Reauthoring STEM Narratives Towards Black Joy

by

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Abstract

Despite an increasing understanding of how underlying systems of oppression show up and operate in STEM classrooms, little is known about how Black joy and reauthoring can be utilized in supporting Black youths' navigation of oppressive, anti-Black systems as STEM learners. Partnering with community educators, scholars, and middle and high school teachers collectively called the Black Joy Group, this study conceptualizes the role of *joy* in Black youth's STEM identity development. Further, this study examines salient narratives of STEM, which often exclude Black joy and frame Black youths' STEM participation from deficit perspectives. The Black Joy Group sought to develop a framework for reauthoring to support Black youths' negotiation of dominant STEM narratives. Reauthoring was investigated from a decolonial perspective, centering embodied learning as a sensemaking strategy. For this participatory model, the Black Joy Group conceptualized Black joy in STEM classrooms through body mapping, drawing, collaging, and by setting intentions to better notice and honor the feelings and sensations of the body. Data sources include interviews and artifacts from Black Joy Group meetings and student reauthoring sessions with Black youth. Data were analyzed thematically to identify instances of STEM reauthoring, classroom practices that best support STEM reauthoring, and abolitionist strategies to support students in expressing *joy* as an act of reauthoring within a white-dominated space. Results from this study suggest that the constraints of Black joy often stem from whiteness and capitalist pressures that shape how both Black youth and educators of Black youth show up and engage in STEM spaces. Additionally, results suggest

that students perceive their belonging in STEM as contentious since they view themselves as STEM people both inside and outside of traditional STEM domains. These findings may support education researchers in continuing to challenge dominant deficit narratives that negatively portray Black youth. Finally, these findings may support educators in providing opportunities for Black youth to exercise their agency to reauthor in STEM classrooms and positively renegotiate their identities in relation to STEM.

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Table of Contents

Tables

Figures

Chapter 1. Introduction

Narratives, or stories that represent events and people, have the power to shape the way individuals are perceived by others, and how individuals perceive themselves. For Black youth who are interested in STEM (science, technology, engineering, and mathematics), narratives about their likelihood or unlikelihood of success in STEM classrooms and STEM career fields have pervaded public perception about who gets to be successful in STEM spaces, and who does not. Narratives about STEM also include public perceptions of how success in STEM is defined. Though dominant narratives disrupt access for Black youth and discourage them from pursuing STEM-related interests, Black youth can exercise their agency to challenge these dominant narratives and the anti-Blackness at their core. Through reauthoring, Black youth may negotiate narratives of themselves as STEM learners to affirm their identities as 'STEM people' to more accurately reflect their rich and often joyous relationship with STEM.

Dominant narratives about Black youth in STEM are born out of stereotypes (Hanson, 2008; Lynn et al. 2010; Howard, 2013; Grossman & Porsche, 2014; Williams, Coles & Reynolds, 2020), majoritarian narratives (Solórzano & Yosso, 2002; Smith, Yosso, & Solórzano, 2011), and other narrow depictions that have been perpetuated and reinforced over time, creating inaccurate, dominant narratives. Despite their lack of evidence, these narratives may go unchallenged, eclipsing the positive narratives that also represent Black people's experiences. For STEM subjects and STEM careers, deficit narratives formed about Black people and their potential for success represent a single story narrative (Adichie, 2009; Quaye, 2017) that lacks the variety and richness of the many ways that Black people can identify with STEM.

Due to historical and systemic racism and prejudice, particularly against Black people, Critical Race theorists argue that their access to quality STEM education and opportunities to

experience STEM in meaningful ways have not been equitable (Stinson, 2006; Berry, 2008; Martin, 2009; Hand, 2012; Gutiérrez, 2013). In addition to racism and prejudice, other challenges such as academic tracking, educator bias, and hyper-segregation due to historical neighborhood segregation and school choice also limit Black youth's access to STEM (Massey & Denton, 1993; Denton, 1995; Howe, Eisenhart & Betebenner, 2002; McGee, 2020). Though Critical Race theorists find systemic racism to be present in all institutions, dominant narratives about Black youth and STEM rarely include the challenges that Black youth face as a result. Instead, color-blindness (Bonilla-Silva, 2006; Leonardo, 2009; Annamma et al., 2017) is employed to invisibilize Whiteness (Massey, Scott & Dornbusch, 1975) and anti-Black ideology that depicts Black youth as uninterested and unsuccessful in STEM unlike white and Asian youth who have been perceived less negatively (Lee, 2015).

Perceptions of STEM learners and their capabilities are often framed around their achievement and success with the subjects without taking into consideration how both STEM and success have been framed from a white, capitalist perspective. STEM as an institution, or a normative social structure, includes a history that is both racialized and gendered and made up of its own norms, goals, practices (Gräbner & Ghorbani, 2019). This study intentionally excludes STEAM (science, technology, engineering, arts, mathematics) which is more inclusive of less traditional STEM domains. However, STEAM programs and curricula remain accessible to many minoritized youth, so its inclusion in this study is unhelpful in critiquing the racialized institution of STEM as it is understood, validated, and perpetuated through whiteness.

Historically, the United States has profited from the success of STEM learners, identifying the most talented students to help innovate and maintain US supremacy in space and military technology (Burke & McNeill, 2011). Although global competition with STEM may

seem far removed from the experiences of students in their classrooms, students are not removed from the testing culture and gatekeeping that works to position youth as ‘STEM people’ or not ‘STEM people’ (Verdín, Godwin, Ross, 2018; Dou et. al, 2019). Dorph et al., solicited students’ ontological perspectives of STEM People using what they described as "an open-ended survey item about what they want to be when they grow up" (p. 1042), implying that they are not yet STEM people and must 'become' one. The norms and practices of STEM often exclude Black and Brown people and women, contributing to the underrepresentation of minoritized groups (Thompson & Windschitl, 2005; Ong et al., 2011; Kang et al., 2019; Miles et al., 2022), helping to reify a narrative about what STEM success looks like and who is capable of achieving it.

The demographic most represented in higher-level high school STEM classes and also STEM careers is white males (National Research Council, 1989; Riegle-Crumb & King, 2010; Ong, Smith, & Ko, 2018). Unequal representation between white and non-white students reinforces harmful narratives that depict Black students as incapable of achieving the same success as white students in similar subjects. However, this narrative leaves out the diverse learning experiences and forms of success with STEM that Black and Brown students have in less traditional capacities and outside of school spaces. Within STEM classrooms and STEM fields, the over-representation of white youth and white teachers maintains a culture of whiteness (Flowers & Banda, 2016) that shapes more than just student participation and STEM identity construction. Adams (2022) describes the parallel between anti-Blackness in the institution of STEM and society, stating, “STEM spaces are a reflection of larger society and are therefore also hostile to Black bodies” (p. 202). The ideology that upholds anti-Blackness in STEM is the same ideology that upholds white, western ideals of what success in STEM looks like, mainly, through proving students’ knowledge through mastery and the useful application of mastered skills. This

framing of success and also Black and Brown youth from a white, colonial perspective reduces STEM and its learners to participation that is measurable and applicable to the societal goals of the greater good.

Research investigating Black girls' identity construction finds that they identify with STEM and participate through authentic engagement in formal spaces but also in informal spaces where STEM norms and practices may be more inclusive of them (King, 2017; King and Pringle, 2018; Garibay & Teasdale, 2019; Wade-Jaimes, King, & Schwartz, 2021). For example, identity construction of Black girls in relation to STEM shows that they are actively engaged in both formal and informal STEM settings, however, these girls identify with STEM more meaningfully when STEM norms and practices are more inclusive of them (King & Pringle, 2018; Garibay & Teasdale, 2019; Wade-Jaimes, King, & Schwartz, 2021). Joseph, Hailu, and Matthews (2019) find that to better support Black girls in sustaining meaningful connections with their STEM learning and their interests, Black girls should be "encouraged to learn collaboratively with others while being treated as respected and valued members of the mathematics classroom". Similarly, research on Black boys has been found to strengthen their participation in STEM, leading to positive STEM identities and authentic engagement (Davis, 2014; Dumas & Nelson, 2016; Flowers & Banda, 2019). Similarly, research investigating Black boys also finds that they participate in STEM in meaningful ways that support authentic engagement and leads them to develop positive STEM identities (Davis, 2014; Dumas & Nelson, 2016; Flowers & Banda, 2019). Although it is documented that Black youth identify with STEM and persist within the institution of STEM, their opportunities for participation and membership in STEM are limited by how they are positioned in relation to white youth whose STEM identities are often validated through their success on assessments. For example, Black girls' opportunities for participation

are limited by the ways that Black girls are positioned as less successful as a result of patriarchy and whiteness (Archer et. al, 2012; Carlone, Johnson & Scott, 2015) which leads educators to expect less from them and therefore provide them with fewer opportunities for meaningful STEM engagement. Also, Black boys' participation in STEM is limited due to their favored positioning in relation to Black girls whose intersectional identities as Black and female ascribe them as more of a 'problem', Black males are still perceived negatively due to their positioning in relation to white females and white males to which their achievements are most harshly compared (Howard, Flennaugh & Terry, 2012; Gholson, 2016).

There is a preoccupation with the measurable achievements of STEM learners that can be described as gap-gazing (Guiterrez, 2008), or the fixation on the difference of achievement through assessments for various student groups. Phrases like 'the achievement gap' are used to describe academic discrepancies between groups of students and suggest a deficit perspective of underperforming groups. Deficit perspectives of Black students and their learning perpetuates harmful narratives and stereotypes about their abilities and capabilities as learners. Despite narrow perceptions of success and discrimination, and discouragement, Black youth persist in STEM spaces and maintain a STEM identity. Strategies for persistence, like Black X Consciousness (Morton, Gee, & Woodson, 2020) support Black youth in reconciling their identities in relation to STEM, though it does not support them in shifting perceptions and narratives about their capabilities. Scholars find that many Black and Brown people persist in exclusionary spaces like STEM through more emancipatory acts like reauthoring; the political action geared towards resisting systemic oppression by reclaiming a narrative or authoring a new one in opposition to dominant narratives.

Why Reauthoring?

Reauthoring is a method for non-dominant storytellers to challenge their ascribed narratives. Reauthored narratives aim to challenge the status quo (Delgado, 1989), however, reauthored narratives also aim to challenge the narratives that minoritized people hold about themselves. Often, uncontested dominant narratives construct reality for much of society, and these narratives may also inform the opinions of people belonging to minoritized groups. Dominant narratives that are recounted again and again may reinforce stereotypes of minoritized people for dominant storytellers, but also, for non-dominant storytellers, helping to maintain oppressive identities (Lindemann & Nelson, 2001).

Staples (2008) defines the process of reauthoring as "a self-reflective process of naming and ascribing personhood" (p. 80). Reauthoring is a negotiation of identity that Swart (2013) frames through human narratives or "the meaning of life through stories told" (Swart, 2013, p. 20). Swart (2013) understands human narratives to be largely determining factors in people's lives and the decisions they make, describing narratives as "a multiplicity of stories and meanings, all running concurrently, about who we are and what we can become that informs our identity and actions as human beings" (Swart, 2013, pg. 20). In the context of education, Graven (2012) finds the process of reauthoring teacher identities to 'give increased agency" to teachers as learners. At the same time, Graven (2012) views teachers' negotiation of their identities as a way to open space for "deliberately challenge existing negative stories and to reflect on their own authoring" (Graven, 2012, pg. 130). In the context of students, Staples (2008) finds Black males to have increased agency over their own narratives as they examined and negotiated dominant narratives of Black men in media. This had implications for students' own sense of identity which was described as 'intertwined' with social forces like authority and knowledge which is

politicized through gatekeeping. Reauthoring provides Black youth the opportunity to be self-reflective and renegotiate their identities to reflect who they see themselves as outside of school. (Staples, 2008, p. 379). Little is known about how reauthoring may support Black boys and girls in negotiating STEM identities both in and out of school.

STEM learners' reauthored individual STEM narratives may also provide opportunities to reimagine STEM narratives more broadly. Reimagined narratives of what STEM is like, who STEM is for, and how STEM can be utilized can be reimagined to focus less on measuring student performance based on white, colonial standards. Reimagined narratives take away the impacting factors that constrain joy and Black joy (Dillard, 2019; Love, 2019; Tichavakunda, 2021) in STEM spaces making it more difficult for students to feel validated and welcome to bring their whole selves into STEM spaces. Additionally, reimagined narratives of STEM may decenter whiteness and traditional conceptualizations of schooling that exclude holistic ways of learning, being (Wagner & Shahjahan, 2015; Joseph, Hailu, & Matthews, 2019; Adams, 2022) and feeling (Hughey & Goss, 2015; Hoffman et al., 2016).

The proposed study furthers research around Black mathematics learners and how they perceive themselves in relation to STEM (Gholson, 2019) while also investigating where Black youth and their joy fit into STEM narratives. The study investigates the ways that teachers and students who may not see and interpret Black joy in affirming ways, re-envision STEM narratives in ways that center Black joy and support the reauthoring of STEM narratives.

Research Questions

1. How do participants in an educational counterspace re-imagine STEM education that centers Black joy?
    a. How do the participants define, notice, and embody Black joy broadly speaking?
    b. What do the participants name as shaping Black joy in STEM education?
    c. How do participants envision changes in the ways Black students experience STEM, towards broadening joy in STEM?

2. How do Black youth both figure and re-author themselves in STEM?
    a. How do students define STEM and its purposes?
    b. How do students re-imagine STEM learning and STEM classrooms?

Significance

This study builds on Gholson and Robinson's (2019) identity work on the authoring of the self in the context of STEM to help facilitate Black youth in reauthoring STEM narratives. Additionally, this study builds on work around counterspaces (Solórzano et al., 2000; Yosso, 2013; Ong et al., 2018), supporting teachers and students in better noticing, interpreting, and nurturing Black joy. Centering Black joy was an intentional choice made by myself and the other participants in this study. The collaborative decision made by the participatory group sought to challenge the focus on *the trauma of media* (Boaler, 1999) and fetishization of Black pain (Kaplan, 2005; Rothe, 2011) that is pervasive in media and also research. In doing so, we did not seek to ignore or diminish the historical and generational harm, trauma, and the systemic marginalization that Black people have experienced. Instead, we aimed to reauthor the dominant narrative of the Black experience by highlighting the underrecognized emotion and state of being of joy. From this perspective, this study supports teachers and students in making STEM spaces joyful spaces.

Theoretical Framing

Situating in CRT

This study investigates STEM as an institution and dominant narratives about STEM that shape, and are shaped by, systemic inequity. Critical Race Theory (CRT) exposes systemic racism that exists within systems and institutions (Bell, 1980; Ladson-Billings & Tate, 1995; Gillborn, 2005). For this reason, I employ CRT as a conceptual framework to interrogate forms of anti-Blackness in STEM, while also providing counter-narratives that highlight Black joy that

is often invisibilized in STEM spaces. From this framing, I focus on the CRT tenets of whiteness as property (Harris, 1993) and counter-narratives (Solórzano & Yosso, 2002) to examine the harms of whiteness in STEM education and how youth resist such harms.

As minoritized youth construct identities about their capacities as learners of STEM, they do so amid systemic barriers that constrain access to, and experiences with, STEM education and STEM fields broadly, shaped by racism and whiteness in schools and in all aspects of society. Critical Race Theory (CRT) challenges past and present racial injustices through exposing the ways that institutions and systems privilege white people, thereby contributing to racism, prejudice, and marginalization that people of color often experience (Crenshaw, 1988; Delgado, 1989; Freeman, 1977; Harris, 1993). Through exposing the systematic marginalization of minoritized groups, CRT aims to highlight social and racial injustices, with the goal of one day achieving racial justice (Ladson-Billings, 1998; Bonilla-Silva, 2001; Bell, 2004; Delgado & Stefancic, 2007; Basile & Lopez, 2015; Vakil & Ayers, 2019).

Critical Race scholars take a critical approach to the systemic, racialized underpinnings that shape our society (Ladson-Billings, 1998; 2009; Delgado, 2010, Delgado & Stefancic, 2013; 2017). Critical perspectives of societal behavior and practices requires a constant challenging of structures of power and privilege. To this end, CRT provides a lens for analyzing and gaining an understanding of how racism, whiteness, and anti-Black ideology pervade the systems, institutions, and spaces that minoritized groups such as Black learners participate in and experience. Additionally, CRT provides a lens through which dominant, negative narratives about people of color can be revealed and challenged.

In the context of STEM education, Tate (1995) argued against inequitable practices regarding mathematics assessment and reform for Black students. Ladson-Billings and Tate

(1995) connect inequities in mathematics education to inequities in housing, curricula, and other resources where Black people have limited access compared to the access of white people. Further, Bullock (2019) conceptualizes STEM as a political system, operating from a racialized perspective in order to gatekeep academic opportunities through the problematizing of Black youth. Bullock (2019) calls for a decentering of 'fixing culture' (Tyson, 2002) and reframing of Black counter-stories to progress systemic change for mathematics education. More recently, Martin, Price, and Moore (2019) note the persistence of fixing culture in reform efforts for mathematics while also acknowledging the cognitive dissonance that takes place for white people encountering counter narratives that directly refute a narrative of progress toward equity. The willful ignorance and outright refusal of many white people to accept counter narratives about STEM education and the field writ-large has led critical scholars to call for liberatory mathematics extricated from whiteness altogether. Martin, Price, and Moore (2019) call for a prioritization of humanization for Black learners rather than the continued efforts of achieving true equity that remains elusive due to systemic whiteness.

Making Black Joy Visible

Critical theories of STEM may invisibilize Black joy by making it synonymous with other asset-based and culturally-centered pedagogical theories aimed at creating equity in STEM classrooms. Culturally Responsive Pedagogy (CRP) centers Black youth by incorporating their cultural backgrounds and experiences into STEM curricula (Ladson-Billings, 2017; Brown et al., 2019; Paris, 2021). In this process, Black youth could also be invited to share and learn more about how their backgrounds and experiences contribute to the greater narrative of past and future STEM learning that is not adequately documented in curricula. Further, Culturally Sustaining Pedagogy (CSP) builds on culturally relevant pedagogy by aiming to maintain and

extend students' cultures in regard to their learning (Gutiérrez, 2015; Paris, 2012; 2021). Since CRP and CSP are not domain-specific, they are sometimes taken up in ways that narrow students' opportunities to learn STEM subject matter. It is important to maintain powerful opportunities to learn for Black students.

Additionally, centering Black joy in critical theories of STEM maintains rigor by incorporating more interdisciplinary methods of learning and non-traditional methods of learning, providing opportunities for students to drive their advancement through the joy of their interests. Although STEAM has been intentionally left out of this study to better focus on STEM as a traditionally non-inclusive, and anti-Black field, making STEM more interdisciplinary helps push the definition of what it means to do STEM and be a STEM person. The inclusion of the arts and other domains like literacy does not redefine STEM as a more fluid field, however, it does open up conversations about the potential of these intersections to forge new paths of learning and STEM connection for youth. Ultimately, fostering positive, affirming experiences for Black learners and providing opportunities for youth to perceive themselves as capable, confident STEM learners are all part of centering Black joy.

Ideology and Anti-Blackness

Ideologies serve as frameworks through which we view, understand, and re-make the lived experiences of people and how they interpret the world. Leonardo (2000; 2003; 2005) describes ideology as a 'distortion of reality' that is perpetually being re-created through the everyday actions and realized perspectives of people who are re-constructing their realities from partial and/or inaccurate perspectives of structural hierarchies. The biases that people hold as well as the different ways that they experience the world leads to this distortion. Leonardo (2003) likens the idea of ideology to the idea of utopia; not an actualized reality, but an idea of what

reality could and *should* be. In framing this study around the perspective of ideology, I aim to highlight the ways that ideology provides a framework for better understanding how anti-Black rhetoric and anti-Black ideology contributes to the racialized experiences of Black youth and their pursuits within STEM. Through critical perspectives of dominant ideology, this study also highlights the prevalence of white perspectives in the creation of ideology which serves as the foundation of dominant narratives that reauthored narratives aim to counteract.

Due to its colonial origins, US public schooling has been constructed from a white, western perspective that maintains superiority through anti-Black practices and rhetoric (Dumas and Ross 2016; Ross 2018). From this perspective, schooling can be described as "notorious sites for the performance of anti-Black and anti-Brown coloniality of being" (López López & Nikey (2021). Kumashiro (2000; 2001), discusses ideology in education in relation to Whiteness, arguing that Whiteness contributes to perpetuating 'the ideological failure' of Black people as a narrative, and the maintenance of anti-Black ideology. Further, Kumashiro (2000) recognizes that schools and their oppressive practices 'other' students and are thus complicit in forms of harm, not only in overt ways but also by not pushing back against mainstream ideologies that cause such harm. Similarly, Leonardo (2003) notes the racial bias of ideology in education and also the potentially harmful effects that some ideologies may inspire as a result of anti-Blackness. An example of this ideological underpinning is Herrnstein & Murray's (1994) *The Bell Curve* where their findings on race and achievement were not simply flawed, but reified anti-Black ideology and also promoted contemporary forms of eugenics.

