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EDITED BY
Lauren Mims,
New York University, United States

REVIEWED BY
Luis Leyva,
Vanderbilt University, United States

*CORRESPONDENCE
Channing J. Mathews
cjmathews@virginia.edu

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Cultivating Black liberatory spaces in science, technology, engineering, and mathematics education: What does it take?

Channing J. Mathews[1]*, Darrius Robinson[2] and Charles E. Wilkes II[3]

[1]Department of Psychology, University of Virginia, Charlottesville, VA, United States, [2]School of Education, University of Michigan, Ann Arbor, MI, United States, [3]Center for Research in Mathematics and Science Education (CRMSE), San Diego State University, San Diego, CA, United States

Black youth who reject this belief carry a heavy burden to resist anti-Black attitudes and continue to strive for excellence. As a result of this antagonistic relationship, many Black learners are led to believe that high competence in the areas of science, technology, engineering, and mathematics (STEM) are beyond their grasp. Such beliefs can lead Black learners to determine that the pursuit of success in STEM is not worthwhile. In our vision for Black Liberatory STEM Spaces, the antagonistic relationship between Blackness and success in STEM is dismantled and the forms of violence that support this association are non-existent. The purpose of this paper is to highlight concrete educational practices that move us toward pedagogy that centers Black joy, creativity, imagination, and liberation within STEM education.

KEYWORDS

Black liberation, STEM, adolescence, Afrocentric pedagogy, Black joy

Introduction

Anti-Blackness is a framework that makes visible the ways in which schooling continues to be a site of suffering and marginalization for Black learners. Anti-Blackness refers to a web of attitudes, practices, and behaviors that work to oppress communities of color and foster an antagonist relationship between Blackness and humanity (Dumas and Ross, 2016; Black Liberation Collective, 2017). Though we recognize that anti-Blackness dehumanizes communities of color broadly through structural and ideological violence, this commentary specifically centers Black learners in science, technology, engineering, and mathematics (STEM) disciplines. Scholars of STEM education use anti-Blackness as a lens for demonstrating how Black learners are marginalized and dehumanized within STEM learning environments (Cedillo, 2018; Martin et al., 2019). In STEM education, anti-Blackness refers to the antagonistic relationship between

Blackness and the possibility of success in STEM fields and the systemic violence that perpetuates this relation. In the United States this relationship is bolstered by structural racism and racist schooling practices that communicate to Black learners that their Blackness and associated ways of being are barriers to success in STEM (Cedillo, 2018; Martin et al., 2019).

As a result of this antagonistic relationship between Black STEM success and anti-Blackness, many Black learners are led to believe that high competence in the areas of STEM are beyond their grasp. Such beliefs can lead Black learners to determine that the pursuit of success in STEM is not worthwhile (McGee and White, 2021). Black learners who persist in STEM must do so despite the racial identity attacks they endure in these spaces, attacks that intensify as they achieve higher levels of success (Mcgee, 2020). In our vision for Black Liberatory STEM Spaces, the antagonistic relationship between Blackness and success in STEM is dismantled and the forms of violence that support this association are non-existent. The purpose of this paper is to highlight concrete educational practices that move us toward pedagogy that centers Black joy, creativity, imagination, and liberation within STEM education (**Figure 1**). First, we examine how Anti-Blackness emerges in STEM education and renders invisible the competence of Black learners. Next, we highlight critical school and classroom practices to challenge Anti-Blackness by creating visible connections between Black learners and Black historical contributions to STEM fields. Instead of focusing on deficit framings of Black children, we name and unpack individual and contextual factors that support the strengths and development of Black STEM learners. Finally, we explore the role of teacher practice and pedagogy in cultivating Black youth's interests, creativity, and joy as key ingredients to fostering liberated STEM learning spaces.

