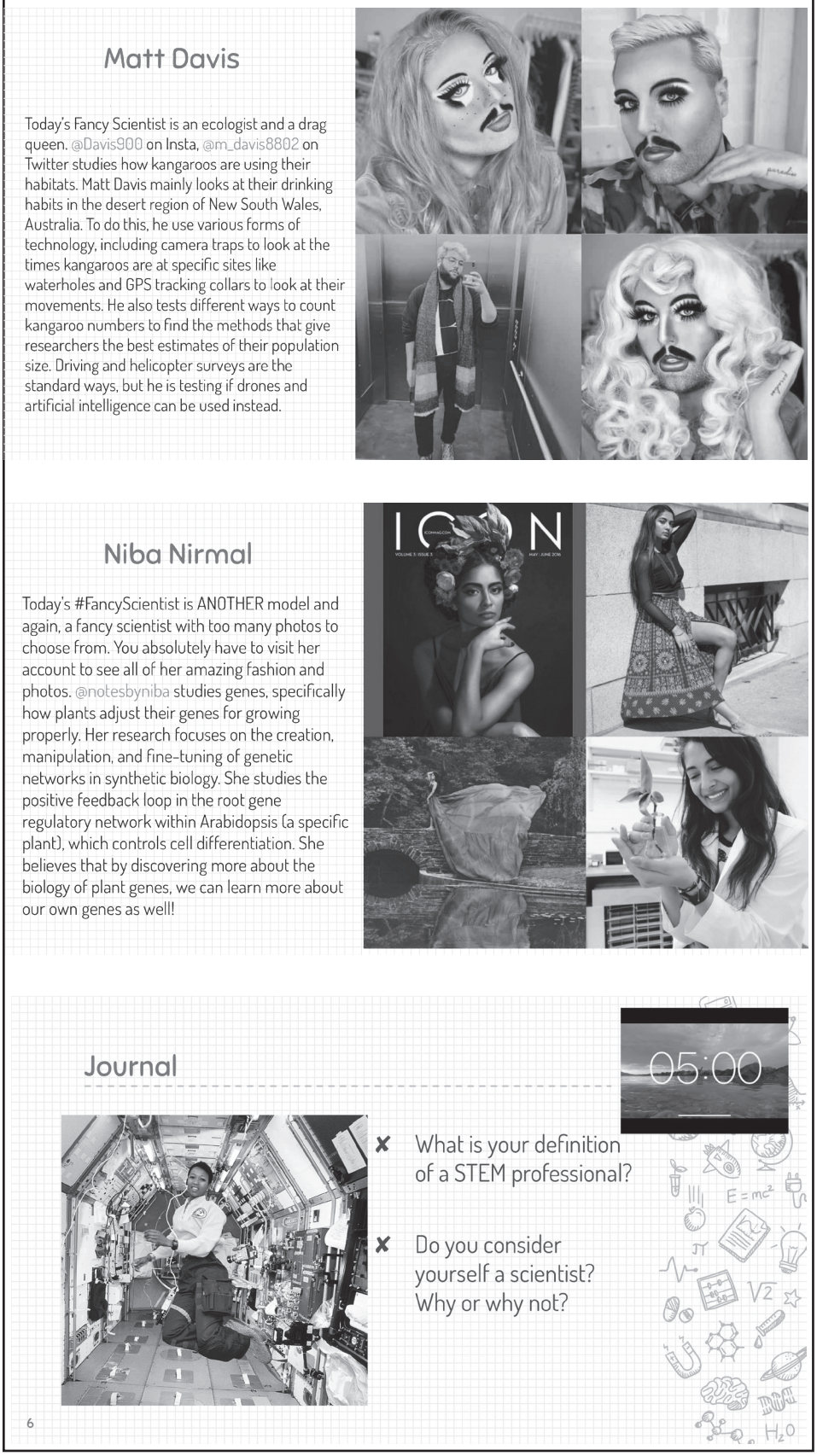
Teacher Mila then asks questions, reading off the slide [see Figure 18], "Okay. How do you think his identity played a role in what happened? And then, how do you think technology played a role in what happened?" Several students begin sharing at once, to which Teacher Mila has students share their thoughts one at a time. Teacher Mila then has a student who has been silent share their thoughts. The student believes that the facial recognition software falsely identified Mateo as a criminal because he has a common name. Teacher Mila advances the slide and then explains to students that they will design and create an app that uses artificial intelligence and machine learning to solve problems in the community. Teacher Mila then asks students, "How could we design technology and AI better so that it fights against injustice?" (Composite narrative, 2022)