Similarly Jonathan Kozol (1991), while aiming to highlight the harmful effects of segregation and inequality for Black students, details the conditions of urban schools in East St. Louis, and reifies a deficit ideology about Black students and their families by omitting

important forms of agency and resistance, and aspiration and joy. In Kozol's "stock story" about the educational experiences of Black youth, the material inequities that circumscribe their education as predominant, to the exclusion of their community's cultural wealth, including resiliency and agency" (Farmer-Hinton et al., 2013). Failing to see the value of Black students and their contributions to education creates further racial bias for students and perpetuates anti-Black sentiments. Similar to Kozol, several national reports on education have taken a magnifying glass to learning disparities between students of different races, such as A Nation at Risk (1983) and the Coleman Report (1966), which often focus on outcomes of students of color and perceptions of why they do not meet educational standards. The emphasis on outcomes, however, rather than structural issues within education that hinder their participation in schools such as whiteness in curricula, contributes to anti-Black ideology. Indeed, more recently, Coles (2020) frames curricula as property and also as a perpetual site of anti-Blackness, stating "despite how committed and well-intentioned Black and non-Black curriculum workers are to rupturing anti-Blackness with and for Black youth who inhabit the hold, curriculum will be perpetually entangled with anti-Blackness, simply, because it is by design" (p. 51). Research such as those mentioned above expose the racist ideological framings that shape Black students' learning experiences in learning spaces that are shrouded in anti-Blackness.

Due to anti-Black ideology, navigation of white dominant spaces can be particularly challenging for Black youth, especially when racist practices are covert. Williams and Land (2006) find anti-Black ideology to be both blatant and also upheld by color blind ideology which maintains institutional and social inequity for Black people, while at the same time, ignoring their Blackness. Bonilla-Silva (2003) discusses the perceived neutrality of colorblindness which neither acknowledges or atones for the past, present, and future marginalization of Black people

through anti-Blackness. Further, colorblindness does not consider the added labor that Black people take on while navigating spaces that covertly undermine them. In a study examining Black women's pursuit of happiness through travel to Black-centric places like Jamaica, happiness is found to be a process that includes emotional labor and other costs like political decisions about where they might feel welcome and safe from anti-Blackness (Williams, 2018).

Williams and Land (2006) argue that without critical analysis of social inequality, white supremacy is maintained and often normalized through colorblindness as it is "masqueraded as being fair, even-handed, and impartial; therefore, it is rarely contested" (p. 585). Under the generalized ideal of 'equity for all', Basile and Lopez (2015) find that descriptions of students of color in policy reports about STEM education "used broadly defined, ambiguous keywords (e.g., minority/ies and underrepresented) in ways that racially essentialize students of color, erasing many of their shared and unique experiences" (Basile & Lopez, 2015, p. 540). Covert systems of racism operate and invisibilize racist and anti-Black practices in education, contributing to Black people's need to be able to both *see* and *understand* these underlying systems so that they may successfully navigate them.

Anti-Black narratives in STEM encompass racial ideologies that ultimately shape discourse around Black students and how they are perceived. Black youths' positioning reflects a biased perception of the lived realities of Black people, giving anti-Black ideologies the power to shape the way they experience learning in STEM classrooms. Existing amid anti-Blackness and systemic racism asks Black youth to take on the added burden of understanding how these systems operate so they may better navigate them. Anzaldúa (1987) understands the necessity to see and navigate underlying structures and respond to them as *la facultad*. Du Bois (1903) theorizes this navigation as people of color developing a double-consciousness where Black

people's awareness of racist systems shapes the unique challenges of navigating society as non-whites. This awareness, however, of both their subjective experiences as Black people and the dominant perceptions of Black people in a racist society, provides them the opportunity to anticipate and resist white supremacy. Extending Anzaldúa and Du Bois to education, when Black youth are made aware of the underlying structures limiting their learning opportunities and access, they are better equipped to challenge racism through persistence and resistance in anti-Black spaces. However, it is crucial for white people, and in particular, white teachers, to take on the responsibility of understanding these covert systems, and most importantly, how their privilege shapes their classrooms and their students' experiences.

Counterspaces

Solórzano et al. (2000) argue that counterspaces are "sites where deficit notions of people of color can be challenged and where a positive climate can be established and maintained" (p. 70). In naming and exposing the racism that people of color experience with an all-white dominant space, counterspaces provide Black people the opportunity to exercise their agency and take up space for their own benefits and purposes. Counterspaces help minoritized groups to challenge dominant ideologies rather than accepting the racism they experience as normal. Similarly, Yosso (2013) argues that counterspaces can nurture a sense of confidence in students and affirm their abilities and contributions in academic situations. Yosso (2013) finds that for graduate students of color, counterspaces provide essential refuge from the racism that they experience. Counterspaces may also provide opportunities for community-building, a necessary component in success for students of color, particularly in predominantly white institutions. Through the support of counterspaces, students may "choose to redefine the margins as a place of possibility instead of a place of oppression" (Yosso, 2013, p. 133).

Counterspaces and STEM

For people of color, engagement with their peers provides them with opportunities to engage and participate in STEM in a meaningful way with other people of color who understand the challenges involved in pursuing a STEM career (Lane, 2016; Ashford et., 2017; Davis, Wilkins-Yel & White, 2020). Counterspaces which exist in opposition of white-dominant spaces also provide opportunities for people of color to engage in discourse with other people of color who experience racism. In their study, Ong et al., (2018) explore the experiences of women of color in STEM and their persistence in STEM despite microaggressions, bias, and prejudice which works to keep them feeling as though they don't belong in STEM spaces. Findings for this study revealed that women of color and their persistence is greatly attributed to their access and participation in counterspaces outside of traditional STEM environments. Within these counterspaces, women of color are able to discuss their challenges while working in STEM and also seek advice from peers who understand what they are going through. The scholars for this article recommend that we continue to create the necessary spaces for women of color, particularly for Black women whose intersectional identities make STEM an even more unwelcome and hostile environment for their success.

Ong et al. (2018) find that STEM counterspaces geared toward women of color, including those that leverage the unique intersectional identities of Black women, contribute to their persistence in STEM. Within counterspaces, Black women were able to exercise their agency to promote their own learning, while also having their experiences validated as critical knowledge. Other purposes for the counterspaces and how they promote persistence is through allowing Black women in STEM to vent their frustrations and also to challenge the deficit notions of themselves that have been pervasive in the white narrative of STEM. Although we

know much about counterspaces and their benefits, we are just starting to learn about digital counterspaces and the benefits that they possess especially for youth of color as they aspire to pervade white spaces such as STEM (Tanksley, 2022).

Embodied Learning

Supporting work on decolonizing methodologies, this study draws on embodied learning as a way to experience, interpret, and make sense of the world in interdisciplinary ways that include the mind, body, spirit (Freiler, 2008; Rendón, 2009; Wagner and Shahjahan, 2015). Embodied learning aims to decolonize education research by actively challenging white, colonial ideals of epistemology that privilege learning that takes place in the mind. Wagner and Shahjahan (2015) note that within academic spaces, epistemologies that are singular in their ideals of how and where learning takes place upholds "a mind-supremacist epistemology dominates which in turn renders the body invisible" (p. 244). Including the body and its sensations in the learning process shifts learning and research to a perspective that focuses on wholeness and duality of learning and reflection (Rendón, 2009). From this perspective, scholars understand embodied learning to be a social process (Freiler, 2008) and a collaborative process (Boaler, 1999) where learners are "actively connected to what is being learned" (Lachman, 1998, p. 140). Built on a participatory epistemology (Lachman, 1998) aiming to better notice and understand the experiences of Black STEM and learners from a broader and more holistic perspective.

Embodied Noticing

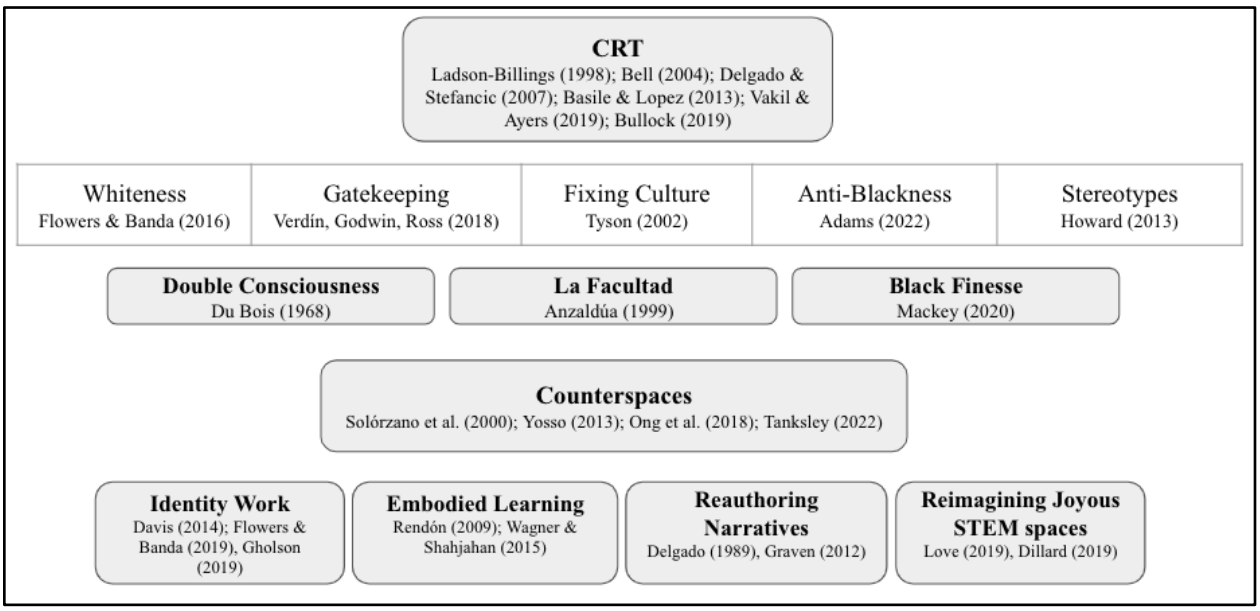
Research on teacher noticing highlights the ways that teachers' experiences and privileges allow them to either better notice or not notice the ways that covert systems operate in their classrooms (Van Es & Sherin, 2002; Carter, 2005; Louie, Adiredja & Jessup, 2021). Louis

(2018) calls for a research focus on teachers and their willingness to challenge dominant ideologies about mathematics, intelligence, and race. Most notably, Louis (2018) calls for more research on mathematics teachers and the types of supports they would need to *notice more equitably.* In response, Shah and Coles (2020) find that teacher education curriculum needs to go beyond only an understanding of racism and whiteness being present in classrooms, but rather, teacher noticing should be more geared towards actively challenging dominant ideologies that result in Black and Brown students experiencing STEM learning differently than white students. Although power, racism, and whiteness are pervasive in society, the ways that each shows up in STEM classrooms can be directly challenged and mitigated by teachers' vigilance and commitment to providing equitable opportunities for Black and Brown youth to engage with STEM and participate in STEM in meaningful ways.

Better understanding the impact that equitable teacher noticing can have on the experiences of minoritized learners, researchers have now begun to think more holistically about how students experience classrooms. Embodiment as a way of experiencing, learning, and interpreting have been found to provide a more holistic perspective of education (Macedonia, 2019). Mendoza et al (2021) investigates the ways that mathematics teachers notice in their classrooms, but also how they attune to the emotions, feelings, and sensations happening within their own bodies while interrogating matters of race, power, and privilege that show up for them while teaching Black and Brown students. Less is known about how Black and Brown youth notice in STEM classrooms, and how the noticing of inequities brought on by a system of oppression lands on their bodies.

Figure 1

Conceptual Framework



Chapter 2. Literature Review

Public Schooling and Inequity

Learning experiences for Black youth are largely dictated by systems of oppression that have been integral to U.S. public schooling from its inception. Inequity in mathematics education has its roots in inequities in the early system of compulsory public education in the US, beginning with the creation of common schools that prioritized the education of white, males (Labaree, 1997). Later, as public schools expanded to include white females, and eventually, students of color, the education of white males remained a priority, earning them access to colleges and universities decades before minoritized groups. A lack of cohesion in common school curricula—shaped by a lack of cohesion in the broad political purposes of education for a multiracial democracy undergirded by capitalist economic relations--and a lack of student achievement within the common schools, called for more standardized measurements of effectiveness and student learning by the end of the 20th century (Haney, 1981; Labaree, 1997). Early norms in education endured over time which continued to center Whiteness in curricula (Harris, 1993) and Western ways of knowing, further alienating Black and indigenous students within an already racially segregated and unequal education system (Martin, 2009).

Many of the goals for schooling in the 19th century were born out of Jeffersonian ideals designed to foster basic literacy for electoral politics (i.e., voting) among white males and thus maintain social hierarchy in a new democracy; a hierarchy that favored White students who were able to receive an education. For example, Wayne Au (2015) argues that standardized testing was applied by educators as early as 1848. Post this era of reform, standardized measurement of student learning became a necessary screening process for identifying those perceived to be academically exceptional. Or, as Thomas Jefferson described the process, “raking from the

rubbish a few geniuses to be instructed at the public's expense" (Spring, 2008, p. 7). This perspective of student learning valued only students who were legally able to obtain an education and also only valuing ways of knowing and learning that meet white standards; a trend that continues to underserve minoritized students today.

Conversely, early Black education centered on the emotional well-being and affirmation of students. Scholars like Anderson describe the student-centered approach of early Black educators who recognize the importance of artistic teachings and self-actualization in students' learning in the development (Hale, 2001) of students' sense of self-worth and pride in schools that reflected their cultures (Anderson, 1990; 2023). Similarly, Siddle Walker (2000) highlights and describes the "merit" of Black schools which added to their value and richness for Black communities. Walker notes that Black education thrived in the schools `in spite of limited resources' compared to that of white education. Black learning sites concentrated on enriching students' minds as well as strengthening their ties to the self and to pursuits that best serve them. Black learning spaces served as counterspaces from white spaces that more explicitly focus on measurable student performance.

Whiteness and Proficiency with New and Old Mathematics Reform

Reform efforts in the early 1900's centered traditional ways of knowing and doing mathematics. Mathematics education during this period saw a battle between two major schools of thought about what students should know and how they should learn it. Reforms of this time swung between student mastery of recall and mathematical computation, and students' deep understanding of mathematical concepts. Little attention was paid to issues of equity, diversity, student identity, and ways of knowing mathematics beyond recall and conceptual understanding.

Each of these oversights affected how Black students learned and experienced mathematics which was unresponsive to their unique needs and strengths.

In the face of the international Space Race from the mid 1950's through the mid 1970's, New Math rose to prominence as a result of the National Science Foundation's (NSF) new curriculum (Ravitch, 2000). The new curriculum focused on more modern mathematics and science content and student conceptual understanding of numbers (Berry, 2018). More specifically, New Math pushed students to be efficient at computation and problem solving rather than just the more traditional rote memorization required of the previous reforms. After focusing on more conceptual understandings of mathematics and science, the late 1970s incorporated more traditional practices into curricula by going 'back to basics'. The Back-to-Basics movement (Newsweek, 1974) referred to the pre-Sputnik era during the Cold War where mathematics education focused more on the computational skills and procedures of mathematics. Because the Back-to-Basics reform movement focused on what was considered the foundation of mathematics, problem solving skills and critical thinking had not received as much attention in curricula as it had during the New Math era (Gibson, 1995; Kessinger, 2011).

Lack of student achievement was targeted in the release of A Nation at Risk in 1983 which reported on the declining achievement outcomes of public school students in the United States (NCEE, 1983). As a result of this report, national leaders and their constituents grew concerned about the nation's ability to compete economically and educationally with other countries who were out-performing the United States on norm-referenced exams like SATs (Ornstein, 1993). A Nation at Risk depicted a grim picture of education in the United States, citing declined SAT scores as evidence of the current generation being less proficient mathematically where previous generations had excelled (NCEE, 1983).

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Reform efforts of the mid and late 1900's viewed student outcomes and proficiency of mathematical standards as the sole measurement of student learning. Whether students were learning mathematics to master computational fluency or conceptual understanding, the standards by which students were being measured lacked the versatility to apply to Black students being held to standards of Whiteness. Viewing student outcomes as the sole evidence of learning reduces all student achievement to numbers and percentiles. Perspectives of student learning that account for student achievement in this way only perpetuates Whiteness in mathematics education. For Black students especially, it is important to acknowledge the inherent Whiteness in mathematics standards and STEM classrooms in general. By not doing so, mathematics education does not take into consideration other ways that Black students might demonstrate their learning.

A Nation Risk was credited with drawing attention to a lack of rigor in US education. However, the National Research Council's release of Everybody Counts in 1989, addressed specific concerns over the future of mathematics education. Everybody Counts (1989) stressed the urgency of a recently mathematized workforce claiming that the "economic demands make mathematics a prerequisite for many jobs" (National Research Council, 1989). In the report, the

National Research Council noted a shift in the job industry moving from industrial and agricultural jobs to more technical work requiring greater knowledge of mathematics. Furthermore, the report highlighted for the first time, the overwhelming number of white males in science, engineering, and mathematics (National Research Council, 1989). This finding was reported in addition to an overwhelmingly white and female teacher pool. By acknowledging and raising concerns about the lack of diversity in STEM, for the first time, Everybody Counts (1989) forced the nation to acknowledge its shortcomings with equity and strive to provide "true equality in opportunities to learn" (National Research Council, 1989, p. 19).

The National Research Council's acknowledgment of a lack of diversity in the mathematics field and also mathematics teachers revealed a lack of role models for Black and Brown students. Everybody Counts (1989) cited a lack of proper foundation in mathematics and a lack of cultural identification with high-level mathematics as the reason for such small numbers of Blacks, Latinx, and Indigenous people in the field of mathematics and other STEM careers (National Research Council, 1989). This finding was significant for taking into account more than just students' performance and proficiency in mathematics, but also taking into consideration their status as minoritized groups in the United States. Although revolutionary in changing the nation's view of minority access to mathematics, Everybody Counts (1989) failed to highlight systemic barriers that also contribute to the underrepresentation of Black and Brown folk in mathematics and a struggle to culturally identify with the subject.

Equity and Recent Reforms

Despite critiques of educational policy and curricula that centered Whiteness and western ways of knowing such as standardized testing, more recent reforms have failed to decenter practices in mathematics education that perpetuate inequity. No Child Left Behind (NCLB),

passed in 2002 under the Bush Administration, served to provide disadvantaged students with equal educational opportunities. Students who fell under the disadvantaged label included minority students, students living at or below the poverty line, students with special needs, and students with limited English proficiency (NCLB, 2002).

Despite attempts to create more equitable learning opportunities for students labeled as disadvantaged, No Child Left Behind's vision fell short of creating equity for all students and all schools. Student achievement became magnified by the accountability measures adopted by NCLB (2002). Under the reform, schools were tasked with meeting Adequate Yearly Progress (AYP) via annual standardized tests (NCLB, 2002). NCLB penalized students, teachers, and schools from districts that did not meet proficiency. As a result of stringent accountability measures, the students and teachers most often penalized were typically from minoritized groups, contributing to inequity within education. More specifically, NCLB made it clear that academic success in the United States rests on students' performance on standardized tests and teachers' effectiveness.

In 2010, still in the midst of the NCLB (2002) era, Common Core Standards attempted to standardize curriculum across the nation. The goal of Common Core Standards to standardize curriculum across the United States was to create curricular equity. However, Common Core Standards were a one-size-fits-all approach to curriculum reform, resulting in the standards not serving minoritized students the way they were intended. In 2015, the Every Student Succeeds Act (ESSA) (Act, 2015) replaced NCLB. The ESSA Act, signed during the Obama administration, modified some of the accountability measures and evaluation standards placed on schools under NCLB. However, standardized testing remained the basis of student proficiency and teacher effectiveness.

STEM Narratives and Student Identity Construction

Despite efforts to directly challenge the dominant narratives created through a fixation on assessments and measurement, beliefs about achievement in STEM remain closely linked with race. General perceptions about the abilities and successes of Black youth in STEM as well as the way youths' identities in STEM are constructed, are largely perpetuated by majoritarian narratives (Solórzano & Yosso, 2002) that compare the performance of Black and white youth in STEM without taking into consideration the pervasive racism and whiteness leading Black and Brown youth to experience STEM in ways that do not adequately support their interests in the subjects, or their success. Understanding how the perception of Black youth shapes their experiences with learning STEM, researchers began to ask questions related to STEM success and participation such as *how important is identity?* (Rowley et al, 1998), and *how might students construct a STEM identity amid dominant, deficit narratives?*

Beliefs about Black youths' abilities and successes in STEM are often perpetuated by majoritarian narratives, depicting white students as capable STEM learners, and Black youth as not as capable. Often, these majoritarian narratives are perpetuated by white and western ideals of what it means to be successful in STEM, mainly, performing well on assessments and thriving in higher-level STEM courses which are mostly white due to gatekeeping strategies such as tracking (Heubert & Hauser, 1999). Defining talent and success in STEM by assessments does not take into consideration the systemic issues like racism, power, and whiteness that help construct narratives about who belongs in STEM and why (Roby & Calabrese, 2019; Vakil & Ayers, 2019).