Theoretical framework: Naming anti-Blackness in science, technology, engineering, and mathematics spaces

In explicating the way anti-Blackness manifests in mathematics education, Martin and colleagues name three forms of violence that are exacted through institutionalized procedures and practices: physical, symbolic, and epistemological (Martin et al., 2019). Physical violence against Black children is explicit in the physically harmful and destructive ways it occurs in classrooms. Such violence has torn through the headlines as we bear witness to young Black girls being thrown across classrooms by law enforcement (Shakara) and arrests of those who stand up for them (Niya Kenny) (Hines and Wilmot, 2018). Symbolic violence is enacted when words, symbols, and standards are used to inflict psychological wounds (Martin et al., 2019). This violence occurs as Black students navigate STEM learning in environments riddled with interactions that invoke racial stereotypes. Epistemological violence occurs when empirical data is interpreted in ways that construct Black learners as inferior, especially when compared to their White and Asian counterparts, when there are other equally plausible interpretations available (Martin et al., 2019). For example, notions of an "achievement gap" dominate literature that examines the differences in academic performance of Black students as compared to White students. However, this framing rarely considers the psychological and systemic barriers to achievement that Black youth have generationally faced given limited access to highly resource schools, and highly skilled and trained teachers (Ladson-Billings, 2006a,b).

Our review extends Martin and colleagues' framing of anti-Blackness to all STEM contexts. We suggest that physical, symbolic, and epistemological forms of anti-Black violence are also prevalent in science, technology, and engineering education albeit in different ways given that anti-Blackness emerges uniquely within each discipline (Mcgee, 2016, 2020; Cedillo, 2018; Jones and Melo, 2020; Nxumalo and Gitari, 2021; Holly and Quigley, 2022). While physical violence is deeply embedded in the systemic integration of anti-Blackness in policy, this commentary focuses on two implicit forms of violence: epistemological and symbolic. For example, recent calls for more inclusive hiring and training of racially minoritized groups in computer science are driven by gaps in the workforce, particularly in the development of artificial intelligence (AI) and facial recognition technologies (Nkonde, 2019; Jones and Melo, 2020). Though research funding has been dedicated to creating pipelines for students of color to enter computer science, little of these training mechanisms interrogate the problematic relationship between AI and surveillance of Black and other racially minoritized groups (Nkonde, 2019; Jones and Melo, 2020). In engineering, anti-Blackness emerges in how resources are allocated to support Black engineers across the education pipeline, but particularly in higher education. Though historically Black colleges and universities are the most successful in graduating Black engineers, they receive less than 1% of federal funds allocated to support science and engineering innovation (Holly and Quigley, 2022). Though these are only two examples of how anti-Blackness transforms across STEM disciplinary spaces, it underscores the need to interrogate the unique roots and symptoms of anti-Blackness across science, technology, and engineering in addition to mathematics. The prevalence of these forms of violence across STEM leads to a relation wherein success in STEM is equated with adopting White ways of being (Byrd and Chavous, 2011; Mcgee, 2020; McGee and White, 2021).

Black students' thriving in STEM requires that they have the choice to participate and experience success at a level similar to their non-Black peers. Offering such opportunities requires contending with how anti-Blackness is enacted through

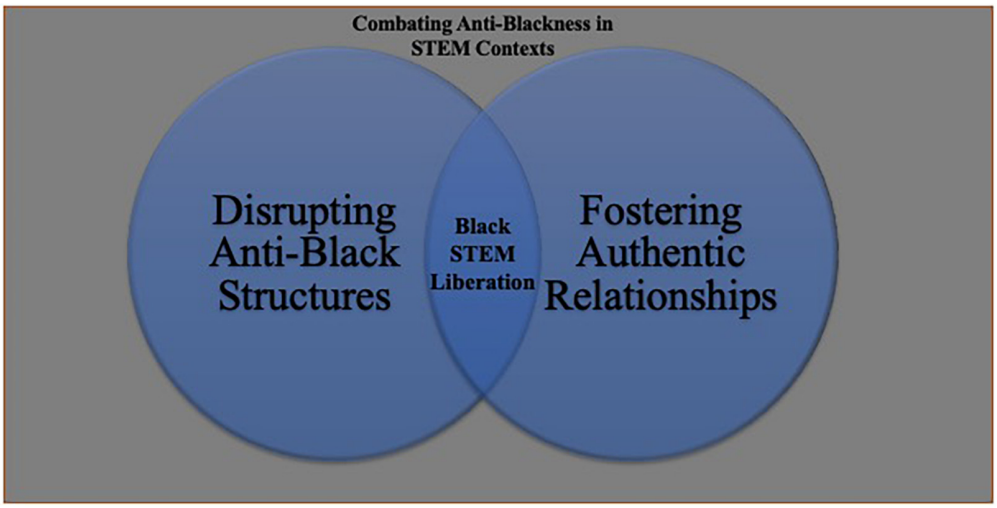

FIGURE 1
Conceptual model for combatting anti-blackness in STEM education.