Discussion and Recommendations

Students of color are not entering the CS pipeline at an early age. If they do, there are many sites of attrition along the way, as evident in a nationwide study that showed only 16% of all students in AP Computer Science A were Black, Latinx, or Indigenous (Scott et al., 2018). One hope and possibility for the diversification of CS resides in the knowledge that students who form a positive STEM identity at a young age will better overcome STEM-related barriers (Mattheis et al., 2020).

As more students with marginalized identities heal their STEM identity, engage in critical consciousness, and develop a strong sense of agency and belonging, hope increases for the collective action needed for transformative change within the computing professions. Diversifying

Figure 13
Teacher Slides of Diverse Scientists and Dr. Mae Jennison



the CS workforce may likely counter biases and discrimination in computing (Benjamin, 2019; Garibay, 2018; McGee, 2020; McGee & Bentley, 2017; Turner Lee, 2018). Increasing the visibility of queer STEM professionals may counter the heteronormative culture of CS and STEM (Mattheis et al., 2020). Similarly, increasing Black STEM professionals may counter the White supremacist culture of CS and STEM workplaces (Benjamin, 2019; McGee, 2020).

As computing aims to solve social problems and algorithms provide collective instructions and rules intended to address those problems (Benjamin, 2019), who gets to participate in making complex computing decisions depends on teachers who broaden participation in their classrooms through tangible actions and intentional practices. We offer the following