Student conceptualization of what makes a 'STEM person' are racialized and gendered, mirroring dominant narratives that identify minoritized students as less likely to do well in

STEM subjects. Nasir and Shah (2011) investigate how racialized narratives and STEM are constructed, finding that Black male students believed Asian students to naturally be better at mathematics. This finding highlights the pervasiveness of racialized narratives and also the model minority stereotype of Asian students whose narratives included being the exception to Black and Brown youth when it comes to STEM success. Differences in the amount of support that Asian students' received in schools and teachers' higher expectations for Asian students to outperform their peers was not as salient of a belief. Other characteristics of a successful STEM person include more traditional ideals of what it means to be a 'good student'. For example when Black girls' definition of a 'STEM person' is found to reflect "traditional views of knowing facts and being quiet and focused in class" (Wade-Jaimes, King, & Schwartz, 2021, p. 872). In research involving multilingual Black and Brown girls, Harper and Kayumova (2022) find that despite mostly fitting dominant narratives about 'STEM people', such as being a 'good student', The girls were still positioned as not being STEM people based on the criteria of race and their command of the English language. Despite the girls showing a strong interest in STEM, they were *raciolinguistically positioned* as not being STEM people based on their race and English language proficiency, limiting opportunities for full participation in their classroom further contributing to deficit-based majoritarian narratives (Solórzano & Yosso, 2002).

In addition to majoritarian narratives and dominant narratives about STEM learners, Black youth also face added challenges of surveillance and violence in schools, further separating them from dominant narratives of 'STEM people'. Nolan (2011) discusses the impacts of the history of policing on schools as "an omnipresent culture of control and aggressive policing practices". Swart (2013) also cites *internalized self-surveillance* as a measure or judgment "of ourselves and others on how well we are doing in terms of society's

requirements" (Swart, 2013, pg. 34). The behavior of Black youth is often policed not only in school hallways and classrooms particularly in STEM classrooms where the idea of what a STEM person looks and acts like it's directly compared to that of white students who are not as closely surveilled. Often Black youth are faced with psychological negotiation about their Blackness and how they are able to show up and STEM spaces which directly shapes their STEM participation. Due to the disproportionate policing of Black bodies in schools, there is not only a lack of acknowledgment of the added burden of Black youth having to navigate surveillance, but also a lack of acknowledgment of the constant psychological negotiations they make about their Blackness in schools and STEM spaces (Mackey, 2020). Further, Mackey (2020) provides a framework to recognize and honor the psychological negotiations that Black youth make in their day-to-day lives as they navigate systems of oppression. The scholar defines Black Finesse, an integral part of the Black experience, necessary for Black youth who are navigating the socio-political context of schooling while also engaging in the work of protecting their souls. Through the lens of Black Finesse, students are able to exercise agency in negotiating *how* they show up in STEM spaces, without adjusting or compromising their Blackness. Black Finesse as a lens for students reclaiming their ways of knowing and being also has implications for students experiencing STEM in ways that are meaningful to them.

Researchers have aimed to better understand the circumstances in which Black youth are able to show up as their whole selves in STEM spaces by better understanding STEM learning from a more holistic perspective. Viewing Black youth and their STEM identities through the lens of Black Finesse presents a more nuanced understanding of how Black youth construct STEM identities and narratives about themselves as STEM learners.

Equity and Teacher Practice

As issues of access and equity in mathematics education began to take precedence in education research, equity in relation to teaching also became an area of focus. Mathematics education began to consider factors such as the level of preparedness of white teachers to engage with minoritized students and more inclusive curricula.

Ladson-Billings (2000) analyzes the specific needs of Black students when preparing teachers to educate them. According to Ladson-Billings, teacher preparation is an ongoing reflective process as well as an ongoing reflexive process. Ladson-Billings (2000) advocates for leveraging the power of autobiography storytelling to guide teachers in their reflective and reflexive practices. Teachers are encouraged to continually reflect on their own identities and experiences. Much of teacher preparation in STEM reform involves teachers becoming more self-aware and doing the identity work necessary for reflexive practice (Ladson-Billings, 2000; Braaten & Sheth, 2017).

Scholars like Anyon (1981; 1997) analyzes opportunities provided for students to learn. and again finds that curricula varies across schools with populations belonging to different social classes. Due to class and race being inextricably linked, Anyon (1981; 1997) finds that lower-class schools are typically made up of more Black and Brown students than white students. Findings also revealed those students to more likely be engaged in learning that is traditional (Spencer, 2006) or even remedial. Middle and higher class areas provide schools that encourage students to be creative, analytical, and to tie their interests to their learning. In a qualitative study investigating student learning experiences and persistence in STEM courses, Harper, Weston, and Seymour (2019) find that quality teacher practice greatly affected students' relationship to STEM and their decision to pursue it. They also found that white male and white female students

were less impacted by negative experiences in STEM than their Black and Brown counterparts. In addition to positive STEM experiences, STEM students pointed to opportunities to engage in interesting and fun STEM learning which made them feel more connected to the subjects.

Furthermore, Sherin, Jacbs, and Phillip (2011) call for teacher reflection and reflexivity in the form of noticing, or the moment-to-moment decisions that teachers make in their classrooms (Louie, 2018). Teachers' moment-to-moment decisions and the time between them provide teachers with space to be reflective about their noticing and practice. Differences in teachers' noticing within classrooms affects students' learning experiences. The ways teachers notice their students can either provide or limit opportunities for students to engage and participate as learners (Sherin, Jacobs & Philipp, 2010). Teachers' understanding of noticing's relation to privilege and power, help highlight how they potentially reproduce dominant practices in their classrooms (Ladson-Billings, 2000). Teachers' noticing practices have the potential to promote equity in mathematics classrooms by attending to Black students' needs and their strengths rather than noticing students from deficit perspectives. Viewing students from asset perspectives helps teachers push against racist, anti-Black norms in mathematics education that position them from deficit perspectives. Mathematics education's goal to provide equitable instruction to students begins first with teachers' understanding of what equity looks like, and also how privilege and racism uphold educational inequity. Through reflexive and reflective practice, teachers engage in work necessary for humanizing classrooms for Black learners.

Purposes of STEM

In a previous section summarizing STEM education reform, I emphasized a focus on measurement and achievement for students. Other goals of reforms have included increasing the amount of students choosing STEM fields as a career with an added value placed on students

being intrinsically motivated to learn and perform better on assessments, however without an explanation for *why* it is imperative that students perform so well.

Martin, Price, and Moore (2019) argue that recent mathematics education reforms striving for equity, are only superficially inclusive of Black youth to maintain "mathematics education institutions and organizations that maintain their status as White institutional spaces". Martin, Price, and Moore (2019) also argue that because reforms do not directly challenge the anti-Blackness at the root of inequitable STEM learning opportunities, reforms uphold inequity and continue to cater to capitalism and nationalism. The scholars describe this commodification of resources, stating:

> "The lure of inclusion into mainstream mathematics education for Black learners has always been accompanied by notions of democracy, nationalism, and prospects of integration and fuller citizenship. More pragmatically, there have also been implied promises of access to higher-level coursework, college access, and participation in science, technology, engineering, and mathematics (STEM) careers. Yet, these promises also reflect the commodification of Black learners to serve the interests of others under systems of racial capitalism" (p. 47).

Martin, Price, and Moore (2019) describe how Black learners hold a peripheral positioning within society, gatekeeping them from full participation within it. From this perspective, they critique the promise of education for all students, but especially for Black youth who have been positioned in ways that limit their access to coursework, college and ultimately, STEM careers. In a study investigating the STEM career interests and goals of students ages 10-14, Dorph et al. (2018) found students mostly identified a typical STEM career. This included high-status careers that use rigorous STEM such as being an engineer or a nurse. Though education may be viewed

as a vehicle towards better learning experiences, it encourages a transactional relationship between the U.S. and its students, ultimately supporting and upholding capitalist ideals that result in the commodification and profitability of successful STEM learners. Similarly, Martin, Price, and Moore (2019) problematize how the students more likely to be successful in STEM are positioned as the most valuable. Further, perceiving student performance through the lens of a free-market in which only some students are expected to succeed (Boyles, 1998).

With its roots in military and space technological advancement, STEM subjects are valued for their potential to maintain U.S. supremacy at the forefront of innovation. Placing such value on the success of technology places similar value and competition on student performance in STEM subjects. Education reports such as A Nation at Risk (1983) and Everybody Counts (1989) remain two of the most prominent reports on the state of US education, while policy reform efforts such as No Child Left Behind (2001) inspires a sense of urgency about how U.S. education measures up globally, particularly in the field of STEM. Reforms have prioritized foundational skills, conceptual thinking, and more hands-on learning experiences to instill a genuine love for STEM subjects in the hope that students develop a genuine and intrinsic affinity for STEM subjects, while also commodifying their success to maintain the U.S. as a prominent world power.

Calls for Intrinsic STEM Learning

Examination of the education students receive often expresses the desire to improve STEM curricula and student experiences with STEM learning by catering to students' intrinsic and natural interests in the subjects. Jackson (1992) critiques the pattern of defining and redefining what curriculum is, and how it should be taken up. In this work, Jackson (1992) cites Bobbitt who advocates for students receiving a ‘curriculum of life’. The point is made that

everything students come into contact with has curricula built into it because students are constantly learning despite formal attempts to develop student knowledge. Dewey (1910) also shared sentiments of a more progressive view of curriculum which involves centering the whole child in a more holistic approach in an effort to foster student interest to better promote their learning. These views differ from that of more traditional approaches to curriculum which focus more on what students learn directly from learning materials rather than acknowledging the everyday, moment-to-moment learning that occurs regardless of intention or design.

Everybody Counts (1989) is a report that looks directly at the types of learning experiences of various students. In the report, William Graham laments the restrictions around what schools teach students and what students learn based on the limited expectations we have of students and their learning. Graham states, “we've inherited a woefully limited set of expectations of what schools can accomplish and what children can learn" (Everybody Counts, 1989, p. 9). This statement offers commentary on the curated learning experiences that rarely deviate from what is expected from curricula and the assessments that follow. Similarly, Meltzer and Otero (2015) expresses a hope for science education to revisit more progressive values, increasing enrollment for physics courses through students’ love and curiosity for the subject.

Barriers to Intrinsic and Joyous STEM Learning

When describing joy, Brooks (2020) defines the emotion as “great happiness and pleasure”, but also “divine purpose in action, paying homage to our ancestors, and the celebration of sacredness” (p. 71). Similarly, Dunn and Love (2020; 2021), define joy as “a vital force that is deeply rooted in the internal and purpose-driven nature that lies in every single human being” (p. 213). Joy as *vital* and *purposeful* framed the way the Black Joy Group thought about supporting joyful STEM learning from Black youth. Calls for intrinsic learning, though

admirable, are often met with barriers that undermine the possibility for increased enrollment, participation, and genuine love for STEM subjects. This can also be found in reports that highlight a lack of enrollment, participation and love for STEM for students from minoritized groups. Everybody Counts (1989) is one such report that highlights this issue, while also situating the issue in the larger issue and context of global competitiveness in STEM fields. The NRC reports:

> "We are at risk of becoming a divided nation in which knowledge of mathematics supports a productive, technologically powerful elite while a dependent, semiliterate majority, disproportionately Hispanic and Black, find economic and political power beyond reach" (Everybody Counts, 1989).

Here, the issue for curricula is not only that it is limited to what students might learn in science technology engineering or mathematics classes, but is also limited to how students are performing in comparison to other students. Most concerning is that this competitiveness is in reference to economic and political power that is to be gained from meeting expectations of what success in these subjects looks like.

The Coleman Report (1966) also focuses on the differences between groups of students by highlighting the achievement gap between students of color and white students. This report found that schools are not necessarily responsible for the differences between the learning and success of various groups of students, but that this difference can be attributed to students' family backgrounds. This finding is significant when situated in the larger context of power, implying that students of color are at a disadvantage. Although this perceived disadvantage impacts how students may participate in STEM classes, it may also impact how students are allowed to show

up in STEM spaces, especially when learning falls outside of the constraints of what current curricula offers them.

Constraints such as these are inherently oppressive as students are intended to learn within bounds that offer educational products or outcomes. The United States education field has a history of promoting and utilizing STEM education as a means to a political and or economic end. In result, it is challenging for intrinsic learning to take precedence in curricular reform because student learning often occurs as a transactional process for the benefit of others rather than solely for students themselves. The Carnegie Report (1929) describes the inextricable link between student success and national success in terms of its workforce, stating:

> "The nation's capacity to innovate for economic growth and the ability of American workers to thrive in the modern workforce depend on a broad foundation of math and science learning, as do our hopes for preserving a vibrant democracy and the promise of social mobility that lie at the heart of the American dream" (Institute for Advanced Study: Commission on Mathematics and Science Education, 2009, p.1)

Workforce development and international competitiveness are reported as being dependent on the foundation of math and science learning. Little attention is paid to how math and science learning would be beneficial when they exist outside of the expectation that students contribute their knowledge to the function and advancement of society. Along with a prioritization of global standing, is the fear expressed by A Nation at Risk report (1983) which warns of the United States falling behind other nations in commerce, industry, science, and technological innovation. The report foreshadows other nations and how they fated to the background by not prioritizing education that contributes to their dominance, warning that "history is not kind to idlers" (Denning, 1983, p. 469). Additionally, A Nation at Risk (1983) names mathematics as one of the

key subjects and maintaining the United States' global standing. The report claims that math is the building block of science and engineering; a way to continue economic and military dominance. Although concern is given to the status of the United States and US students' role in maintaining that standing, little emphasis is put on the type of mathematics and science learning that is beneficial for students' well-being and joy. There is little attention paid to the daily mathematics which is also relevant in students' lives outside of classrooms. In this example, the transactional nature of curriculum reform is most evident.

According to A Nation at Risk (1983), the state of STEM curriculum is a concern because as it stands, it threatens a way of life. From this perspective, what the nation pours into students by way of funding and curricula, should be later repaid through students' contribution to maintaining economic and military dominance. In this scenario, the intrinsic desires of students to pursue STEM learning is not as important as their preparation and readiness to carry the gauntlet. And although reports such as A Nation at Risk (1983) typically serve to frighten policymakers into making changes that trickle down to student success, the implications of prioritizing citizens' general wellbeing over the immediate needs of students show up in later years. A Nation at Risk (1983) later spurred the NCTM standards in 1989, the creation of the Eisenhower grants in 1992, and other types of funding geared toward these same extrinsic motives for student success.

Reimagining STEM Learning

Black and Brown youth getting access to quality STEM curricula is one of the main gatekeepers for them pursuing STEM in ways that are meaningful to them, however, it is also important to think about the role that capitalism plays and pushing students to pursue certain

careers over others and pushing certain students over others to believe that they could be successful in STEM fields.

Efforts to humanize STEM education has implications for better understanding ways to extricate student interest, passion, success from capitalism and the commodification of student success. In addressing the lack of representation of Black and Brown students in STEM fields, pedagogy has shifted to be more inclusive through culturally relevant pedagogy and culturally sustaining pedagogy that include Black youth culture and previous knowledge into classrooms and curricula by drawing on the ways they already see, do, and learn STEM. However, using these types of pedagogies are often measured through student success and performance on assessments. The commodification of students enjoying STEM is still prioritized over students' learning of STEM for their own enjoyment. Additionally, research around the retention of Black people in STEM fields shows that oftentimes Black people go into STEM fields for monetary or status reasons, not necessarily for the love of STEM. In many ways, the narrative of STEM continues to be a third to be more humanizing but also to allow students to be their whole selves and to just exist and do the type of STEM that brings them joy without their joy being exploited.

Continuing the work of creating equitable learning, scholars reimagine mathematics learning as not only equitable, but humanizing by validating different ways of knowing (Warren et al., 2020) and purposes for learning and doing STEM. Scholars like Gutierrez (2006) advocate for moving past the old dichotomy of traditionalist vs. progressive education which inspires many reform efforts. Instead, Gutierrez (2006) calls for education to find something beyond those two schools of thought that allows students to practice mathematics to exist someplace more current that decentralizes practices and ways of knowing and learning that perpetuate inequity for Black and minoritized students.

Other scholars focus on rehumanizing classrooms through student perspectives. Gutstein (2006) discusses the importance of students drawing connections between the world they live in and the mathematics that they learn. Gutstein (2006) advocates for political awareness and cultural sensitivity for students to better locate themselves in mathematics curriculum. Gutstein's (2006) perspective highlights the importance of students connecting to the mathematics curriculum they are learning in engaging ways. Additionally, Basu (2007) found that when middle school students were asked to envision their futures regarding STEM, their responses included career choices, but also other ways that a career in STEM has the potential to connect them to others within their communities to improve their communities. Basu and Barton (2007) found that a Black girl in their study framed her sustained interest in science by connecting present-day issues to the future. Their student, Anna, listed pollution and littering and unhealthy habits within her community as issues in her world that could potentially be addressed by entering a STEM field. She went on to envision a future where she might help her community build relationships, and for alliances against social issues.

Both Gutstein (2006) and Guteirrez (2006) call for a shift in how we define, teach, and think about mathematics. Gutierrez (2006) argues for a broad shift in mathematics education that is more inclusive and reciprocal by including other ways of knowing and doing mathematics outside of 'whitestream knowledge' which limits students' exposure to other knowledges about mathematics and also, the connections they could make between mathematics and other systems like nature. According to Gutierrez (2006), like Nepantla, mathematx acknowledges the tensions that exist between spaces, or in this case between ideas of what mathematics could and should be. Mathematx values those tensions and asks researchers, educators, and students to live with and in those tensions rather than dismissing them. By valuing tensions in different knowledges,

mathematics becomes more inclusive and gives students the time to engage with ideas and concepts outside of themselves.

Gutstein (2006) makes a more localized argument calling for a major shift in mathematics that happens inside classrooms. In his argument, Gutstein (2006) criticizes the way mathematics is often referenced as apolitical. When mathematics is viewed by researchers and teachers as a neutral subject, Gutstein (2006) argues that it is more difficult for teachers to understand the inherent bias and inequity within mathematics. In order to directly challenge this bias and inequity, Gutstein (2006) advocates for a shift towards teaching for social justice by intertwining mathematics with social and political issues that spark student interest and extend their understanding of the world. In Rethinking Mathematics, Gutstein (2005) provides educators with real life examples and testimony of how mathematics becomes more engaging and purposeful when it is presented in a way that is more accessible for minoritized students.

Findings from Joseph, Hailu, and Matthews (2019), find that Black girls' positive connections to STEM is strengthened by their "bond with skilled mathematics teachers in fun and relaxing ways". Basu and Barton (2007) found that Black youth from urban schools describe science as "a discipline that generates sentiments such as boredom, anxiety, confusion, and frustration". Meanwhile, Davis (2014) affirms these findings, noting that students in their study reflected less favorably on instances in STEM classrooms where they were bored, citing as an example, "mostly reviewing old material instead of learning anything new". Other research has found student disinterest to greatly influence how they connect to STEM (Logan & Skamp, 2008; Marshall, Horton, Igo, & Switzer, 2009). Sentiments from these students point to student connection and interest as essential to students' general happiness and engagement in STEM classrooms.

Gutstein's (2006; 2005) perspective meets students where they are by utilizing world topics they are interested in learning more about, while also providing them opportunities to view mathematics as more than just standards and principles which is typical in schools. By allowing students to engage with mathematics in ways that are non-utilitarian, students get the opportunity to understand how mathematics shapes the world outside of the classroom.

Reimagining STEM as Intrinsic and Joyous

It is difficult to imagine any classroom, let alone a STEM classroom that allows students to explore science technology engineering and mathematics without asking them to prove that they are learning. It would be challenging for a student to take their love of music, learn about music theory and composition, create a final project that involves those skills, and then continue building on those skills throughout their schooling career, and not assess them on whether or not they understand time signature. Despite the difficulty in achieving this vision, this is the type of education that I believe would help education reform make the changes that they seek. I believe this to be an issue of control, or rather an issue in relinquishing control over how people learn and for what purpose. This would require a selfless perspective of what students choose to pursue regarding their learning, and why.

Weil (1954) calls for education to be a source of intellectual excitement to the brink of the unknown, however it is easier said than done to allow students the space to learn in that way without interference from others wanting to know what sort of products that process could provide. A Nation at Risk states that "it is the expectation that students should and do want the responsibility of carrying the gauntlet". The issue I take with this way of thinking is that hardly anyone asks students if they would like their triumphs in STEM to be triumphs for society. Much of society exists through the assumption that what is in the interest of all would be in the interest

of one, but I argue against this idea by proposing a left transactional approach to educating students and furthering the nation. Centering students' joy in subjects first is a great way to create the lovers of STEM that so many would like to see.