systemic violence in STEM education and incorporating practices that counter its effects. Black learners need and deserve to develop their STEM competence in environments where their ability is not questioned and where they are not forced to sacrifice parts of their being to belong (Morton et al., 2019). In the remainder of this commentary, we focus on confronting epistemological and symbolic violence in STEM learning environments as these forms of anti-Blackness persist in STEM classrooms. While there are multiple dimensions to cultivating a Black liberatory STEM education, we focus on two aspects: structural and interpersonal classroom transformation. We first highlight curricula and pedagogical practices that serve to normalize and celebrate Black success in STEM. We then explore how teacher-student relationships can foster STEM spaces that allow joy, creativity, and personal interests to be the drivers of Black students' STEM development. We conclude with a call to partnership between scholars, practitioners, and community members to manifest transformative STEM learning contexts that support the brilliance of Black youth.

Disrupting curricular structures: Reimagining science, technology, engineering, and mathematics spaces for Black liberation

In his most recent book entitled *STEM, STEAM Make a Dream*, Dr. Christopher Emdin argues that we are not preparing today's youth for the STEM careers of tomorrow given that schools remove the context, emotions, and play that is needed to foster innovation within STEM careers (Emdin, 2022). This removal is a form of both epistemological and symbolic violence, given that the absence of context ignores (1) how STEM principles can be applied to solve issues related to the community and (2) how Black people have contributed to STEM innovation and development. The erasure of both application and Black innovation emphasizes deficit notions of Black intelligence and STEM capability that Black youth regularly face when entering STEM classrooms. Epistemological violence occurs through uplifting white-washed curricula as the standard for STEM innovation, explicitly casting Black contributions as inferior by excluding them from mainstream curriculum. Subsequent symbolic violence occurs as Black youth are socialized to believe that STEM learning only occurs in lab-based environments, with White men in white coats, versus understanding the community as the lab space (Carli et al., 2016; Tintori and Palomba, 2017; Morton et al., 2019; Emdin, 2022). This absence robs Black youth from making connections between themselves and STEM, both by ignoring the link between Afrocentric innovation to modern STEM technology, as well as limiting opportunities for practical application that matter for challenges Black youth may face in their communities.

To build Black liberation spaces, we must return to the often-erased link between African centered pedagogy and advancements in STEM. This reconnection addresses epistemological violence because it explicitly acknowledges Black people's contributions to STEM innovation. Afrocentric based curricula center Black learners by rooting their knowledge in African identity, values, and culture. In doing so, learners are empowered by the recognition of their own culture within the classroom and challenge deficit-based notions of Black STEM performance (Shockley and Cleveland, 2011; Van Wyk, 2014). In one Afrocentric program, youth learning in STEM is grounded

in the assumption that technology is a vessel for culture, rather than being acultural or neutral in nature (Burbanks et al., 2020). The instructors with this Afrocentric program decenter Eurocentric narratives that emphasize Greek populations and philosophers (Plato, Aristotle, etc.) as establishing the foundational principles of mathematics and physics knowledge, and instead highlight the places where such philosophers studied this knowledge, in the ancient Black civilization of Kmet. In doing so, instructors acknowledge the stolen legacy of Black intellectual contributions to STEM by emphasizing African cultures as the source of STEM knowledge, rather than being peripheral to its development (Burbanks et al., 2020).