Figure 14
Student Artifacts of STEM Identity and Journal Response

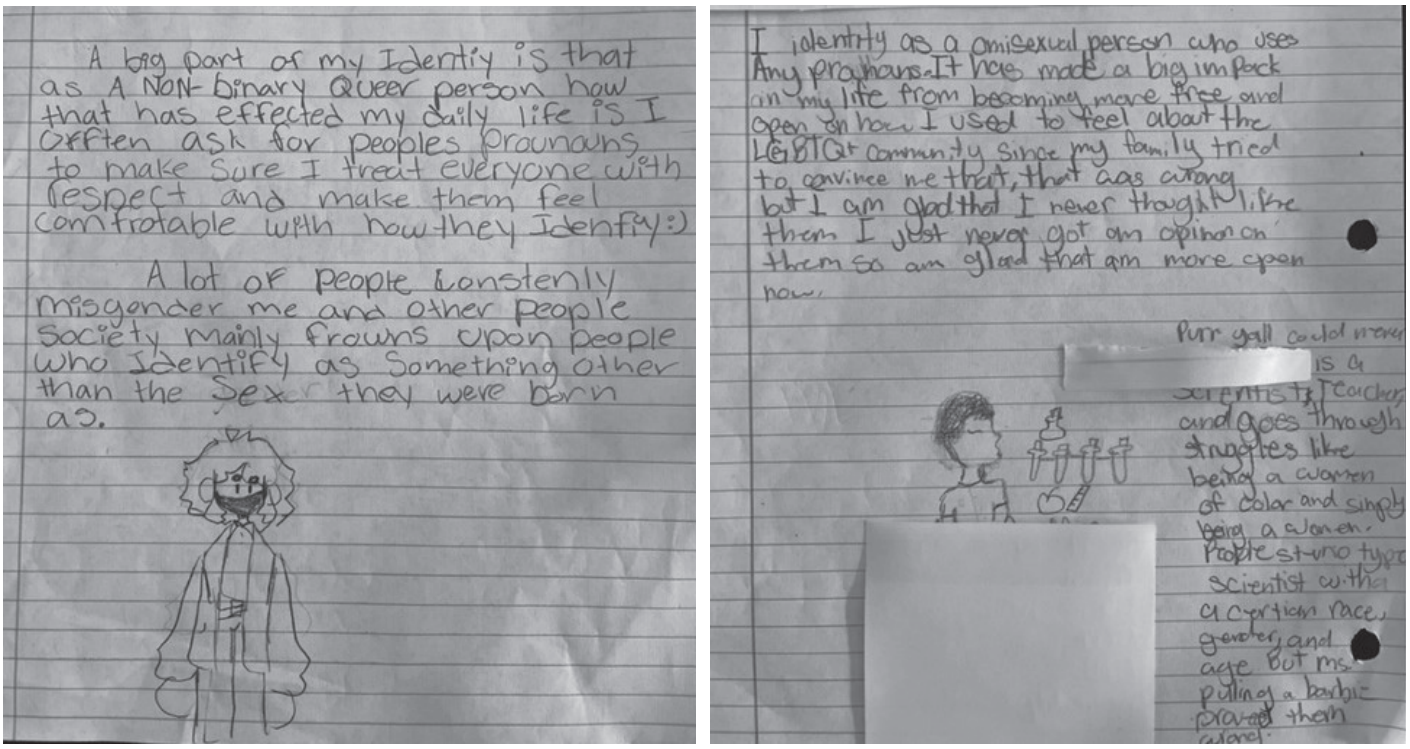


Figure 15
Visionary Women Scientists and "We the Future" Posters

recommendations for STEM educators and teacher education programs to take action and resist social and institutional oppression:

1. When recruiting students, STEM teachers should prioritize creating a classroom culture of rightful presence for students with marginalized identities. Teachers often reproduce systemic injustices in teaching and classroom practices despite students having opportunities to participate in STEM (Calabrese Barton & Tan, 2020). Beyond inclusion, rightful presence shifts the power dynamic in the classroom by "*making present* the political struggles" students embody and experience (Calabrese Barton & Tan, 2020, p. 434).

2. STEM teachers can empower themselves and students with marginalized identities to use their voices in STEM spaces through counter-storytelling. Teachers of color and social justice-oriented teachers are likely to engage their students in discussions of race, culture, and power in STEM (Goode et al., 2020; Ivey et al., 2021; Kokka, 2018). Using counternarratives to examine traditional STEM stories that focus only on the genius White man and claim objectivity and neutrality through the practice of personal storytelling and the centering of other people's counter-stories creates opportunities for students with marginalized identities to feel who they are matters.

3. STEM teachers can create a sense of belonging and agency by facilitating culturally responsive/sustaining discussions. Broadening participation begins with students with marginalized identities feeling they matter, the discussions they engage in are meaningful to their lived experiences, and the academic content provides them with opportunities to enact power and agency (Rodriguez et al., 2020; Ryoo et al., 2020).

4. STEM teachers should know theory and apply a purposeful framing of their philosophy of education in their praxis. The four collaborating STEM teachers in this study referenced pedagogies in critical race theory, rightful presence, Freirean critical pedagogy, and critical theories like DisCrit and QueerCrit. The participating teachers are well-read, knowledgeable, and reflexive about their teaching practices in social justice education. Ivey et al. (2021) also recommended that teacher education and professional development should "center these anti-racist pedagogies, rather than leaving them in the margins of teacher learning" (p. 4). Without a solid conceptual knowledge of antiracist theories and pedagogies, teachers' strategies and practices will fall short of abolitionist teaching in making real changes in their students' lives (Love, 2019).

As Baldwin (1998) stated, "The force of history comes from the fact that we carry it within us, are unconsciously controlled by it in many ways, and history is literally *present* in all that we do" (p. 723). The collaborating teachers politicized and racialized discussions in the classroom and challenged issues of objectivity and biases in socioscientific issues. They view themselves as activists and approach teaching and learning as a process of co-constructing knowledge with their students, creating space for profoundly personal and emotional discussions.