My own research focuses on joyous STEM learning for Black youth to counter anti-Black ness of STEM, and also the perception of STEM as apolitical (Gutstein, 2006) and emotionally neutral Ahmed (2014). I believe that this work is important in the face of anti-Blackness and negative attitudes towards anti-racist teaching that has become more prominent in recent years. Challenges to The 1619 Project (Hannah-Jones, 2021), or school districts pushing against ethnic studies and multicultural classes that center students of color, or more recently an uproar about Critical Race Theory trickling down to public school classrooms are all examples of resistance to allowing minoritized students and particularly Black students to show up in STEM spaces in ways that feel and are genuine to them. Especially now, even the phrase Black joy comes with political, anti-Black connotations that invite critique and pushback from those who may view the joy of Black youth as a threat to the joy and learning of non-Black students. However, to recognize a moment of Black Joy, or moments of affirmation, is also the act of noticing moments of joy for others and encouraging those moments. Black Joy, which is difficult to extract from other contexts like whiteness, which exists almost as an opposition to intrinsic joy of Black youth. It is also difficult to separate student learning and talents from the selfish desire to place extrinsic value on it. STEM research and reform should move to conceptualize learning Black youth through a lens that extricates their genuine interest, and ultimately, their *joy* from political and economic agendas. I call for STEM learners to leverage the interest and love for STEM that they already possess by allowing students to explore their interests in ways that feel

unique to them, without the added pressure of demonstrating how it can be beneficial for purposes besides their own intrinsic enjoyment.

Methodological Framing and Rationale

Introduction

This study incorporates calls to continue to decolonialize research through a participatory model to decenter White, dominant practices from more positivist perspectives (Patel, 2015; Anzaldúa, 1987;1999). Traditional qualitative methods such as surveys and interviews were utilized in this study (Given, 2008), however they were not enough to convey the internalized and embodied experience that the participants in this study wanted to speak to. Embodied noticing was introduced to this work from a previous study on noticing for equity in mathematics that some of the participants and myself had been part of. Through this lens, embodied learning informed how the participants in this study described and experienced affirming and non-affirming practices in STEM classrooms (Mendoza et al., 2021). Attending to emotions and feelings during conversations about Black youth and STEM supported participants in learning and bridging knowledge between the mind and body (Rendón, 2012; Anzaldúa, 1999). This knowledge was processed socially and collaboratively by participants (Jacobs & Philipp, 2010). The wisdom gained and dispersed through participants' observations of the sociopolitical landscape of STEM paired with participants' embodied processing of their emotions served as a methodological framework to conceptualize Black joy in STEM classrooms.

This framework served as a vehicle to enable participants to learn and process information, as well as to provide a space for participants to depict their theorizations and conceptualizations of Black joy through body mapping, collaging, and other forms of creative expression.

This study took a qualitative approach (Erickson, 1985) modeled after Erickson's work on data collection as an inquiry process to better understand how supports can be designed and implemented to help Black youth reauthor dominant narratives and challenge anti-Black ideologies in STEM. Additionally, this study took a decolonial approach to qualitative investigation by centering less dominant methods of inquiry and data collection that ask researchers to think more critically and equitably about their own roles in research, and also that of their participants (Caelli, Ray, and Mill, 2003). The following sections frame the methodological choices in the study through decolonizing and affirming methodologies, reauthoring as methodology, counternarratives and narrative-based inquiry, and creative story-making as methodology.

Decolonizing and Affirming Methodologies

Traditionally, education research has privileged individuals and their perspectives as investigators in discerning and understanding phenomena concerning students and their learning (Stanton, 2014; Probst, 2016; Thambinathan & Kinsella, 2021). Although researchers bring a wealth of knowledge to education research and our understanding of teaching and learning experiences, reframing education research as both a collaborative and participatory process (Anzaldúa, 1987; 1999; Patel, 2015) brings a more nuanced and insightful understanding of students, their learning, and how they navigate the sociopolitical landscape of education. Participatory research not only decenters dominant, colonial methodologies, but also challenges traditional design processes. Efforts to decolonize research designs and methodologies have aimed to decenter White, dominant practices that often separate the individual researcher from their research and also their participants. Decolonizing practices have sought to bridge the distance between the individual researcher, their research, and their participants (Anzaldúa,

1987;1999; Patel, 2015), but also to include more Indigenous Research (Wilson, 2001; Chilisa, 2019) and ways of knowing, sharing, and production (Anzaldúa, 1987; Lincoln and Gonzalez y Gonzalez, 2008; Paris & Alim, 2017).

Similarly, affirming methodologies aim to privilege shared knowledge and production by bridging multiple knowledge systems by completely moving away from colonial narratives (Haynes et al., 2022), standards of research, and validity (Nakhid et al., 2022). From this perspective, scholars aim to completely move away from dominant practices by taking "a more liberatory approach of centering and valuing the lived cultures of racialized and minoritized students" (Nakhid et al., 2022, p. 78). Participants have the opportunity to build reciprocity and trust between researchers and members of the participatory group.

Reauthoring as Methodology

This study focused on the act of reauthoring dominant narratives by leveraging *reauthoring as methodology* (Oklan, 2017), which is aligned with qualitative approaches. Modeled after counterstorytelling methodology (Given, 2008), reauthoring methodology documents the creation of new narratives, or the shifting of dominant narratives that have wrongly depicted individuals and groups of people over time. These counternarratives challenge dominant narratives and the power dynamics that maintain them (Delgado, 1989; Bell 2004; Solórzano & Yosso, 2002). Scholars have utilized counter narratives as a way of pushing against oppressive structures and provide opportunities for less dominant representations of minoritized experiences (Anzaldúa, 1987; Crenshaw, 1989;1990). Reauthoring is a reclamation of dominant narratives that takes place through the act of counterstorytelling. Furthermore, reauthoring provides storytellers from minoritized groups the opportunity to push against dominant narratives to investigate how these narratives relate to individuals' past and present (Bennett and

Detzner, 1997). Reauthoring functions as a methodology by allowing youth and adult participants to interrogate the past and present narratives that do not include the perspectives of non-white storytellers. In this study, participants were invited to forge counternarratives that offered an alternative perspective of how Black youth can and are included in the dominant narrative of STEM. Similarly, Black youth were invited to reauthor or reclaim these counternarratives as their own, which highlights the importance of narratives in shaping perception, and also, the agency Black youth possess over changing harmful narratives (Wagaman, Obejero & Gregory, 2018).

Counter Narrative And Narrative-Based Inquiry

Counternarratives challenge dominant narratives and the power dynamics that maintain them (Delgado, 1989; Solórzano & Yosso, 2002; Bell 2004). Scholars have utilized counter narratives as a way of pushing against oppressive structures and provide opportunity for less dominant representations of minoritized experiences (Anzaldúa, 1987; Crenshaw, 1989;1990). Within a counterspace, members of the Black Joy Group were able to provide counter narratives of their experiences as STEM learners and as STEM people which pushes against dominant narratives that portray women and women of color as less suited to the field. Black youth in this study had the opportunity to utilize counter narratives in their collages in which they depicted themselves as STEM people. Each example of participants in this study utilized encounter narrative pushes against dominant narratives about Black youth and other minoritized groups in relation to STEM. Framing this study through counter narrative allowed for the participants to provide alternative representations of underrepresented people in STEM from their own perspectives.

Narrative-based methodology that centers the lived experiences of minoritized groups diminishes the power of dominant storytellers to dictate the hows and whys of a particular person, context, or event (Farmer-Hinton, Lewis, Patton & Rivers, 2013). Through the creation of counter narratives about Black people in STEM, Black youth have the opportunity to gain some control over the way they have been depicted and perceived over time. Rice and Mundel (2018) believe that "we make stories at the same time that stories make us", and so the reciprocal process of reauthoring of the dominant narrative allows Black youth to reclaim past narratives and envision possible future narratives that portray Black youth more positively.

Creative Story-Making as Methodology

Using creative mediums to craft narratives and tell stories is a large part of storytelling for minoritized groups (Willox, Harper, and Edge, 2011; Rice & Mündel, 2018; Rice, LaMarre, Changfoot, & Douglas, 2018; Boatwright, 2019). This was particularly important in supporting participants in their study in providing STEM counternarratives. Oftentimes, narratives in the form of artwork like pottery, weaving, and sketching provide a glimpse into 'the state of a society' and the series of events that helped to create it (Rudrum, 2005). These narratives help us to better understand the events and experiences of people that shape the present world and the future. This provides minoritized communities with the opportunity to tell their stories from their own perspectives and reclaim narratives in spaces that are more visible and consumable by dominant populations.

Rice and Mündel (2018) explore creative story-making methodology with multimedia. The scholars argue that the act of storytelling is ageless, however modern methods of storytelling such as storytelling through the arts has the potential to open up conversations about difficult or sensitive topics. Another example of this type of storytelling is a study from Willox, Harper, and

Edge (2012) that highlights the ways Indigenous communities have used digital storytelling to disrupt dominant narratives and stereotypes of Indigenous people.

Decolonizing and affirming methodologies, narrative storytelling, reauthoring, and creative story-making all form a layered methodological framework through which participants conceptualized their identities, experiences, and re-imaginings of STEM learning. This framework also serves as a vehicle to help challenge dominant STEM narratives about Black people and Black youth by decentering dominant narratives and stereotypes that often position them as not 'STEM people'.

Participants

The Black Joy Group

This two-year study was conducted with two groups of participants. The Black Joy Group contained seven people who self-identify as female, all with experience working with Black youth either formally or informally. The members of the Black Joy Group collaborators include Tasha and Cindy, two Black mathematics classroom teachers based in the Midwestern US, Jayla, a Black University scholar, researcher, philanthropist, community leader, and community educator based in Colorado, Jin-Joo, an Asian-American student researcher, and community educator based in Arizona, Leah, a Latinx university scholar and researcher based in California, and Valerie, a White university scholar and researcher based in Colorado.

Although Jin-Joo and Jayla came to the study primarily as previous participants who held roles as community educators, and Tasha and Cindy came to the study primarily as classroom teachers, while Valerie, Leah, and I originally joined the Black joy group as scholars and a graduate researcher respectively. It is important to highlight the fact that the roles participants held throughout the study were unfixed and intentionally fluid. In addition to the roles

participants held in official capacities I also acknowledge that participants came to the study with other identities relevant to the nature of the research such as experiences as former youth in STEM classrooms, or their experience being parents, siblings, and forming other supportive relationships with Black youth. The participants' wealth of knowledge in this study combined together to unearth what it meant to center joy for Black youth, and how to better support educators and students in reimagining STEM spaces.

Table 1

Black Joy Group Members

Participant	Identity	Role
Jayla	Self-identified Black Woman	Community Educator & Scholar
Jin-joo	Self-identified Asian-American Woman	Community Educator, Graduate Student
Leah	Self-identified Latinx Woman	Scholar
Valerie	Self-identified White Woman	Scholar
Michelle	Self-identified Black Woman	Elementary Mathematics Teacher & Graduate Student
Tasha	Self-identified Black Woman	High School Mathematics Teacher
Cindy	Self-identified Black Woman	Middle School Mathematics Teacher

Student Reauthoring Group

Additionally, this study was conducted in mathematics classrooms with Black youth. The youth were students in classrooms of two of the Black joy participants: Tasha and Cindy. As

Black educators, Tasha and Cindy were interested in supporting their students in developing counternarratives about themselves as Black youth in relation to STEM. Students were recruited from Tasha and Cindy's classrooms using parent interest and parent consent forms that the two teachers handed out at the end of a class period. Only consenting students were surveyed and were asked to create collages during reauthoring sessions. Included 15 students from Tasha's classroom, and 12 students from Cindy's classroom.

Prior to collecting data in the teachers' classrooms, both Tasha and Cindy suggested that the consenting students be involved in two online introductory sessions to introduce myself and form a connection to the youth outside of the research. Following those initial introductory sessions, I intended to meet with each classroom where students would participate in a survey that asked youth to define STEM its purposes. Due to Covid restrictions, I could only physically visit one classroom for a reauthoring session. I worked with youth in the restricted classroom virtually. During these reauthoring sessions, students participated in creating collages that depicted STEM and also reimagined STEM classrooms in the future. Aligned with the goals of the study, it was important to better understand STEM classrooms with a perspective of students learning in STEM classrooms. More importantly, it was important to understand those experiences from the perspectives of Black youth who are positioned as the least likely student group to formally pursue their STEM interests (Martin, 2012; Gholson & Wilkes, 2017; Miles & Roby, 2022).

Table 2

Student Reauthoring Group

Teacher	Class	Number of Students
Cindy	Middle School Mathematics	12
Tasha	High School Mathematics	15

Positionality

As a member of the Black Joy Group, at the time of this research I held a role as a graduate researcher and former elementary educator. Most importantly, I came to this work with my experience encountering dominant STEM narratives as a Black youth. Despite holding ascribed, deficit narratives resulting from prolonged challenges as a student who struggled to master mathematics, science, and other STEM-related subjects, it is important to me as a Black woman entering STEM education research to better understand the perspectives of educators and Black youth from a STEM context. Although this narrative was constructed over time by anti-Black stereotypes and deficit perceptions of Black girls' capacity for STEM mastery, I authored a similar self-narrative by excluding the ways that I used and succeeded with STEM through less traditional and 'legitimate' avenues.

My conceptualization of successful STEM engagement and participation has been largely shaped by my experiences in performance and outcomes-based learning environments that privilege measurable STEM learning and participation. Through this lens, I had been perceived as a student with deficits, but also, as a student who was labeled as academically gifted. Like many students who have gone through public schooling in the United States, increasingly, the years they spend in classrooms are defined by their performances of assessments and high-stakes

tests (Anderson, 1998; Moses & Nanna, 2007). In my schooling career, the end of the year assessments served as the main criteria for promotion to the next grade. Though I was never retained due to my proficiency with other subjects, throughout my primary, secondary, and higher education, I would routinely fail to meet proficiency standards on mathematics assessments. For this reason, I did not consider mathematics or STEM as part of my identity. However, I started to form a relationship with STEM and negotiate an identity within it through my interests and enrichment in the arts.

As a youth, I had the opportunity to join concert bands and ensembles. During this time I learned to sight-read music and play the clarinet. After six years, I learned to play other instruments such as piano and the acoustic guitar. Other areas of my life where STEM showed up were through my interests in sewing and cooking with friends and family, but also in more traditional STEM activities like coding on Myspace, and participating in the school's Technology Olympics. As an adult, my years as an elementary classroom teacher also supported me in renegotiating my STEM identity through working with students who struggled with mathematics in the same ways that I did.

Identifying relationships between my interests and STEM are obvious to me now. However, when I was younger I never made the connection about just how much mathematics I was doing and succeeding at. As I have been working on this dissertation and trying to make time for selfcare, I have taken up clarinet again and I found myself amazed at the amount of real-time calculations I did as a young person sight-reading difficult sheet music. This is a skill I am still working to restore as my adult brain struggles to accept that making timing and rhythmic mistakes are a part of mastering difficult pieces. However, I continue working towards this goal with the confidence that these are mathematics skills I can learn again because I learned them

before. Similarly, I feel confident about my abilities to use them in ways that are purposeful and meaningful to me.

My STEM identity was not constructed through Western ideals of success in STEM. I got to renegotiate my STEM identity and where I fit within narratives of STEM by participating in ways that helped bring me joy. Through my non-traditional connections to STEM, I was able to be a more traditional participant in higher education STEM classes where I continued to negotiate a STEM identity through various successes and failures. For this reason, I describe myself as holding a *peripheral perspective* within traditional STEM. My positionality informed the way I came to my dissertation work aimed at supporting students in renegotiating and reauthoring their relationships with STEM. By being perceived as both a problem and an exception, I aim to contribute to research that shifts monolithic narratives of Black youth and of STEM people.

Context for Study

Dominant STEM narratives that exist about Black youth are often narrow and deficit-oriented (Martin, 2009; Spencer & Hand, 2015; Battey & Leyva, 2016; Gholson, 2017; Gutiérrez, 2017). These narratives influence the ways that Black youth and their joy are perceived in STEM classrooms, and how they perceive themselves (Gholson, 2019). This qualitative study was designed to support teachers and students who may not see and interpret Black joy in affirming ways to re-envision STEM narratives in ways that center Black joy. The study took place for two years in two different contexts. One context was a participatory research group that focused on Black joy that met virtually online. The second research site was two mathematics classrooms in the Midwestern United States. The area, which is also predominantly

Black (see Table 3), had been receiving media attention portraying it from a deficit perspective for over twenty years.

Table 3
Participant School Demographics

	Magnet Middle School	Magnet High School
White	3.7%	11.8%
Black	90.2%	81.9%
Multi-Racial	4.1%	3.4%
Latinx	2.0%	2.5%
Asian	0%	0.2%
Native/Indigenous	0%	0.2%
Total Student Population	245	526

Note: The percentages in the table represent the proportion of each racial/ethnic group in the total student population.

The second group of participants in this study included 15 high school mathematics students and 12 middle school mathematics students. Both schools are located in the same city in the Midwestern United States. The youth participants in this study were recruited from two classroom teachers and members of the Black Joy Group, Tasha and Cindy. Their classrooms featured mostly Black youth studying either Algebra or Math II. The youth were also simultaneously taking classes in science or engineering with other teachers in their schools. It was the goal of this study to not only conceptualize Black joy within a STEM context, but to notice and understand Black joy, what constrains it, and how to better support it in a space with a

history of anti-Blackness. Further, this study sought to better understand the nuanced relationship between STEM, Blackness, joy, and the self from the perspective of Black youth.

Study Design

This study had two phases that unfolded over the academic years of 2020 and 2022. Described below are the details for Phase 1 of the research which involved the Black Joy Group. This section details the data that was collected during this first phase of the study, and outlines the analysis for the data collected. The next section details the design for Phase 2 of the study which involves the Student Reauthoring Group.

Phase 1 Black Joy Group Design

Intentional and Inclusive Study Design

In this research, the participatory group and I aimed to incorporate non-traditional approaches like creative inquiry to better understand mathematics education (Bullock, 2012). Given the diverse backgrounds of our research group (including various racial identities, roles, and levels of expertise) we felt it was crucial to collaborate and make joint decisions about how to examine the experiences of Black youth in STEM classrooms. Building trust was a key focus throughout the process.

Vakil et al. (2016) discuss the complexities of working with participatory groups and the power dynamics that can arise. They note that building 'politicized trust', or trust across lines of difference, requires ongoing effort to cultivate mutual trust and solidarity. However, they also note that there can be resistance or disinterest from collaborators and that issues of belonging tied to factors such as race and gender can emerge and need to be addressed in order to sustain engagement and solidarity (Vakil et al., 2016; Vakil and de Royston, 2019).

Recognizing that this research would be emotional, and at times, challenging due to the

need to discuss past and current tensions and harm, the Black Joy Group worked to build trust by setting intentions and sharing their truths. The first two meetings focused on setting our purposes for the research and setting goals for our time together. Participants were invited to talk about their motivations for joining the study, their desired outcomes of the research, and their preferred approach to engaging in the work. Although the ultimate goals of the research were not yet clear, we emphasized the importance of approaching the study with a focus on joy and a celebration of Blackness to avoid perpetuating deficit perspectives about minoritized youth in STEM fields.

This research was conducted over a two-year period. The Black joy meetings involved sharing and bearing witness to *testimonio* (Haig-Brown, 2003; Villenas, 2019), sharing our own histories, and discussing our experiences working with Black youth. We used various methods to share and learn from each other, including traditional facilitation and more non-traditional techniques like collaging. For example, Jayla, a Black scholar, presented the concept of Black Finesse (Mackey, 2020) as a potential framework for understanding how students make decisions in STEM fields, Black Joy Group member, Jin-joo, and I co-presented on the idea of extricating Black joy from Whiteness. Through co-presentation and the sharing of ideas and perspectives, the members of this participatory group often moved between moments of teaching and learning. This collaboration was crucial in incorporating the knowledge and ideas of participants, which helped to deepen our understanding of Black joy and how to better extricate it from whiteness. It was essential to recognize and utilize the diverse expertise and experiences of all the women in this group who each have a background in conducting research from critical perspectives and are experts in equity through their expertise as teachers, scholars, and community educators. The Black Joy Group's collective knowledge and experiences were invaluable in conducting a thorough and nuanced investigation into the intersection of STEM

and joy.

The Black Joy Group and I desired to better understand how the Black youth understood personal and STEM narratives in the context of their hometown. As members of the Black Joy Group, we prioritized salient student perspectives and narratives of STEM classrooms as they actively learned and did mathematics, while also actively experiencing joy. The Black Joy Group met 16 times for 1.5 hours via Zoom. Data collected from these meetings included video and audio recordings. Members of the Black Joy Group participated in semi-structured baseline interviews (see Appendix A) and semi-structured closing interviews (see Appendix B) that were created collaboratively by the members of the Black Joy Group to ensure questions contained the level of nuance necessary to adequately elicit participants' developing conceptualizations of STEM identity and Black joy. This collaborative approach allowed for the sharing of ideas and the creation of a more holistic understanding of the issues being investigated. Additionally, data included transcripts and memos of the Zoom meetings and each round of interviews to synthesize participants' noticings, theorizations, and ideas to continue pushing on traditional, colonial perspectives of qualitative research. Data also included artifacts from Black joy meetings and baseline and closing interviews conducted at the beginning and end of the study. Artifacts included identity maps, body maps, journal entries, digital art, and digital collages. Participants used these creative mediums to visually conceptualize their identities and their embodied noticings.