In addition to linking historical contributions of Black people to the foundational principles of STEM, Black liberation spaces must foster the buy-in of the community, including, but not limited to the Black family (Muhammad, 2020). Centering the family challenges both epistemic and symbolic violence by highlighting that learning and knowledge is not created by individuals but are fostered in intellectual community with others. Mainstream STEM pedagogy often emphasizes the roles and contributions of individuals, particularly White men, to STEM innovation (Burbanks et al., 2020). However, families, especially parents, play a critical role in early STEM experiences, as they are often first to see and nurture burgeoning interests in math and science (Burt and Johnson, 2018; Burbanks et al., 2020). In a study of early STEM interest Black male engineering students, participants described their parents as key facilitators of their STEM interests, serving as both teachers and affirmers of their STEM journey. Further, parents contextualized the importance of education as a tool to address social and economic inequity among Black communities (Burt and Johnson, 2018). By cultivating STEM learning spaces that focus both on the student and the family, STEM becomes embedded in students as a multilayered and community practice (Burbanks et al., 2020).

As youth matriculate into higher education spaces, a continuation of this community-oriented perspective is important to fostering STEM imagination and visibility among Black youth who may not be readily exposed to early STEM learning experiences. For Black STEM innovators who return to their communities, they serve as a tangible challenge to the symbolic violence leveraged against Black youth in STEM classrooms. As STEM scholars return to their communities, they not only challenge notions of Black intellectual inferiority through their achievements, but they also serve as representations of what future generations of Black youth can dream of being in STEM. For example, the Meyerhoff Scholars Program at the University of Maryland Baltimore is a nationally acclaimed bridge program to prepare talented but often overlooked youth of color for engagement in STEM majors and future careers (Freeman and Hrabowski, 2018). In addition to integrated parental and family involvement throughout matriculation and graduation from the program, Meyerhoff scholars apply their STEM learning through STEM based community service and engagement. Serving as tutors, teachers, and innovators, Meyerhoff scholars maintain standards of STEM excellence and culturally engaged practice by investing their talents within the community. In both the Meyerhoff Scholars Program and Afrocentric programming, youth are socialized in this community centered perspective, as they are encouraged to refer to one another as family throughout the program. Such practices underscore that STEM success is not an individual experience, but a collaborative and intergenerational mission available for all to pursue.

To cultivate Black Liberatory STEM spaces we must create opportunities to link Black youth's identities to STEM success and to recognize the scientific inquiry embedded in their daily lives (Freeman and Hrabowski, 2018; Davis, 2020). In doing so, educators disrupt traditional symbolic violence of STEM classrooms that frames Black knowledge and engagement as unscientific (Morton et al., 2022). Practitioners and scholars forge this link by helping Black youth see themselves in the curriculum, by sharing the stories of scientists who look like them. Further, teachers can serve as primary exemplars of STEM success and applied STEM pathways (Brown et al., 2017; Burt and Johnson, 2018). In a study of the institutional practices and messaging of one Afrocentric boy's school, scholars noted how the institution socialized youth to see themselves as scientists and scholars by displaying examples throughout the school such Neil DeGrasse Tyson, a notable Black astrophysicist. Additionally, the school intentionally modeled Black success through its teachers and administrators, who regularly wore or displayed regalia from their college alma-mater to underscore the expectation striving for higher education (Brown et al., 2017). In addition, the school used daily mantras to start their learning day to internalize the roles and responsibilities of being a scholar. These institutional practices are examples of how practitioners embody and convey Black history, culture, and high expectations to Black learners which they often do not experience. Further, as newly told histories such as the 1619 Project and Hidden Figures reveal, Black imagination and STEM contributions are prominent and fruitful, but are stifled because of systemic oppression (Morton et al., 2019; Emdin, 2022). Building meaningful classroom spaces for Black children requires that we show them their histories, including but not limited to the various leaders, scientists, inventors, and mathematicians who made notable contributions to American history, but whose stories are absent in traditional STEM based curricula.