Notably, the STEM+CS teachers repeatedly expressed the importance of a supportive community of teachers, peers, mentors, and leaders to sustain their work. Through collective support

Figure 16
Teaching Slide of "Do Now" Journal Questions

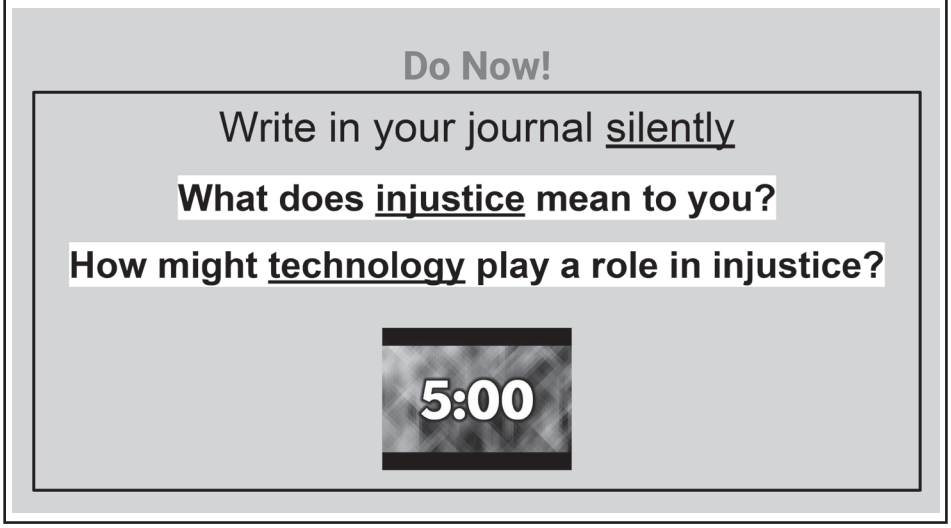
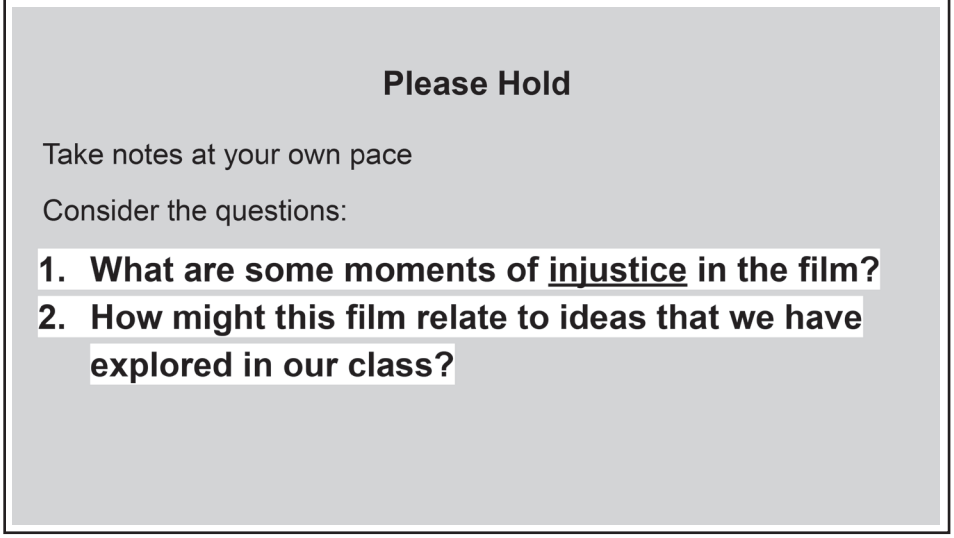


Figure 17
Teaching Slide of "Please Hold" Questions to Consider



and reflexivity in education spaces, STEM and CS teachers can and should learn to embrace healing pedagogies that support humanizing all students through a collective struggle and commitment to creating STEM and computing spaces in which all students thrive (Ivey et al., 2021; Love, 2019).

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Figure 18
Teaching Slides of Discussion Questions and Looking Ahead

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