The Black Joy Group relied on three activities - embodied noticing, body mapping, and collaging - to collect data and inform their discussions and theorization of Black joy in STEM classrooms. These activities allowed participants to more effectively visually depict their internalized experiences and encouraged them to engage the complexities of conceptualizing

overlapping concepts and ideas they held. This approach was influenced by scholars who challenge traditional notions of what primary sources of data should be and encouraged the group to embrace the messiness of this process.

Phase 1 Black Joy Group Data Collection

Data collection for the first phase of the study included 16 Black joy meetings which were held over Zoom and recorded and then later transcribed. These meetings lasted an hour and a half and were held bi-monthly. During meetings, participants would journal about how conversations were landing on them mentally and physically.

In addition to Black joy meetings, data from the Black joy group included 5 baseline interviews and 4 closing interviews which asked participants to provide their perspective on the potential that reauthoring holds for shifting the way Black youth are perceived from a STEM context. And, most importantly, how reauthoring could support Black youth in *seeing* themselves in the narrative of STEM. Artifacts included online mediums for collaging, painting, and drawing. Participants also used Jamboard, journals, and paper and pencil to illustrate their processing across the two years that the Black Joy Group met.

Table 4

Comparison of Participant Groups on Year 1 and Year 2 Data Collection

Participant Group	Phase 1 Data Collected	Phase 2 Data Collected
The Black Joy Group	Zoom Meetings of Black Joy Group (8) Baseline Interviews (5)	Zoom Meetings of Black Joy Group (8) Closing Interviews (4) Meeting Artifacts
Student Reauthoring Group		Student Surveys (27) Student Collages (27) Field Notes & Memos

Phase 1 analysis

In the analysis phase of the qualitative study, the open-coded final interviews with Black joy participants were carefully reviewed and coded for themes related to how the participants were noticing, thinking about, talking about, and representing Black youth's experiences with STEM. The emergent codes from this process included personal experiences in school systems, parenthood, and the body and its senses. These codes were then used to begin to generate a codebook, which provided a systematic framework for organizing and analyzing the data. Examples from the codebook include: parenthood, community/relationship building, institutionalized schooling culture, and teaching/sharing/connecting.

From there, the final interview data were re-analyzed using a combination of the emerging codebook, open coding, axial coding, and selective coding techniques to identify relationships and themes within the data (Khandkar, 2009; Flick, 2013). This process involved

reading and re-reading the transcripts, identifying key themes and patterns, and making connections between different codes and categories. The resulting findings were turned into a second iteration of a codebook that included codes such affirmation, healing, both/ands, and acts of resistance.

After coding the interviews, I began to code artifacts from the Black Joy Group using the codebook, as well as open coding to see if other themes emerged. I further refined codes in my codebook as a result of this process, categorizing experiences from the Black Joy Group members as either manifesting joy, reauthoring, reimaging STEM classrooms, and identifying constraints of Black joy.

This coding process and emergent themes provided insight into members' perspectives on the experiences of Black youth in STEM education, and helped to identify ways to support and enhance their learning and engagement in these subjects. Questions that emerged and informed this initial phase of analysis included: *How do Black youth experience surveillance and how do they navigate this in STEM education? How do Black youth negotiate the tensions between different identities and experiences in STEM education? And What are examples of Black joy within and outside of the classroom?*

Phase 2 student reauthoring group design

The second phase of the study builds on Phase 1 which supported the Black joy group in conceptualizing Black joy and how it is allowed or not allowed to show up in STEM spaces. Phase two also aimed to better understand how Black youth conceptualize STEM, STEM narratives, and STEM learning.

The youth in this study were students in the classrooms of two of the Black joy participants: Tasha and Cindy. As Black educators, Tasha and Cindy were interested in

supporting their students in developing counternarratives about themselves as Black youth in relation to STEM. Continuing to set intentions around trust, data collected from Tasha and Cindy's classrooms did not include video or audio. This choice was made to strengthen and develop relationships between parents, teachers, students, and the researcher by helping students feel more comfortable in sharing their ideas and perspectives.

Prior to collecting data in the mathematics classrooms, both educators suggested that the students be involved in two online introductory sessions in order to introduce myself and form a connection to the youth outside of research. Following those initial virtual introductory sessions, I intended to meet with each classroom for two reauthoring sessions where students would participate in a survey that asked youth to define STEM its purposes, and create collages about STEM. It was important to better understand STEM classrooms with a perspective of students learning in STEM classrooms. More importantly, it was important to understand those experiences from the perspectives of Black youth who are positioned as the least likely student group to formally pursue their STEM interests (Martin, 2012; Gholson & Wilkes, 2017; Miles & Roby, 2022). Although student participants were not explicitly asked to engage in embodied learning through body mapping, youth did create collages depicting STEM, joy, and their hopes for STEM classrooms in the future. Through collaging, students engaged in reauthoring, which supported the re-envisioning of dominant STEM narratives. Due to Covid restrictions, I could only physically visit one classroom. I worked with youth in the restricted classroom virtually.

Phase 2 Student Reauthoring Group Data Collection

Student participants engaged in two reauthoring sessions where they made collages with materials provided by the researcher and their teachers (magazines, books, photos, and other art supplies) (See Table 4). Each student reauthoring session lasted 1.5 hours; students were given

1.5 hours to complete their survey questions, and an additional 1.5 hours to make their collages. The reauthoring activity was designed to give students an opportunity to consider their perceptions of STEM education as well as ways to enhance their understanding of these subjects. After students created their collages, they participated in a quick Q&A interview when I asked them to describe their collage and how it relates to STEM (see Appendix D)

Before creating their collages, students were asked to participate in surveys about their experiences with STEM education (see Appendix C). Surveys had seven question prompts that asked students questions like: *What is your happiest memory around STEM? What kinds of activities do people do that involve STEM?* and, *Who belongs in STEM and why?* This data was used to better understand students' attitudes and needs, and to identify ways to better support their learning in these areas. Data from this phase of the study also included field notes that were taken during classroom visits and then synthesized through analytic memoing (Rodgers, 2018).

Phase 2 Analysis

In the second phase of the study, I analyzed the student surveys and collages for themes related to how Black youth define, represent, and envision their participation in STEM.

I applied the codebook from Phase 1 to the surveys. I further refined the codebook to reflect themes emerging from the analysis of student data. Codes that emerged from this analysis included: positive emotions, negative emotions, neutral emotions, representing STEM, and representing STEM people. Themes that emerged included: STEM as a career, STEM and personal interests, STEM as traditional and non-traditional.

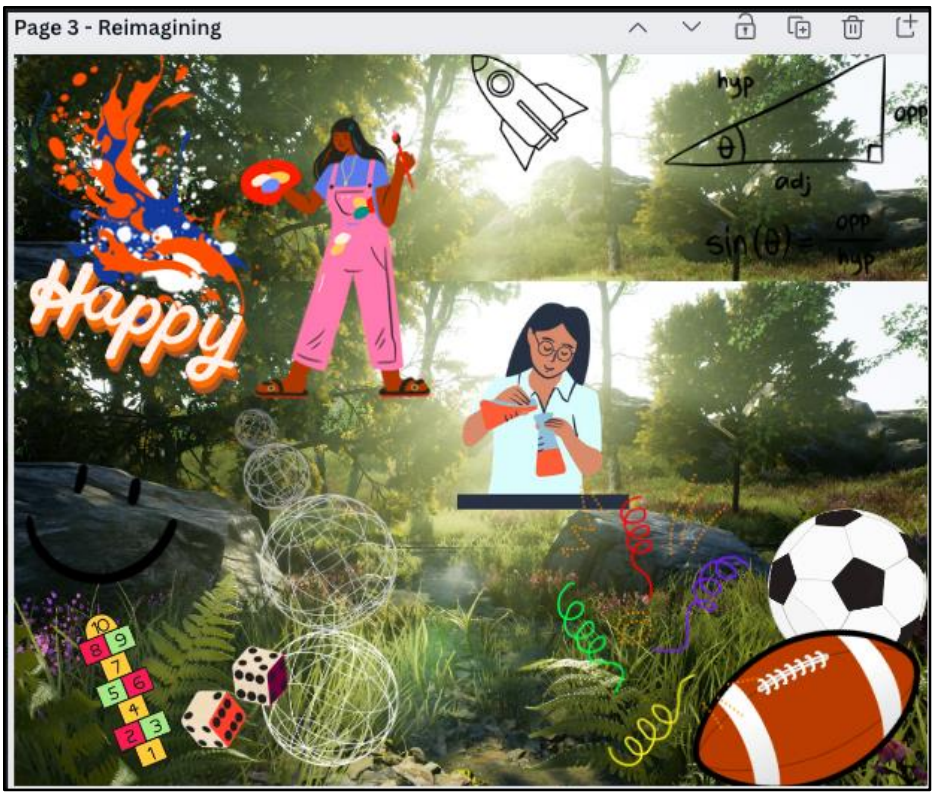
I noticed that students made doodles and drawings in the survey. I decided these were relevant and coded them using the newly refined codebook. From there, I began to code the student collages. The data were then analyzed using selective coding techniques (i.e., the

codebook) to identify patterns and themes within the data. STEM narratives, belonging, and reimagined STEM spaces. Questions that emerged and informed the phase of analysis included: *How do students see themselves in relation to STEM, what does STEM mean to Black youth, and how are whiteness and societal constraints showing up in the way they talk about STEM?*

To synthesize the themes most frequently showing up in student collages, I created digital analytical collages that were composites of what students chose to highlight in their art. These themes included future climate change, hands-on learning, learning in nature, and including sports and other activities in STEM curricula.

Figure 2

Researcher Analytical Collage - Students Reimaging STEM



Creating composite and analytical collages from student collages in both classrooms allowed me to better identify the most salient ideas and perspectives represented. Additionally, creating

analytical collages was an intentional choice to continue decolonizing the analysis process and *colonial logics* (Patel, 2015) by using non-traditional and creative avenues to make sense of what students produced.

Chapter 3. Findings Phase 1

Introduction

The findings chapter will present findings from Phase 1 of the study, followed by Phase 2. The section for Phase 1 will present findings and sub-findings that emerged from thematic coding of the data. The chapter is organized by research questions. Phase 2 findings will be presented in the second half of this chapter.

Phase 1 sub-findings focus on how adult participants from the Black Joy Group defined, noticed, and embodied Black joy. This section also describes the ways that participants believed Black joy to be constrained by systemic oppression, how participants reframed salient narratives about Black youth, and lastly, how STEM spaces can affirm Black youth and their joy. The findings present themes that emerged from the following research questions:

1. How do participants in an educational counterspace reimagine STEM education that centers Black joy?
    a. How do the participants define, notice, and embody Black joy broadly speaking?
    b. What do the participants name as shaping Black joy in STEM education?
    c. How do participants envision changes in the ways Black students experience STEM, towards broadening joy in STEM?

Finding One: Black Joy is Internalized, Embodied, and Different From Joy

RQ1a) How do the participants define, notice, and embody Black joy broadly speaking?

The following sub-findings reveal how participants of the Black Joy Group conceptualize Black joy and how it mirrors or differs from other emotions and states of being. I present the themes that emerged from participants distinguishing Black joy as a unique and nuanced experience.

Happiness Does Not Equal Joy

The Black Joy Group entered into this research with the goal of focusing intentionally on positive emotions which are understudied in relation to Black youth and their STEM learning (Bonilla-silva, 2019; Tichavakunda, 2021). The Back Joy Group considered instances where their happiness, especially as STEM learners, was dependent on external factors like location and their positioning (Williams, 2018; Iceland & Ludwig-Dehm, 2019).

As participants began theorizing Black joy in STEM spaces, it was important to first distinguish Black joy from other emotions and states of being such as happiness and joy. With an understanding that positive feelings can resemble one another, participants first began to define joy as an *internal lightness*. This definition of joy was different from *happiness* which was described as a more temporary, and materially dependent feeling. In a meeting with the Black Joy Group, one participant, Valerie, a white scholar, described happiness as "something that comes from *external sources*" (Mtg_03_07_22_Valerie), like, for example, when Leah cited flowers as something that can bring her instant happiness. This finding overlaps with the findings from Iceland & Ludwig-Dehm (2019) that Black people's happiness is often dependent on factors that bring safety and comfort that stem from consequential choices (Williams, 2018). During this meeting, in a shared collage created by the Black Joy Group, I added a photo to represent happiness (See Figure 3). The photo shows a Black woman sitting in a sunlit room with a laptop, furniture, plants, and a dog to represent material things. I later described joy as the ability to "feel the same lightness" (Mtg_03_07_22_Michelle) that is represented in the picture, but without the material things having to be in the photo with her.

Figure 3

Michelle Happiness/Joy for Group Collage

Members of the Black Joy Group defined joy as existing independent of material things. Similar to Dunn and Love (2020), Valerie defined joy as "*something more internal*" (Mtg_03_07_22_Valerie) than happiness, like a strong sense of self or a sense of community. Jin-Joo defined joy as "something happening and being within your body" (Mtg_03_07_22_Jin-Joo). Discussions about joy from Jin-Joo's definition guided other members of the Black Joy Group to recognize how joy felt in their bodies, and how it was most noticeable in moments of just being. The codes 'just being', 'internalized', and 'lightness' emerged from instances like this where other participants described joy as a feeling or state of being that involves feeling pride that manifests as a feeling of lightness. Tasha, a Black teacher, cited an internal sense of pride and lightness that she felt in relation to having or feeling joy, like the warm feeling she got while watching Black youth *just being* and in their element while sharing their talents in dance and music (Mtg_03_07_22_Tasha). Similarly, Leah, a Latinx scholar, described joy in terms of joyous activities that are done in community like dancing. Leah defined joy as warmth from memories that have stayed with her such as images of ancestral dancing and connection. She stated that her joy, "comes from a place of peace in my heart, where I can have my own light in

my own space" (Mtg_03_07_22_Leah). Aligned with Brooks' (2020) definition of joy as a deep-rooted vital force, Leah recognizes joy as a deep-rooted connection to her ancestors inspiring joy inside her heart.

The featured excerpts from conversations and group collages above frame happiness as an emotion that is dependent on external factors. When describing these external factors, participants listed flowers and possessions as sources of happiness. Additionally, the featured excerpts from conversations and group collages above frame joy as an emotion that is not dependent on external factors. Participants described joy as internal and existing independent of the material things that participants named as sources of happiness. Things that are held within such as memories, connection to ancestors, a sense of self, and lightness within the body were named as sources of joy.

Black Joy Is Mental, Emotional, And Physical Freedom

To distinguish Black joy from joy, participants likened Black joy to lightness, but also freedom (Golden & Utah, 2015). This distinction was made after conversations shifted to joy often feeling constrained by societal factors, particularly for Black and Brown people expected to adhere to white, Western standards of behavior. With the understanding that all people and students have the capacity to feel joy, Black joy was defined by the liberatory joy that is observed and felt when Black people exist without having to conform to the white gaze.

Tasha, a Black educator, drew a connection between the feeling of freedom and the experience of feeling joy, particularly in a Black body. The codes 'freedom' and 'existing without constraint' emerged from instances where participants described the freedom and lightness of doing things for oneself. On a Jamboard page, Tasha wrote: "[Black joy is] the freedom of being able to do the things that you want to do, when you want to do it"

(Mtg_03_07_22_Tasha). Similarly, Valerie described Black joy as "being able to do what makes you happy without having to think about it" (Mtg_03_07_22_Valerie). Tasha and Valerie's definitions of Black joy relate to Golden and Utah (2015) and Adams (2022) who conceptualize Black joy as freedom. The scholars cite chains as the confines that restrict Black joy. For example when asking Black students what Black joy means to them, the most common answer was "to unapologetically be myself,". Here, Tasha and Valerie define Black joy as the freedom of doing *what* one wants, *when* one wants. In this instance, the chains that Black joy is restrained by are whiteness and the white gaze. Existing outside of whiteness and the white gaze, allows one the ultimate freedom to be one's self and make choices that honor that.

In a journal entry, Leah further elaborated on the feeling of joy as being free of expectation and responsibility, stating: "Black joy is being free of the responsibility to convince or of assessment from the white gaze. No need to prove" (Journal_04_03_22_Leah). Acknowledging STEM spaces as political spaces, Leah recognized a lack of freedom that students may feel, particularly if they are Black students. When conceptualizing what Black Joy looks and feels like in STEM spaces, Leah defined it as a freedom from Black students having to convince white people of their belonging.

Further, Jin-Joo spoke to joy and how it is experienced within Black and Brown bodies. The codes 'embodiment' and 'tension' categorized instances where participants like Jin-Joo defined Black joy as the absence of tension, noting the physical manifestation of pressure and freedom that a person may feel under the white gaze. Jin-Joo stated: "Sometimes, I can feel myself like, holding myself in tension. I can feel my shoulders, just up like this [shrugs tensely], but I don't realize I'm doing it. But, then, I just *relax*. And, so, I think about like *that* joy. Like, *what it means to just relax totally in your body*" (Mtg_03_07_22_Jin-Joo). Here, Black joy was

defined as an embodied experience, and also a freeing experience. Jin-joo's draws on her embodied experience of holding herself in tension under the white gaze to frame her perspective of Black youth and the tension they may experience under the white gaze. The absence of that surveillance and need to conform is how Jin-Joo perceived Black joy. Her conceptualization ties together the perspective of her fellow Black Joy Group members who defined Black joy as liberation. This includes liberation and freedom of the body. Their perspectives aligned with scholars Golden and Utah (2015), and Adams (2022), who speak to the freedom and liberation that support Black joy and their ability to show up without having to conform to the expectation of the white gaze.

The featured excerpts from Black Joy meetings frame Black joy as an emotion separate from joy because of its political connotations, particularly for people in Black and Brown bodies. Members of the Black Joy Group like Leah understood Black joy as a liberatory emotion, describing it as a feeling of being free. Jin-Joo, another Black Joy Group member, elaborated further on this feeling of freedom by noting how her body relaxed when she imagines being separated from the white gaze. Tasha and Valerie defined Black joy as freedom of decision and behavior, citing being able to *do what one wants, when one wants*. Overall, the Black Joy Group understands Black joy and the expression of Black joy as being negotiated by Black people, particularly in white spaces. Notably, they frame Black youth's Black joy as constantly under surveillance from the white gaze.

Finding Two: Black Joy Can Have Constraints Stemming from Whiteness

RQ1b) What do the participants name as constraints for Black joy in STEM education?

The following sub-findings reveal what participants of the Black Joy Group named as the external factors that oppress and constrain Black joy in STEM spaces. Members analyzed joy

from a context of STEM as a political system (Bullock, 2019) citing STEM spaces as spaces that seek to manage student behavior before prioritizing their joy. I present the themes that emerged from participants theorizing how Black joy is noticed and interpreted and constrained through the white gaze.

Constraining Black Joy Through Surveillance and Compliance

Despite perspectives that position STEM as neutral and non-racist, researchers have found racism and anti-Blackness to pervade STEM classrooms and help shape anti-deficit narratives of minoritized youth (Gutstein, 2006; Harper & Kayumova, 2022). Acknowledging that whiteness thrives through conformity (Leonardo, 2002), the Black Joy Group considered how the surveillance of Black youth reinforces this narrative and anti-Black ideology that frames Black behavior and expressions of joy as problematic.

Continuing to theorize the nuances of experiencing Black joy, participants named surveillance as a main constraint of Black joy for Black youth, particularly in STEM spaces. The codes 'whiteness', 'compliance' and 'surveillance' categorize instances where participants described white, western expectations that inhibit Black and Brown people's ability to 'just be'. Tasha described the surveillance of Black youth and their joy in the context of traditional schooling. When talking with the Black Joy Group about Black youth and the joy they naturally embody and experience, Tasha mentioned her own students and the joy they naturally exude when singing, dancing, rapping, and engaging in other activities together outside of her classroom. However, Tasha also acknowledged that her students' joy is constantly surveilled by authority figures within the school, including herself as a teacher. She states:

> "You can just look [outside the classroom] and see that they're having fun with each other. And I always tell them, 'It's alright that you're lingering and having fun, just make

> sure you're in class by the time that bell rings. And they get mad [and say] "Well, we can talk to our friends!". You know, taking that whole joy out of it. I'm guilty of it too, but for the most part, *it's like we're stopping them from doing the things that they naturally enjoy.* So, how do we get them to do those natural things that come to them, but at the same time, do the responsible thing like getting to class on time?"
>
> (Mtg_03_05_21_Tasha)

As a Black educator, Tasha's example also included her perspective of the ways educators may reinforce narratives of Black youth's joy as disruptive through surveillance and encouraging students to remain in compliance with behavior expectations. Tasha acknowledged her role in the surveillance of Black youth and the constraining of their joy, but at the same time, she wanted to find ways to bring the type of joy that students are experiencing outside of her classroom inside of her classroom where her level involvement in the surveillance of Black youth and the expression of their joy may be negotiated.