For example, the framing of medical spaces has been shaped by the narratives and experiences of White men (Gewin, 2019). The image of the Black doctor has been labeled as exceptional and not traditional to a legacy of Black excellence. Further when positive images of Black medical professionals emerge within the cultural zeitgeist, they are often limited to one or two individuals that are tokenized. They are essentialized as representative of the struggle to achieve in medicine rather than being recognized

for the notable contributions that they made to the medical field. For example, Dr. Ben Carson has been widely touted as an innovator in the medical industry given his meteoric rise through pediatric neurosurgery, given his work on conjoined twins (Carson, 2011). However, prior to Dr. Carson's medical career, Dr. Vivien Thomas revolutionized pediatric surgery with his solution to blue baby syndrome (cyanosis). However, Dr. Thomas' contributions were not officially acknowledged until 1976 when he received an honorary Doctor of Laws from Johns Hopkins University, where he had been working for Dr. Alfred Blalock. Prior to Dr. Thomas's honorary doctorate, Dr. Blalock received all the credit for Dr. Thomas' contributions, due to the institutional racism that only allowed Dr. Thomas to be recognized (and paid as) a janitor and a lab technician (Joyner et al., 2015). Despite the impact of both Dr. Thomas and Dr. Carson, it is unlikely that Black youth encounter these men in their classroom's texts, but through popular media (i.e., the films Gifted Hands and Something the Lord made are two autobiographical films of Dr. Carson and Dr. Thomas respectively), if the youth are exposed to these men at all. Understanding the contributions of Black people cannot be limited to 1 month or one set of social studies courses but must traverse across all types of curricula including STEM (Akins, 2013).

However, some scholars are challenging the marginalization of Black history by highlighting how Black history knowledge has meaningful associations with academic achievement for Black youth. One study found that Black history knowledge, defined as awareness of the people, events, and achievements related to the history of the African diaspora, was associated with higher educational aspirations (Adams-Bass and Chapman-Hilliard, 2021). This association suggests that youth with knowledge of their Black history may use it as a lens to motivate their academic futures. This connection may be particularly true for Black youth who are aware of Black struggles for education during the Reconstruction and Civil Rights eras, underscoring the importance of educational access for Black youth today.

Traditional STEM courses are framed as culture absent and often ignore the historical connections of how we come to know what we know (Morton et al., 2019). Additionally, STEM narratives often center a stance of neutrality and objectivity that frames STEM as depoliticized rather than a space where power, identity, and social justice meet (Leyva et al., 2022a). In doing so, traditional STEM curricula implicitly embed symbolic and epistemic violence by failing to acknowledge the ways that (1) Black people have used STEM as a tool in service to social transformation and (2) STEM practices have been used to "prove" Black intellectual inferiority. Traditional STEM pedagogy is absent of meaningful contextualization; youth rarely get the opportunity to apply STEM concepts to real life scenarios, nor are they offered multiple opportunities to discover such concepts beyond the classroom through play. However, it is through these applied opportunities that Black youth can reignite their imagination and boldly envision how STEM can have a meaningful role in their lives. For example, a longitudinal study of Black girls' exposure and engagement with gaming design suggested that an important link to bolstering Black girls' interest in technology was producing technology in service of salient social issues (Joseph and Thomas, 2020). Nasir highlighted the importance of contextualizing mathematical concepts through her analysis of Black middle and high school basketball players' mathematical thinking. She found that the link between statistics associated with game play (total score, number of rebounds and assists, average points per game) and evaluation of who is or is not a strong basketball player became increasingly salient as youth matured. Middle school players were less likely to use multiple mathematical calculations to evaluate game play, whereas high school students employed multiple statistical indicators to evaluate the strength of the player (Nasir, 2000). Yet, despite the contextualized use of mathematics, this form of mathematical inquiry is often made invisible given the salience of Black youth as anything but mathematicians (Gholson and Wilkes, 2017). A longitudinal study of Black girls' exposure and engagement with gaming design suggested that an important link to bolstering Black girls' interest in technology was producing technology in service of salient social issues.