Other participants acknowledged and expanded on the nuances of the surveillance that is prevalent in schools with Black and Brown youth. The code 'both/and' emerged in instances where participants noted both positive and negative elements to constraining factors. For example, in a collage, Jayla described a "both/and element" regarding surveillance within schools, noting how on one hand, surveillance can be "dehumanizing" and is "indicative of past traumas at the hands of the police". At the same time, Jayla noted how surveillance is also "necessary" in schools right now, citing safety and wellness concerns for Black and Brown youth due to "institutionalized, white supremacy". Members of the Black Joy Group recognized the legacy of policing in hyper-segregated BIPOC schools and the unique implications for Black

youth (Nolan, 2011). The Black Joy Group also considered their own roles in upholding standards of whiteness in schools by participating in surveillance culture.

Leah, a Latinx scholar, also grappled with the both/and of surveillance in schools as well as her role in participating in surveillance culture. In a journal entry, Leah wrote:

> "But what if it was not about surveillance? What if it was the inbetweenness. The way we correct grammar, punctuation, emotions- the ease with which we welcome joy and happiness but try to cover and isolate the hurt. I surveille, I am surveilled. I cause harm through the rules that I buy into with and without reflection. What does that mean in my body? All of it? It means I need to feel and honor all of it."
>
> (Mtg_02_09_21_Leah_Journal)

While thinking broadly about the constraints for Black joy in STEM, Leah's journal entry speaks to the both/and of surveillance she feels as a Latinx woman who is often surveilled. In her entry, she also acknowledges her role as a surveillant, sometimes even of herself, which aligns with Swart (2013) who cites *internalized self-surveillance* as a measure of how well one adheres to societal standards. While she is acknowledging the messiness and "inbetweenness" of these two realities of upholding whiteness through surveillance, Leah is asking what it means for her to *be* both of these things at once, and to *feel* the tension of these things in her body.

In this section, The Black Joy Group identified the ways that whiteness constrains Black joy, mostly through surveillance and compliance expectations for Black youth. Members of the Black joy group, like Tasha, acknowledged that in school settings, Black youth are expected to behave and comply with school rules and expectations, many of which are steeped in whiteness. In her quote describing her own tendency to be focused on the compliance aspect of students coming into class on time, Tasha is identifying the ways that teachers as well as students

negotiate how Black Joy is expressed in schools. Additionally, by discussing the tension of participating in surveillance, Leah recognized the ways that whiteness showed up in surveillance, particularly in *fixing culture*, or the maintaining of whiteness and white standards through the problematizing of Black and Brown peoples' behavior. Lastly, Jayla talked about the both and elements of surveillance in schools, noting the negative impacts of surveillance of Black and Brown youth in schools hyper surveillance and contributions to fixing culture which positions Black youth as opposite to whiteness. At the same time, Jayla acknowledged that there are positives to police presence in schools like having students feel safe in their learning environment.

The Currency of STEM and Joy

Similar to how participants explored 'both/and' elements of Black joy, participants did the same with the exploitation of Black joy in STEM spaces. The profitability of students and their performance in STEM subjects has been critiqued by Morales-Doyle and Gutstein (2019) where they describe the relationship between student performance and stakeholder interest in student performance as transactional. The Black Joy Group perceived the commodification of STEM performance (Martin et al., 2019) as a devaluing of joy and non-monetary ways that students use and experience STEM.

For example, Jayla expressed frustration with the narrative of STEM as a career and the financial success it may lead to. She stated:

> I am feeling math fatigue from various lenses because of being a parent and a nonprofit executive who is hearing philanthropic spaces begin to talk about math as though it is the end all be all, rather than a conduit toward many beautiful life manifestations" (Mtg_04_02_21_Jayla).

Here, Jayla spoke as both someone who is running a nonprofit and educating Black youth in the community, and also as a parent to Black students and the seemingly conflicted narratives they receive about STEM as a means of achieving success. She talked about both philanthropic spaces creating narratives about STEM as something profitable, but rarely does she see STEM being portrayed by philanthropic spaces as a tool to enrich life beyond finances and gain.

I echoed the previous sentiment expressed by Jayla who was frustrated by salient narratives of STEM from a profitable and capitalistic perspective. I stated,

> "We don't include things like Black Joy [in being successful in STEM], or even just joy period in success. It's like, well, is that going to pay your bills when you're older? No. Is that going to help you be successful in that way, no. So, it's not something we prioritize because it's not something we can- *it's not currency that we think we can use*" (Mtg_03_05_21_Michelle).

I negotiated narratives of success and profitability involving STEM, echoing common beliefs of what STEM can give to successful performers, like financial security and stability. From her perspective, salient narratives about STEM frame STEM as a type of currency, whereas Black Joy is perceived to have less value.

In this section, Jayla and I were speaking to the way STEM and careers involving STEM are positioned as means to financial success. Jayla's frustration stems from the way STEM has been presented to her children as a vehicle for success. However, she was not hearing philanthropic spaces that she occupied framing STEM as intrinsic enjoyment and fulfillment. I added to the sentiment, recognizing success as a type of currency that is viewed as more valuable by society than joy. In her quote, she expressed frustration about Black joy not being prioritized

in STEM spaces because it's not a currency that's perceived as being as useful as students performing well.

Exploiting Student Joy and Resilience

In addition to naming surveillance and compliance as constraints that influence the ways Black Black people and Black youth experience and express Black joy, participants began to think more broadly about the ways that Black joy can be consumed and exploited within a STEM context. The codes 'exploitation of persistence/resilience' and exploitation of joy' emerged from conversations where participants problematized narratives of Black youth and persistence. They noted the burden, sacrifice, and mental load that Black and Brown youth take on in order to exist and thrive in white-dominated spaces, and also the ways that their brilliance and persistence can be exploited to serve purposes besides their joy.

Leah described the conflicting nature of narratives of persistence citing a friend's experience of having her expertise over-utilized and almost expected to solve problems for others. Leah explained how her friend was "tired of being resilient" and "tired of having to always through her brilliance fix the system" (Mtg_02_19_21_Leah). In the same meeting, Jin-Joo theorized better ways to acknowledge the persistence and brilliance of Black youth in STEM spaces besides how well youth navigate and contribute to white-dominated spaces. She expressed a desire for "a different word to honor the labor that Black students have to go through. [...] Oftentimes, it's through celebrating the resiliency of students, right? What are the ways we've normalized celebrating Black joy and then connecting that to being, like *'Oh, because you are resistant- resilient. You have resiliency'* (Mtg_02_19_21_Jin-Joo). Here, Jin-Joo is opening up conversation within the Black Joy Group about reclaiming narratives about Black and Brown youth and their continued persistence in STEM spaces. The Black Joy Group

discussed the shifting of deficit narratives about Black youth and the shifting of perspectives of Black youth as two changes that are essential for framing Black youth, their joy, and in this instance, their resilience, from a perspective that recognizes students' persistence amid anti-Blackness which they navigate in their day-to-day lives.

In this section, the Black Joy Group members further conceptualized the relationship between Black joy and the constraints of Black joy by noting instances where Black youth are not permitted to *own* their own Black joy. Black Joy Group members recognized the transactional relationship between students and education stakeholders regarding their resilience and persistence. They examined this relationship from a STEM context and with Black youth whose resilience is essentially celebrated for surviving whiteness. Leah and Jin-Joo wish to reframe narratives of Black youth that seek to reward how well they withstand anti-Blackness by focusing on the navigational skills they possess, which should be framed as assets.

Finding Three: Reimagined STEM Spaces include Black Joy and Black Finesse

RQ1c: How do participants envision changes in the ways Black students experience STEM, towards broadening joy in STEM?

The third finding from Phase 1 of the study highlights the ways participants envision changes in the way that Black students experience STEM. Many of the discussions about reimagining and re-envisioning STEM spaces that better support Black youth in their learning considered the challenges that Black youth face in white-dominated spaces like STEM classrooms. Continuing to frame STEM as a political system (Bullock, 2019) the Black Joy Group utilized asset-based perspectives such as Anzaldúa's *La Facultad* (1987) and Du Bois' (1903) *Double Consciousness* to frame conversations about shifting narratives of Black youth in STEM spaces to reflect youth's sociopolitical navigation. During two Black Joy Meetings, Jayla presented her work with Black Finesse (Mackey, 2020) as a framework to acknowledge the

agency that Black Youth exercise while navigating STEM spaces. Additionally, the Black Joy Group drew on Black Finesse as a lens to view Black educators like Tasha and Cindy, and how their joy is also negotiated within the socio-political context of schools.

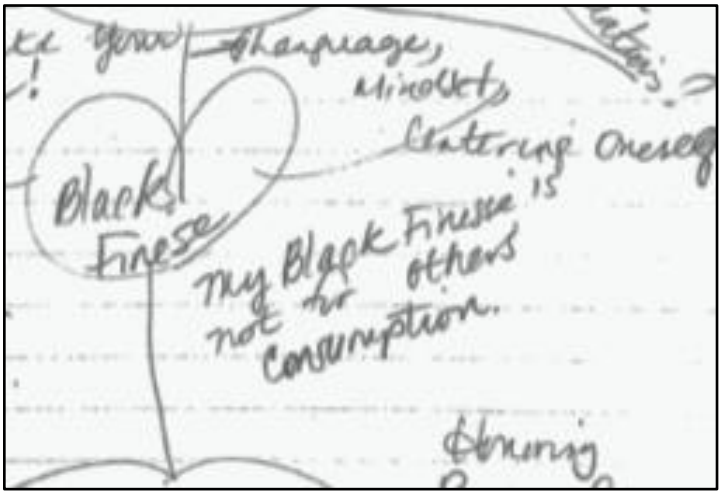
Black Finesse as a tool to Reframing and Reclaim Black Joy

Participants continued to theorize ways to define and reframe Black resiliency through a lens that honors Black youth and their navigation without celebrating or exploiting their persistence. Jin-Joo proposed reframing resilience through Black Finesse (Mackey, 2020), or the psychological negotiations Black people make about showing up in white-dominanted spaces, stating, "Black Finesse, for example. I think that would be really great to replace resiliency" (Mtg_02_19_21_Jin-Joo). Black Finesse (Mackey, 2020) was proposed as a framework to view students' navigation of white-dominated spaces and to replace celebrating their resilience. In a Black Joy Group meeting, Jayla presented her dissertation work about Black Finesse (Mackey, 2020) to help support participants in thinking broadly about Black youth's navigation of STEM spaces.

After this presentation, participants began reframing resilience through this lens. The code 'Black Finesse', and 'shifting perspectives' emerged to describe instances where participants reframed Black experiences. In a body map below, Cindy's embodied noticings show the words *'Black Finesse'* inside a heart drawn over the figure's middle. One of the labels written around the heart reads '*My Black Finesse is not for others' consumption*'.

Figure 4

Cindy's Body Map



Jayla's presentation built on sentiments from previous meetings about 'owning' 'defining' and 'protecting' one's Blackness which later became codes to describe participants' shifting perspectives of Blackness. Jayla's presentation of Black joy allowed participants to think about ways that Black Finesse (Mackey, 2020) may be utilized to support Black youth in protecting their joy as they navigate STEM.

Discussions of reframing narratives about Black youth and their resilience led the Black Joy Group members to think of ways to acknowledge the navigation that Black youth do particularly in white spaces like STEM classrooms. In a previous finding, Jin-Joo and Leah discussed the way Black youth are not allowed to own their own resilience and their persistence in white spaces. seeking to better represent the process of their navigation. Black Finesse (Mackey, 2020) became the lens through which we saw Black youths' resilience and persistence. Although viewing Black youths' navigation through Black Finesse (Mackey, 2020) helped shift deficit narratives of Black youth within the context of the research, ultimately, the Black Joy

Group wanted to extend this asset-based lens to educators and other education stakeholders to view students Black joy, and better support Black youth in expressing their joy in STEM spaces.

Reimagined STEM Spaces Welcome Black Joy and Black Youth as their Whole Selves

The codes 'Wholeness' and 'Manifesting Joy' emerged from instances where participants expressed a hope for future STEM spaces to honor Black students and teachers showing up as their whole selves. When thinking about the way she embodied Black joy and was able to express it through teaching, Cindy talked about the differences in the joy that she felt at school versus at home. She said,

> "How can I, as an educator, bring that [Black joy] into my educational space, you know? To allow kids that? You know, we're in a box in terms of how teaching should look. They put us in a box. You have to pace it. You have to cover this content standard, this way. This has to look this way. At home, I have the freedom to do that. And so, maybe that's why she [her daughter] is where she is... But, how can I bring that to my educational space with students, right?" (Mtg_02_19_21_Cindy).

Cindy detailed the ways that her joy is able to be perceived by the students in her class and her children at home. She also envisioned a future for STEM where she has the freedom to express Black joy in her educational space. She acknowledged that joy is always with her and it is manifested because she's carrying it. Her vision for how students experience STEM is that there is less expectation of what kind of joy gets to show up in classrooms.

Last, Leah created a collage to envision manifesting joy in STEM for Black youth (see Figure 5).

Figure 5

Leah Reimagining Collage

In a meeting, she explained her collage by saying: "That's what to me would be a joyful world-building. I would love to see a system that is created to allow people to be seen for who they are, as is. And then have assessments around that, right? As opposed to something that does not [see students]." To give more context to Leah's collage, she told a story about her experience of attending a public low income oriented folks of color school where a lot of the STEM was happening through farming and just an enjoyment of using your hands and being outside. She then transitioned to a very private high-cost school college, and the natural joy of STEM sort of fell away during that transition. Her vision for future STEM learners are spaces that bring the joy of her early conceptualizations of what joyous STEM was like for her.

The collage and excerpts from Black Joy Meetings presented in this section encapsulate Black Joy Group members' desire to reimagine STEM spaces from an asset-based perspective that better supports Black youth and their joy. In her reimagining, Cindy's quote includes a shift for the way her role as an educator could exist without constraints that do not support her own

Black joy as she teaches her students. Additionally, Leah's collage and quote represent a vision for students and how she reimagines their learning as more holistic and personal because it has ties and connections to their communities and the activities that make them who they are. Overall, these two members of the Black Joy Group reimagined STEM classrooms as spaces that affirm students' and youth's connection to STEM and their purposes for STEM which do not meet traditional expectations of what STEM learning should be in classrooms. Both Cindy and Leah expressed a desire to decenter whiteness in STEM learning and teaching by centering joy.

Phase 1 Findings Summary

The Black Joy Group conceptualized joy as internal and ever-present and different from happiness which they defined as contingent on external or material sources. They recognized joy as an emotion that is able to be experienced by all people; however, participants distinguished joy from Black joy, by defining it as political because of how it can be noticed and interpreted through the white gaze. Viewing STEM as a political system helped the Black Joy Group recognize Black joy as problematic in white space. Due to its political nature, the Black Joy Group understood Black joy to be restrained in white spaces like STEM classrooms, shaping the way Black youth express their joy in STEM learning environments.

Further, Black joy was described as a feeling of being free, and of having no need to prove or conform to the expectations of others, particularly expectations stemming from whiteness and the disproportionate surveillance of Black and Brown bodies. They theorized that the pressure to perform and conform to white expectations can manifest as tension that Black and Brown people hold in their bodies. However, participants noted that the white gaze extends beyond just Black learners and their expression. They understood that Black educators like Tasha and Cindy feel the pressure to teach in ways that meet the expectations of traditional schooling

models, shaping the ways they are able to show up and express themselves in their classrooms, and also shapes their surveillance practices as figures of authority. The conceptualization of the relationship between Black youth, their joy, and surveillance, recognizes an ongoing challenge that Black youth face in schools. Members' understanding of a system that hyper-focuses on Black bodies expressing joy implies that Black learners may hold themselves in tension while learning STEM. This may ultimately affect Black youths' feelings of safety and their comfort level while in STEM classrooms. In response to their surveillance, Black educators and other educators of color may also feel compelled to comply with a surveillance culture that maintains whiteness in spaces like STEM classrooms.

In addition to Whiteness and surveillance, another constraint of Black joy identified by the Black Joy Group is the exploitation of Black joy, persistence, and resiliency. When speaking about Black youth who are able to persist in STEM spaces and outwardly express their joy, participants said these students and their experiences are often diminished by the label resiliency. Participants problematized labeling Black and Brown youth as resilient and diminishing the flair and the psychological negotiations that Black and Brown youth make in their day-to-day navigation of white-dominated spaces. Jayla's presented dissertation work supported participants in viewing Black and Brown youths' navigation of STEM spaces through as Black Finesse (Mackey, 2020); a more nuanced and asset-based framework that more aptly honors and encompasses how Black youth navigate white-dominated spaces. Reframing Black youth's resilience through Black Finesse (Mackey, 2020) allowed the Black Joy Members to view Black youth from an asset-based perspective. This reframing was essential in combating deficit narratives of Black youth who are not successful in STEM in ways that align with white standards of success. This reframing was done in an effort to help Black youth reclaim narratives

about themselves. Additionally, the Black Joy Group framed Black youths' navigation with Black Finesse to protect their joy from being exploited by turning them into success stories about resilience. Celebrating Black youths' resilience in white spaces which may ultimately lead to their success is understood by the Black Joy Group to help perpetuate and uphold white standards that position Black youth in ways that make it more difficult for them to meet those standards.

Lastly, the Black Joy Group theorized ways to manifest joy in STEM spaces by reimagining STEM classrooms to be more inclusive of students' joy and Black youths' Finesse. However, Cindy, a Black mathematics educator, also reimagined classrooms from a teacher's perspective by including her own desire to more genuinely express Black joy by teaching and sharing the joy that she carries with her into her classroom. Leah drew on her own experiences of seeing folks of color learning and doing STEM that involved engagement with the things they did in their everyday lives such as farming and being outside. Leah envisioned joy and STEM as more clearly *seeing* students. To do this, Leah reimagined STEM curricula as including more indigenous and hands-on ways of learning and knowing that focus less on proving and assessing knowledge. Overall, participants envisioned a future for Black educators and Black youth that pushes the boundaries of where joy can go and where it can thrive.

Chapter 4. Findings Phase 2

Introduction

Phase 2 findings focus on the survey responses and collages that Black youth participants utilized to conceptualize STEM, its purposes, and how they reimagine STEM learning and STEM classrooms. The purpose of Phase 2 of the study was to build on the conceptualization of anti-Blackness and Black joy in STEM classrooms for Black youth by the Black Joy Group. After gaining the perspectives of the Black Joy Group which included classroom educators, community educators, and scholars with experience thinking broadly about how youth experience mathematics classrooms, the Black Joy Group wanted to extend their understanding of how Black youth experience STEM classrooms by including the perspectives of Black youth. Phase 2 of the study sought to better understand how Black youth define STEM, use STEM, see themselves in the context of STEM, and lastly, how they reimagine STEM and STEM classrooms for themselves.

The following chapter presents the findings that emerged from phase two of the study through student surveys about STEM and STEM careers, and collages that represent STEM and Black youth from students' own perspectives. This chapter presents sub-findings about students' narratives of STEM including how they defined STEM as a domain, how they define STEM people, and how they believe STEM to be used in various activities and careers. Next, this section will focus on the kinds of experiences students have in STEM classrooms by eliciting their happiest and least happiest memories. Sub-findings in this section reveal the STEM-related experiences, activities, and practices that students describe as positive or negative. Finally, this section describes the ways that students reimagined STEM spaces to be more inclusive of their

personal interests, and of non-traditional learning experiences. The findings present themes that emerged from the following research questions:

2. How did the Black youth both figure and re-author themselves in STEM?
    a. How did students define STEM and its purposes?
    b. How did Black youth experience STEM classrooms?
    c. How did students re-imagine STEM learning and STEM classrooms?

Finding One: Students conceptualized STEM and STEM People in Traditional and Non-Traditional Contexts.

RQ2a) How do students define STEM and its purposes?

Students Define STEM by Traditional and Nontraditional STEM Domains and Careers

In a survey soliciting Black youth's perspectives of STEM and their experiences in STEM classrooms, students were first asked to describe STEM. The code 'traditional STEM domains' was used to describe instances where students explicitly defined STEM as either science, technology, mathematics, or engineering. For the survey prompt '*What does STEM look like to you?*', 25% of students (7 out of 27 students) described STEM as either science, technology, engineering, or mathematics. For example, one student from Tasha's classroom responded to prompt, writing: "STEM stands for science, technology, engineering, and mathematics, basically all subjects" (TResponse 8), while another student described STEM as "Science - making science; Engineering- putting stuff together" (TResponse 7). Similarly, for the prompt, '*What kinds of activities do people do that involve STEM?*' 7% of students answered with traditional STEM practices and activities such as doing science projects and experiments (Dorph et al., 2018).