Leyva and colleagues build upon this principle of contextualization in a study of Black queer undergraduate STEM majors. Students remarked that the issues of equity related to their salient and intersectional social identities (i.e., Black and queer) were motivators to persist in STEM. However, these students highlighted having to move outside of STEM spaces to study connections between STEM (particularly engineering) and issues of equity, especially those related to the interaction between the social and built environments. Though students had the agency to marry their STEM interests with coursework in the humanities to explore the intersection of STEM and equity, the fact that they were not able to meet their needs within STEM highlights the hypocrisy of STEM as a neutral or objective space (Harding, 2020; Leyva et al., 2022a,b). Contextualizing STEM within issues of equity and social justice can serve to draw Black students into STEM classrooms, by bridging the ways that STEM skills can help them to solve challenges related to their multiple communities. Thus, multiple scholars are challenging the field to pivot toward multimodal STEM engagement that allows for students, particularly those from marginalized groups to engage in STEM experiences.

Increasing participation in STEM requires that we center students' interests, by teaching STEM in the context of real-world scenarios salient to Black students. Such STEM learning may occur in relation to social and environmental justice issues that are national or specific to their immediate communities. By teaching STEM in context, students can see themselves within the discipline and forge a STEM identity that is compatible with their racial identity, which encourages STEM

persistence (McGee, 2021). Further, students learn discipline specific content and practices in a contextualized way, rather than through rote memorization, allowing youth to form a deeper network of connections between theory and practice. Mathematics education researchers have provided examples of this link by examining mortgage rates, using mathematics to support individuals with disabilities, and using statistics to see the frequency of which Black people are pulled over by police officers. Science educators highlight important topics such as recycling, renewable energy, and health disparities (Emdin, 2016, 2022). Although we center social and environmental justice as part of liberation, it is also important to center student interests that are not directly connected to social or environmental justice. For example, some students may enjoy the theoretical and abstract aspects of STEM disciplines without the context of practical application. This interest is important as well, as Black youth can build and test foundational theories that broaden scientific perspectives beyond the narratives of White men. However, there is often a tension between theoretical or pure science and applied sciences. Often pursuing theoretical and abstract STEM disciplines is seen as "elite," whereas practical and application is seen as inferior (Gutierrez, 2018). Here we make no evaluative distinction between the two, instead we see both as critical and important options for the liberation of Black learners.

Fostering authentic relationships: Enabling joy, creativity, and imagination through teaching

Enabling joy, creativity, and imagination in a liberatory education requires effective teaching that demands powerful interactions between and among teachers and students. These interactions disrupt both epistemological and symbolic violence by acknowledging and accepting Black learners' ways of knowing and being. This acceptance allows Black learner's experiences to be co-constructed with their teachers and peers in ways that center them. Interactions occur in classrooms through whole group, small group, and one-on-one structures. Positive interactions demonstrate love, care, and joy that foster a supportive and thriving learning context for all students. In contrast, negative interactions are often the source of dismissiveness, harm and hate for Black learners. Thus, we must envision teacher-student interactions, as well as student-student interactions as key opportunities to leverage and cultivate Black joy, creativity, and imagination to challenge both epistemological and symbolic violence.

Teachers promote positive interactions through several practices including: conversations that value students' disciplinary thinking, consider students' wellbeing, and support students' development as learners. Interactions between and among students could include the following: conversations that value one another's thinking, support one another, and center content (Kalinec-Craig, 2017). Teachers play a critical role in promoting positive interactions between and among students. For example, one study highlighted how Black girls in mathematics classrooms who engaged one-on-one interactions with their teachers, had approachable teachers, and could collectively struggle with their peers (e.g., learn from one another and share power) bolstered their mathematics learning (Joseph et al., 2019). As a result of the types of interactions that could occur between and among teachers and students, we could expect outcomes such as students feeling empowered and agentic about their learning, given that they have a supportive and enjoyable work environment with both teachers and peers (Joseph et al., 2019; McKinney de Royston et al., 2021).

In addition to centering the interests of Black learners, we must nurture Black learners' creativity. Doing so requires teachers to develop opportunities for student exploration. Teachers must also develop disciplinary practices which are connected to the curriculum that students have access to and the ways in which teacher practice and implementation supports it. Focusing on teaching practice is important to ensure Black liberatory spaces are filled with teachers who see the brilliance of Black youth and maintain high expectations of them. These expectations are set by teachers having stronger cultural knowledge of the contributions of Black communities to STEM fields, as well as seeing Black youth from a strengths-based perspective (Hammond, 2014; Lee et al., 2022).

One practice that embodies strengths-based support is acknowledging the competence of Black learners through specific feedback on what or how they perform well. Acknowledging competence is an extension of assigning competence (Cohen et al., 1999). Historically and presently, Black learners have not been positioned as smart or competent in STEM classrooms. To integrate the practice of acknowledging competence the teacher must (1) understand the status of students in the classroom, (2) provide structures and activities to see what students know, with an emphasis on how their learning connects to the STEM discipline, and (3) acknowledge the competence of the students privately (individually), semi-publicly (during small group work), or publicly (during whole group discussion). This practice challenges the epistemological and symbolic violence that Black learners too often experience by concretely naming the ways in which their competence contributes to whole class learning (Wilkes, 2022).

By acknowledging the competence of Black learners, we assume they enter classrooms with valued abilities and funds of knowledge instead of as problems that need to be fixed (Shockley and Cleveland, 2011). In doing so we disrupt epistemological violence by highlighting the contributions of Black learners. When the contributions of Black learners are elevated, Black intellectual value is explicitly named and demonstrated for others. Further, seeing students' competence as something that

already exists, but needs to be both acknowledged and cultivated sets the tone for ways of being in classrooms and subsequently disrupts symbolic violence (Muhammad, 2020). Elevating Black intellectual value with fidelity requires intentionality from teachers to see potential harm in assessment practices, curricula, and policies—key sources of symbolic violence—that are problematic for Black children. Examples of this violence include current political agendas that ban the teaching of Critical Race Theory (CRT) in schools and mathematical tasks that create false narratives about Black learners as thugs, gangsters, drug dealers and pimps (Howard et al., 2012; Neal-Jackson, 2018; Morgan, 2022).

Intentionality and what Madkins and Morton (2021) identify as political clarity (i.e., the understanding of how structural and school inequalities work to (re)produce differential learning experiences for minoritized learners) are necessary to combat potential harms. Teacher intentionality that accounts for potential harm requires attention to instructional design. That is, teachers must design and modify, if necessary, lessons and select tasks that highlight the brilliance of Black learners. The type of intentionality with respect to design and in-the-moment response to students' thinking, doing, and ways of being, requires teachers to be both content and culturally competent. They must also be fluent in those competencies to acknowledge the strengths and practices that Black learners have. Being fluent in both content and cultural competence allows for teachers to make explicit connections between the STEM content and practices being taught for students. It is through teacher practices such as acknowledging competence that connect opportunities for student exploration, STEM practices, and the fostering of students' creativity. Integrating this practice means being able to see the brilliance of Black learners through how they look, what they wear, and the language they use, which has historically all been factors that have contributed to not seeing Black learners' competences, ultimately stifling their creativity.

Conclusion

Cultivating Black liberatory spaces in STEM requires many hands to dismantle violence against Black youth. As Black learners exist in a time where even the mention of race in schools can have violent repercussions, it will take all of us as teachers, mentors, and community members to reimagine and rebuild spaces that affirm and assume Black brilliance. We must recognize the cultural assets Black youth bring to classrooms and affirm those assets through our daily interactions (Kalinec-Craig, 2017; Anyiwo et al., 2018; Mathews et al., 2020). Through these concrete practices, we ensure that Black learners can use their imagination in STEM, subsequently disrupting oppressive structures that hinder their development. In this paper we challenge educators, practitioners, and community members to move beyond naming oppressive structures, but to examine how our curricular and interpersonal practices might serve as levers to support Black children's joy, creativity, interests, and imagination in STEM. Here we demonstrated how centering students' interests, nurturing Black learners' creativity, and fostering positive interactions between teachers and Black learners are key components that push back against anti-Blackness. We hope that these suggestions serve as a foundation to build a repertoire of practices that are used in service of elevating Black brilliance, joy, and imagination in STEM contexts.

Author contributions

CM, DR, and CW contributed to conceptualization of the mini review and wrote sections of the manuscript. CM wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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