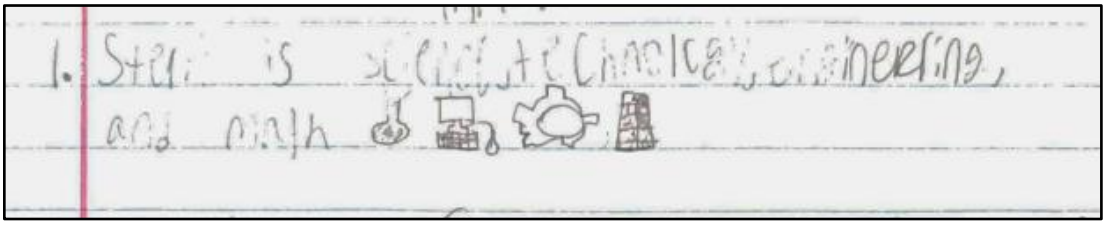
Although 25% of Black youth in this study recognized STEM as an acronym representing science, technology, engineering, and mathematics, 11% of student participants said STEM

encompasses other domains or a combination of both traditional and nontraditional domains, and 29% listed nontraditional STEM practices and activities. This finding coincides with Dorph et al., (2018), who found that students identified scientific pursuits as elements of STEM-related careers, citing careers like astrophysicists who engage in activities such as "coming up with genius theories" and "looking at telescopes" (p. 1035). Similarly, when asked to describe the activities that people do that involve STEM, one student in this study responded by describing activities that involve STEM, writing, "Dissect animals, break down math problems, forensic scientists, microbiologists, account, banking" (CResponse 3). Meanwhile, students from Tasha's class answered, "You can use math to really get around. To count money" (TResponse6) and "People work, they go to school, they build stuff, they play sports. All of them require STEM" (TResponse12). Though a quarter of Black youth in this study identified traditional STEM domains, a larger percent of students (29%) understood STEM to encompass activities and practices that are viewed as less traditional domains of STEM like forensics, playing sports, and using STEM to build things. Activities such as these are often less prevalent in middle and high school STEM curriculum (Spencer, 2006). For these students in a predominately Black school, STEM encompasses more than the kinds of STEM that is most typically offered to them in a schooling context.

Also included in some student responses were visual representations of what STEM looks like to them and activities people do that involve STEM. A student from Cindy's classroom answered, "STEM is science, technology, engineering, and math" and included a visual representation that included sketches of a beaker, a bunsen burner, a wheel, and a number chart (See figure 6).

Figure 6

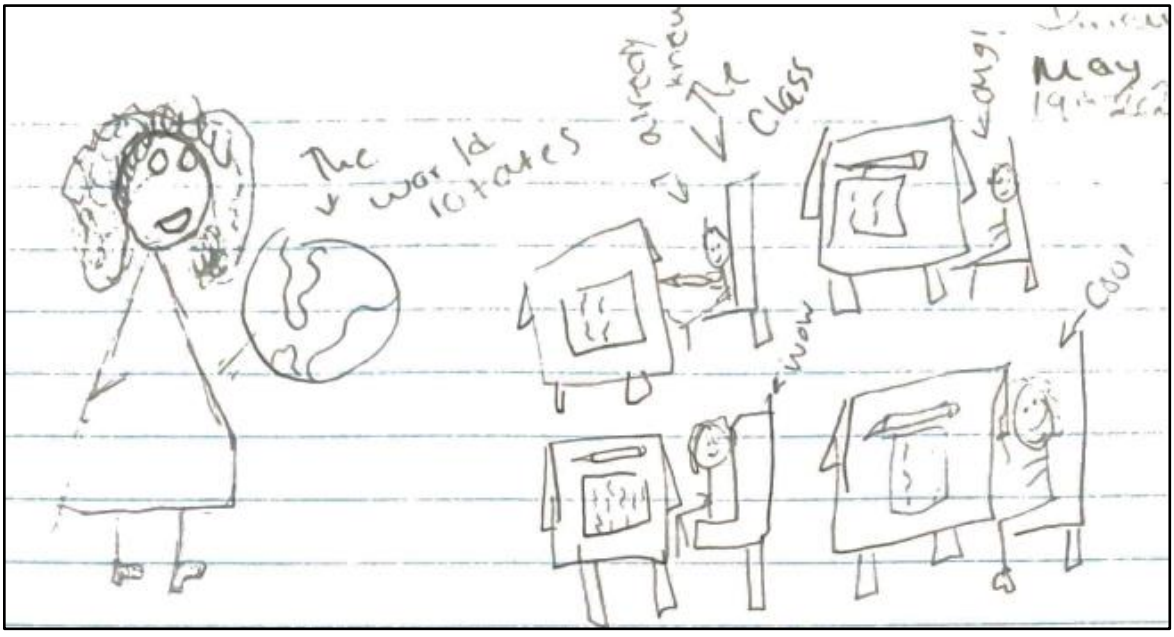
Student Representation of STEM



Another student used the top portion of their paper to illustrate a STEM classroom (see figure 7). The drawing features a teacher wearing a dress and standing at the front of the classroom holding a globe. The teacher is speaking to a classroom of four students while explaining how the Earth rotates, saying “The world rotates”. The students sit at desks with paper and pencils while looking at the teacher and saying things like "Cool", "Wow", "OMG", and "I already knew".

Figure 7

Student Representation of a STEM Classroom



Although this particular student did not define STEM as including science, they depict what someone might see in a traditional science classroom that is learning about the solar system. Connecting this student's response to previous student responses where 25% of Black youth identified traditional STEM domains, it is important to consider how more traditional STEM curricula like a teacher-led lesson about the solar system is more likely to be experienced in Black and Brown schools (Spencer, 2006). Scholars have found that identity plays a large role in how Black students view themselves in STEM (Davis, 2014; Dumas & Nelson, 2016; King & Pringle, 2018; Flowers & Banda, 2019; Garibay & Teasdale, 2019; Wade-Jaimes, King, & Schwartz, 2021. Black youth responses to the survey questions "*What does STEM look like to you?"* and *"What kinds of activities do people do that involve STEM?"* reflected their perspectives of STEM and how it is used. Student responses to the survey questions reflect a more functional view of STEM.

Students Reimagine STEM To Represent Their Interests And Passions

Student participants from both classrooms also created collages to represent and reimagine STEM, and to represent themselves within STEM (see figure 8). One student created a collage with images that were taken from books and magazines. The collage represented the words '*Get Happy!*' along with cartoon images of people of color working in a laboratory, a Black girl holding a pillow, a machine that creates and dispenses pizzas, an iPhone depicting a slice of pizza, a white boy eating a slice of pizza, a bar graph, and a pie chart. The student in this study represented different STEM domains through photos chosen for her collage. Accompanying the student's collage is a written description of the collage and the items that were chosen to represent and reimagine STEM. Most notably, the student included examples of how STEM is utilized in each domain. The student wrote: *"Science: I like to analyze and make*

different chemicals. Math: I somewhat like to measure things. I like to sleep. Sometimes you have to know how long you slept. Tech: I like technology and pizza, you have to divide it into 8 slices. Graphing/Percentages: I like graphing things and make a chart"

Figure 8

Student STEM Collage

In this collage the student included pictures that represent each letter of the STEM acronym except engineering. The above collage the Black creator includes herself among the different ways that STEM shows up in the activities that she likes. In addition to including herself as a Black girl on her STEM collage, she also included a Black male scientist. Some of the vocabulary used in her description are words associated with mathematics like measuring, dividing, and the creation of graphs. This student's representation of what STEM is includes mostly traditional STEM domains, however the student is using it in formal and informal

capacities ranging from exploring science through chemicals, and using math to measure the amount of sleep she is getting.

From Tasha's classroom, a student's collage included pictures and words from magazines and an art book. (See figure 9.) However, in her description of her baking collage, she was unsure how exactly STEM is utilized in the activity, reflecting the findings of Dolph et al., (2018) whose participants were not always sure *how* STEM related to various careers. The collage includes the word "MATH" along with a photograph of a painting, paint brushes, a cartoon cupcake, and a piece of graphing paper. During my classroom visit, I asked the student to tell me about their collage and what it shows about the future of STEM. Below is a conversation that transpired.

Researcher: "Tell me about your collage. What does it show about the future of STEM?

Student: "Sometimes I watch baking shows and I try to bake. That's math, right?"

Researcher: "Yeah, baking involves lots of math, and science too. What about the rest of your collage how is it related to STEM?"

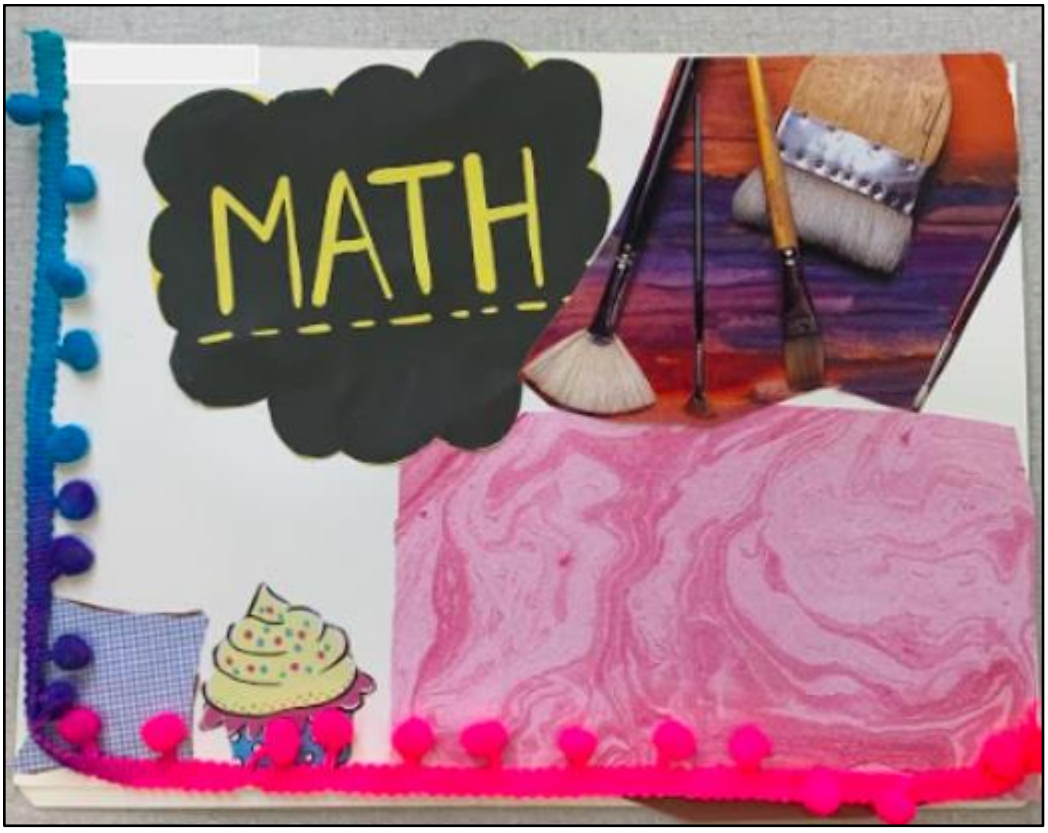
*Student: "I like art and math too." *Points at paintbrushes and MATH on collage* "I draw and make animes at home."*

Researcher: "Oh, wow. That's really cool. How do you think making animes is related to STEM?

*Student: *shrugs*" It's not."*

Figure 9

Student STEM and Interests Collage



The above 'Math' collage and description of it by the student is evidence that the student understands how mathematics is connected with her interests like baking (King & Pringle, 2018; Garibay & Teasdale, 2019; Wade-Jaimes, King, & Schwartz, 2021). However, also in her description, she is not sure how exactly mathematics is applied to something like animation. In our brief conversation, the student seemed excited to tell me about her interests that include math. The above collages represent two Black girls' representations of STEM and its relation to themselves and to their interests. In both collages, STEM is represented in both traditional and non-traditional domains with the first collage naming specific activities like diving pizza using either science, technology, and mathematics. She did not include an activity for engineering

which may reflect a disinterest in the subject or less access to the subject. Meanwhile, the second collage includes more personal STEM-related interests, however she is not completely sure about the type of STEM used. When describing an interest that she enjoys like baking, the student identifies a traditional STEM domain (mathematics) as potentially being related, however not included is baking as a chemical process or the architectural design that some bakers utilize to present their products. Although baking includes many aspects of STEM, it is notable that the student did not include a photo of herself as a baker in her representation of it.

Student Narratives of STEM People

The survey that student participants completed also included the question '*Who belongs in STEM and why?*, which was developed in part by the Black Joy Group to understand how race and gender are constructed within STEM narratives from Black students' perspectives. From students' responses, STEM is mostly used formally in schools and in places of work, by teachers and professionals.

When describing the types of people that belong in STEM, 14% of students referred to teachers. For example, one student described two roles that involve using STEM and also where these two types of people work, writing: "Teachers and scientists, they work at school buildings and labs" (CResponse 6). Another student wrote, "teachers and college students" (TResponse 8), indicating that STEM people are located in schools or universities. The students' perspectives mirror those found in Verdin, Godwin, and Ross (2018)'s study of STEM ontologies of students which found that students' access to different types of STEM shapes their perception of who can be STEM people, or "the type of person who is engaged in these subjects" (Verdin, Godwin & Ross, 2018, p.17).

It was also the case that Black youth in this study cited older age as a characteristic of being a STEM person. In their conceptualizations of STEM people, 11% of students considered the age of people who are considered to be belonging to STEM with students envisioning STEM people as much older than themselves. One student described people who belong in STEM as "mid 20s and they all have good jobs (CResponse 5)". Another student responded, "Teachers. Are usually 35 with old wrinkles (CResponse 7)". While some students conceptualized STEM people as adults holding roles in schools and labs, fewer students also factored race into their responses,', with only 7% of students mentioned race or Black people. A student from Cindy's class named their father as a STEM person and stated his race. They wrote: "My dad works with money as a manager. Black. I don't know his age" (CResponse 2). In previous responses from Black youth, opportunities to connect formal STEM and informal STEM shaped the types of activities that they identified as related to STEM. However, when responding to the types of people who do STEM, access may also play a factor in who Black youth see most often representing members from the STEM community. Similarly to the way Black youth identified traditional STEM domains that they have the most access through curricula and schools, Black youth may also perceive STEM people as they are represented most frequently in media and in STEM spaces, as heteronormative, white males.

In addition to age and race, Black youth described other factors that impact belonging in STEM. Verdin, Godwin, and Ross (2018) found that their students made a distinction between certain kinds of STEM, finding the most rigorous subjects like engineering to be the least accessible, or not for everyone. When asked *'Who belongs in STEM and why?'*, some Black youth expressed similar views, stating their uncertainty that everyone belongs in STEM. For example, one student mentioned race in their conceptualization of STEM people, while also

stating their opinion that maybe not *all* people of *all* colors could belong in STEM. They write: "I'm not sure everybody could belong, all colors, all people; math classrooms, nurses, CNA's" (CResponse 1). Another student answered, "I don't know but not me" (CResponse3). Some Black youth's perspectives differed from a conditional response to the question *'Who belongs in STEM and why?*'. Though most students did not explicitly mention age, race, or access in their conceptualizations of who belongs in STEM, 18% of students' responses indicated belonging in STEM to be unconditional, responding: "Everyone belongs as long as they put in the effort (TResponse 10), and "Anybody belongs in STEM if they want to" (TResponse 3). Continuing to connect previous responses from Black youth regarding the race of STEM people, responses to the question 'Who belongs in STEM and why?' reflect the perception that STEM is not inclusive of everyone. Who students most frequently see in professions and roles involving STEM depends on the access they have to various STEM fields, and also who they most frequently see being nurses and other STEM professionals.

In the above excerpts from student surveys, students show an awareness of narratives of belonging within STEM when thinking about who belongs in STEM spaces. The Black youth in the study describe STEM people as older (Dorph et al., 2018) and having careers where the majority of the workforce is white. This creates a divide between Black youth and the people they most consider to be STEM people. From this perspective, a STEM person is someone separate from Black youth. A STEM person is someone they, or likely white youth, have to 'become', not someone that they actively are as STEM learners.

Finding Two: Black Youth also feel the constraints of Black joy in STEM Classrooms

RQ2b) How do Black youth experience STEM classrooms?

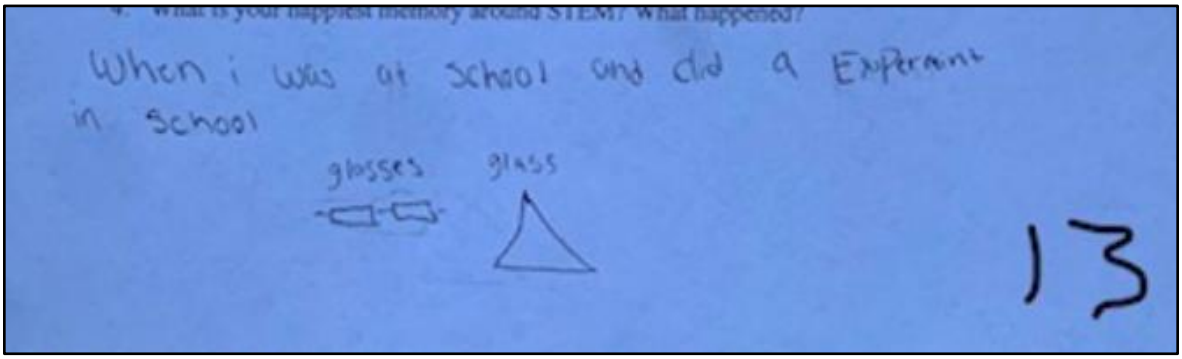
Students Feel Happiness While Engaging With Joyous STEM

Joyous STEM has been found to include instances where students feel engaged, connected, and maintain a sustained interest in STEM learning through their experiences with STEM learning (Seymour & Hewitt, 1997; Harper, Weston & Seymour, 2019). The fourth and fifth question in the survey that Black youth completed invited them to describe their happiest and least happiest memories around STEM. The Black Joy Group co-constructed these two prompts to better understand how Black youth experience STEM classrooms and the feelings and emotions associated with their experiences. The Black Joy Group also designed these two questions to better understand when Black STEM learners are experiencing joy. Out of 27 surveys, 33% students said they did not have a happiest memory around STEM. Although this could be interpreted as the students' memories being generally *unhappy*, their responses could also indicate neutrality about STEM as a subject and as a personal interest. Students' responses could also be interpreted as a limited opportunity to engage in STEM that they view as joyful. Studies have shown that schools that are predominantly non-white or working and middle class are less likely to receive instruction that encourages creative engagement (Anyon, 1997; Anyon, 1981). 29% of answers for the survey question, '*What is your happiest memory around STEM?',* consisted of activities students did in school that were hands-on like completing projects and doing science experiments. For example, a student in Tasha's classroom reported their happiest STEM memory as 'Something that happened in science class. We did a chemical science experiment" (TResponse 8). While another student said their happiest STEM memory was their 5th grade science project, stating "My happiest memory around STEM is my 5th grade science project. I seen if food coloring move faster in hot or cold water" (TResponse 11). A third student described and then illustrated their happiest memory as doing an experiment involving safety

glasses and a glass beaker, writing, “when I was at school and did a experiment in school”, and then sketching and labeling a pair of glasses and a glass (see figure 10). Consistent with findings from Anyon (1981; 1997), Black youth express having associated their happiest memories with opportunities to engage in STEM likely presented through less traditional instruction methods.

Figure 10

Student Illustration of Lab Experiment



Further, 11% of the students who described their happiest STEM memory expressed positive emotions they felt about STEM such as moments where they were having fun or felt happy. Student responses align with responses found by Basu and Barton (2007) who noted the positive association students have to meaningful activities such as hands-on experiments and field trips, or, what one student described overall as ‘‘fun activities’’. Another youth responded, “I was in engineering class and we were doing projects and it was fun” (TResponse 12). Similarly, two students from Cindy’s classroom reported feeling great and feeling happy while engaged in STEM activities, writing, “I felt great counting and adding money” (CResponse 6), and “Science Fair- Happy” (CResponse 2). Aligned with Davis (2014), responses to the survey prompt *“What is your happiest memory around STEM?*”, resulted in students identifying memories of STEM participation they consider fun. Davis (2014) found that students disliked instances where they felt bored in their classrooms. Similarly, responses from Black youth such as doing experiments

with food coloring or using science equipment make up experiences for youth that brought them happiness while learning. While 29% of the students surveyed provided a happiest memory and reported having fun in those moments, it is important to consider what this means for the 33% of the students who reported *not* having a happiest STEM memory, especially when each of those students completed a collage where they identified STEM subjects and activities in which they use STEM. From their lack of a response regarding a *happiest* STEM memory, it could be interpreted that Black youth do not consider the types of STEM they have experienced so far as happy or joyful.

In addition to associating their happiest STEM memory with hands-on activities and experiments mostly involving science, 7% of students also included memories in which they received praise or felt successful while doing STEM or answering questions about STEM subjects. For example, a student from Cindy's classroom reported feeling happiest in a STEM context when they received a high score on a test. The student writes, “When I got the highest score out the whole class on a math assessment” (CResponse 3). Another student described their happiest STEM moment as answering questions that were leading them towards the correct answer when prompted by their teacher. The student writes: “Being in math class, I was on the right track when Ms. T kept asking me questions about y = mx+b” (CResponse 14). Aligned with Wade-Jaimes et al’s., (2021) definition of what makes a successful STEM student, Black youth in this study identified moments where they were being ‘good students’ like answering questions correctly and achieving high scores on assessments.

The survey question, what is your least happiest memory around STEM, was co-constructed and designed by the Black joy group to better understand STEM experiences where students are not experiencing joy. In response to this prompt, 29% of students identified their

least happiest memory involving STEM as pertaining to doing math or science, with mathematics being mentioned most frequently. In response to the question, *'What is your least happiest memory around STEM?',* one student described their least happiest memory, writing "Math. I really don't like it" (TResponse 13). Another student responded, "I don't like doing math a lot" (CResponse 8). Other responses to the survey revealed that 11% of students' least happy memories in STEM classrooms involved tests or assessments. These students identified specific tests that they disliked taking including the NWEA math test (CResponse 2) and the PSAT (CResponse 7). Additionally, 11% students reported feeling bored (TResponse 3) or "drained" (TResponse 12) by the overall experience of being in school. 7% of students described school-related grievances that directly contribute to their unhappiness in STEM classrooms, citing "When the teacher gives us a lot of work" (CResponse 12), and "When something bad happen and you can't go outside no more" (TResponse 1). 25% of the students surveyed reported not having a least happiest memory in STEM. Students' attitudes towards non-engaging STEM reflects findings from Anyon (1981;1997) and Basu and Barton (2007) who find students to be less engaged with traditional instruction methods. Similarly, students' responses aligned with the findings from Davis (2014) that frame student happiness in STEM classrooms as dependent on how engaging they find their learning. Students in this study responded similarly to the prompt "*What is your least happiest memory around STEM?*". Black youth most frequently described classroom practices like doing work and taking assessments unfavorably. Because students cited their happiest memories as doing more hands-on activities like experiments, the Black youth in this study show a desire to move away from classroom practices that are not engaging. Considering the way the Black Joy Group from Phase 1 of the study expressed a desire to express and celebrate joy in their classrooms. Harper, Weston, and Seymour (2019) find that

students are more engaged and connected with the STEM they are learning when their instructors show joy and excitement about the subjects they teach. This can have implications for Black youth in this study who desire less traditional STEM instruction as well as their Black educators who express a desire for their classrooms to be more inviting, welcoming, and celebratory of their joy as teachers.

This section discussed the ways that Black youth associated happiness in STEM education with fun, engaging learning experiences, such as hands-on activities and experiments. On the other hand, students associated negative experiences in STEM education with classroom practices that were unengaging and boring, such as doing work and taking assessments. These findings are aligned with previous research that emphasizes the importance of engagement in STEM education for student happiness. Furthermore, the study shows that Black youth's definitions of a successful STEM student align with traditional views of a "good student" as knowledgeable, quiet, and focused. However, Black youth in the study indicated a desire to move away from unengaging classroom practices towards more engaging, hands-on experiences to improve their learning experiences, which is also consistent with other research (Anyon, 1981;1997; Harper, Weston & Seymour; 2019).

Finding Three: Students Reimagine STEM Learning That is Student and Interest-Centered

RQ2c: How do students re-imagine STEM learning and STEM classrooms?

STEM Learning That Centers Black Youths' Interests

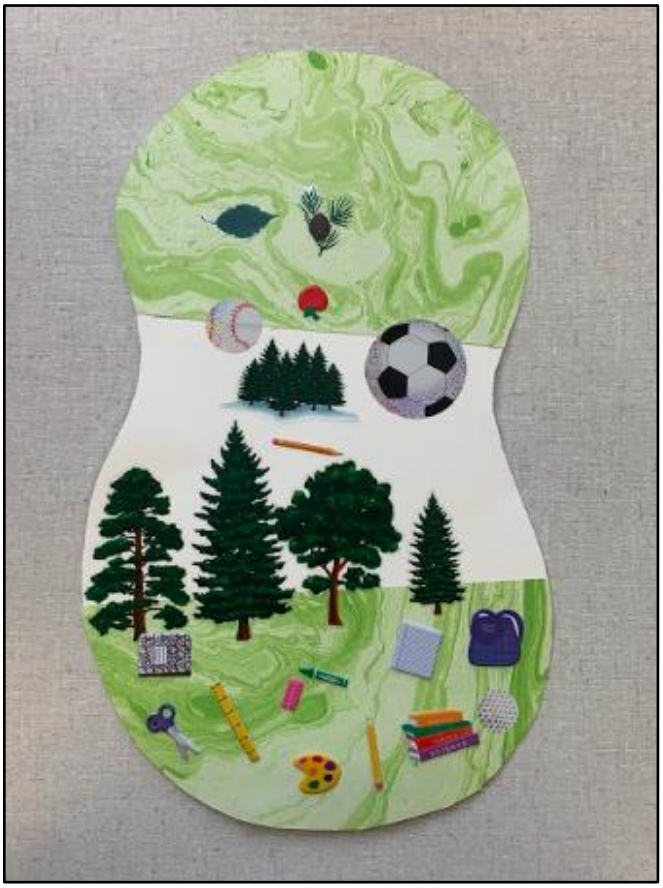
The following results are supported by Basu's (2007) findings that students envision STEM as more than just careers despite salient narratives in schools that frame the purposes of STEM learning as a means of securing a STEM career.

Student surveys and collages indicated that mathematics students hope for a more diverse and interactive learning experience in STEM classrooms in the future. Out of all survey respondents, 14% mentioned the desire for more outdoor and nature-based learning, while 51% of students described their personal interests as a potential element of STEM curricula. For example, at the end of the survey when students were invited to write freely if they had more to add about their perspective of STEM, a student revealed a desire to be in nature when describing things that brought them personal joy, writing, "Joy is going on a walk on a nice day. I like walks, climbing trees, and discovering new things" (CResponse 4). From Tasha's classroom, one student's collage includes a green background and stickers of trees and the forest (see figure 11). Also included in the collage are school supplies like books, paper, pencil, and a backpack. Additionally, the student included a soccer ball, a baseball, and a golf ball. During my classroom visit, I asked the student to tell me about their collage and what it shows about the future of STEM. Below is an excerpt of the conversation that transpired.

> *Researcher: Tell me about your collage. What does it show about the future of STEM?*
>
> *Student: *points at trees* This is for biology… science. *Points at other stickers* this is stuff I wish math teachers did with us. Like going outside or doing something fun.*

Figure 11

Student STEM Collage "Going outside or doing something fun"



From the students' description, they would like STEM to be reimagined to include things that they consider fun like being outdoors and incorporating physical activities like sports. This student also recognizes that STEM, and more specifically biology, can be learned in a non-traditional classroom environment outside of the school.

Previous responses and collages from students have indicated their associations with STEM to be closely linked with the STEM they engage in at school. Students also associated STEM with activities they enjoy doing outside of a schooling context. The above collage aligns with previous responses indicates students' desire to engage in STEM learning and non-

traditional contexts. Also notable from the above collage is a desire to engage in still learning that is also joyful and includes interests that bring the student joy. Building on findings that support students building a stronger STEM identity through engaging and fun experiences (Davis, 2014; Basu & Barton, 2007), the above responses and collage reflect student desire to engage with STEM more authentically and holistically. In their responses, Black youth connected STEM to joy, listing being outdoors and exploring in nature as potential sites for STEM learning. In the description of his collage, Tasha's student included not only trees to represent science, and also sports stickers representing activities that he wished his teachers did with him. In his collage, STEM is accessible when it is presented through lanes of access he already has his enjoyment of sports and the outdoors.

Additionally, students expressed a desire for a broader range of STEM domains to be covered in their classes, including topics such as computer science and engineering. One student created a collage which features a photo of an astronaut on the moon, a ferris wheel, satellite in space, the Eiffel Tower, and a row of numbers lining the side of their paper (see figure 12). When asked to describe the collage and what it shows about the future of STEM the student responded: "[points at picture of eiffel tower] This is the Eiffel tower and that represents engineering and cool architects. And then there's this thing that you see at fairs [Ferris Wheel]. That's the same thing [engineering] and, like science. The space pictures are [science] too, but in the future. I'd like to do that. There's also math in all of it, so I put a number scale on the side."

Figure 12

Student STEM Collage "Engineering and cool architects"

In the above collage, Tasha's student described a future of STEM that includes futuristic architecture, engineering, and technology advances based on structures that the student already admires. In his description of his collage, this student showed an interest in ferris wheels, revealing that he has seen them before at fairs where he may have developed an interest in engineering. For this student, the future includes more of his interests and potential to expand our knowledge of them Weil (1954).

While Tasha's student envisioned the future of STEM to be more inclusive of their interests in architecture and engineering, students in Cindy's class created collages that reimagined STEM that incorporated their interests, they also reimagined STEM as a tool for addressing world issues such as pollution. In the collage below, a student included futuristic

depictions of vehicles, American football helmets, an apartment building, and the cartoon of an indoor aquarium with trash and plastic inside the tank along with the fish (see figure 13). The student provided a description of the collage writing, *1) In the future I would like to build cars, 2) Football is my second favorite sport, 3) I would like to build house like one in the picture, and 4) all bad thing in fish habitats that are hurting and killing the fish* (see Figure 13.2).

This student's collage and their collage description reflects their STEM-related interests which includes mechanics, sports, and architecture. However, their collage also reflects their awareness of climate issues like pollution. Similar to how the Black Joy Group held both/and sentiments in their conceptualization of Black joy expressed in STEM spaces, this student's collage reflects a both/and element of STEM being useful in the future in more than one way.

Figure 13

Student STEM Collage "In the future I would like to build cars"

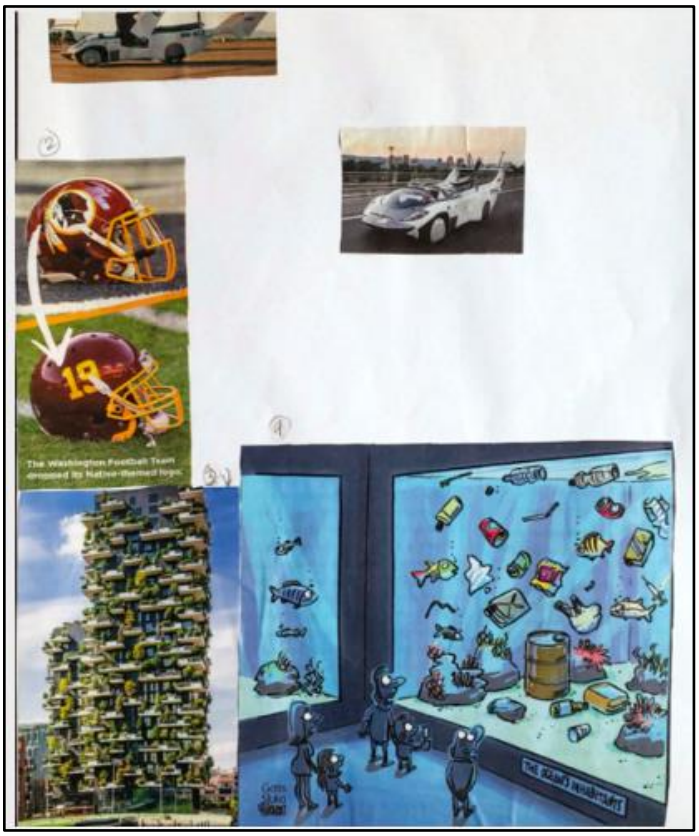
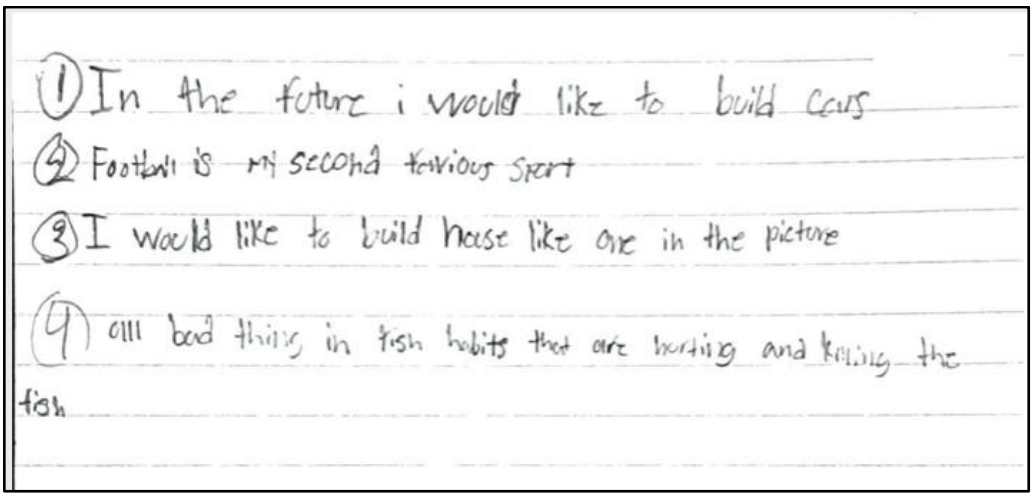


Figure 13.2

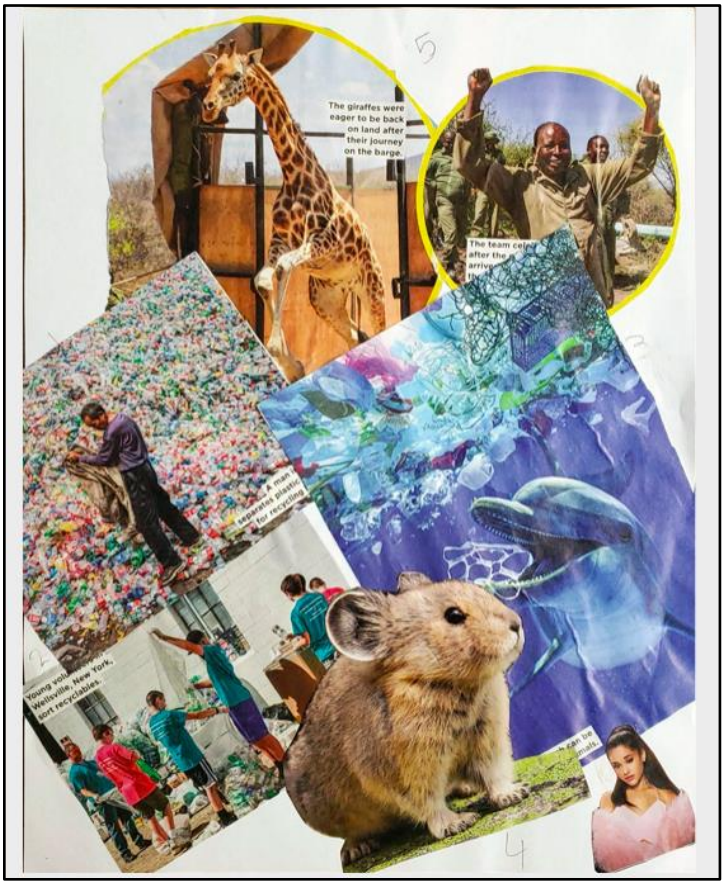
Student's description of STEM collage



Lastly, a student from Cindy's classroom uses their collage to represent nature by adding a giraffe, a hamster, and a dolphin. However, they also included pictures of plastic rings alongside the dolphin like plastic rings and trash in a body of water while a person attempts to clean it (see figure 14). In the bottom left is a picture of young people organizing or volunteering. In the description accompanying the collage, the student only addressed the parts of the collage dealing with pollution color stating "I felt bad cuz all that trash for the animals and people".

Figure 14

Student STEM Collage: "I felt bad cuz all that trash for the animals and people"



From this students' reimagining of the future of STEM, they seem to be representing issues that may arise in the future that STEM could be used to solve issues like preserving the Earth for animals and people who live on it. Both students conceptualized the solving of issues depicted in the collages as something that includes humans and the combined organizing and activism that it would take people to come up with solutions.

Similarly, the students from Tasha and Cindy's classrooms identified issues in their world such as littering and pollution. These students expressed concern for animals, people, and their habitats. Their collages and descriptions were aligned with the findings of Basu and Barton

(2007) who understand Black youth's perceptions of the future to include STEM as more than just a potential career path.

Finding Three: Students Negotiate and Reauthor STEM Narratives Over Time
RQ2: How did the Black youth both figure and re-author themselves in STEM?

Though phase 2 of the study aimed to support students in reauthoring STEM narratives, findings from student collages and survey responses, and also perspectives offered from members of the Black Joy Group reveal that the process of negotiating and reauthoring STEM identities happens over time and through positive STEM experiences.

Student Neutrality to Emotional STEM

When asked, "*When you hear the word STEM how does it make you feel?*" student responses reflected both willingness and pushback to the question linking emotions to STEM. Only 18% of the 27 students surveyed responded to the question by describing emotions or feelings. For example, a student from Tasha's class responded, "I feel *hype* and *joyful* because I can do hands-on things" (TResponse3). Meanwhile a student from Cindy's classroom wrote "It *don't feel good* because I don't like it personally" (CResponse10). However, almost 60% of students surveyed either did not write a response to the question or wrote that STEM did not make them *feel* anything. For example, a student from Cindy's classroom wrote, "STEM does not make me feel any type. I'm not into *that kind of stuff*" (CResponse9). Meanwhile, two students from Tasha's classroom responded, "It doesn't make me feel some type of a way, it's just another word to me" (TResonse8), and "Nothing. It makes me feel like I'm in class" (TResponse11).

One of the goals of the Black Joy Group was to create character spaces for conceptualizing Black joy and STEM for Black youth in a holistic way which included embodied learning. Because students were being surveyed about their experiences with STEM in a STEM classroom, some of the neutrality in responses aligns with findings from Ahmed (2014) who

describes STEM as having a reputation for being a positivist and therefore, *emotionless* field. Some students reflected on their STEM experiences enough to identify feelings they have in relation to hearing the word STEM, while other students seemed less comfortable doing so.

Additionally, Black youth seemed to keep some level or degree of distance between themselves and their collages where they were invited to include themselves in their representations of STEM and STEM people. Only 26% of students (7 out of 27) included either a photo to represent themselves as a STEM person or photos of other people that might represent STEM. The remaining students did not include people in their collages. Students' responses and lack of responses could be attributed to studies that find youths' STEM development and meaningful STEM community membership to be contingent on positive STEM experiences and relationships with other members of STEM communities. Another possible interpretation could be students' comfort level with expressing and speaking up about emotions regarding STEM in a space where they are surveilled.

Reauthoring As An Emotional And Self-Reflective Process

Despite design intentions to reauthor with both sets of participants reauthoring conversations mostly took place in phase one of the study with the Black Joy Group members. Conversations included instances where members of the Black Joy Group had the opportunity to negotiate their identity through positive STEM experiences. Consistent with studies that find STEM identities to be shaped by experiences and relationships within STEM communities (Carlone & Johnson, 2007), Leah cited her participation on her high school's Stream Team as a moment of happiness and reauthoring because it was an experience that allowed her to enjoy science again. Similarly, Tasha reflected on her process of reauthoring her own STEM identity through her perseverance in an engineering course which she described as a moment of immense

pride. As a member of the Black Joy Group, I reflected on my beginning years as a classroom teacher supporting students in learning mathematics as a moment of reauthoring from a time where I did not consider myself to be good at mathematics.

In each of these instances, reauthoring is seen as a self-reflective process (Staples, 2008) that allowed each of us to renegotiate our identities as STEM people over time and through experiences that provided us the opportunity to do so. Graven (2012) understands reauthoring as being given increased agency. From this perspective, members of the Black Joy Group who identify as STEM people in some capacity, have been given the time and opportunities to exercise their agency in negotiating their identities. Though many of Black youth who participated in the study drew connections between the STEM they learn in schools and the STEM they enjoy doing through their own interests, passive responses and collages that do not include themselves as STEM people may be indicative of Black youth not having the time and agency yet to do the self-reflection and engage with them in positive meaningful ways to reauthor.

Phase 2 Findings Summary

Black youth's access to STEM and opportunities to engage in meaningful and joyful STEM is essential to Black youth's ability to connect with STEM outside of school contexts. Also, Black youth's STEM access is essential in supporting Black youth in *seeing* themselves as members of STEM. Dorph et al. (2018) found students to mostly identify typical STEM careers when surveyed which they posit could be a reflection of the types of STEM students have knowledge of and dominant narratives of more rigorous STEM subjects like engineering which may discourage students from participating in them. Black youth in Tasha and Cindy's classes recognized STEM as involving science, technology, mathematics, and engineering. Black youth

also recognized STEM as other subjects and fields like forensics and creating architecture. Students also saw STEM in other more functional activities like building things and doing school work. They most frequently represented STEM with items they most associated with doing science experiments and solving mathematics problems. Examples of drawings included beakers, safety glasses, number charts, and a traditional STEM classroom during a science lesson about the solar system. Students' personal interests were also represented in their conceptualization of STEM and its purposes. For example, student collages included items like sports balls, pizza, and art materials which students reported enjoying outside of school.

Previous research shows that students see individuals who do STEM and use STEM in their everyday lives as professionals or in a schooling context. Students define STEM similarly as science, technology, engineering, and mathematics. Students conceptualized 'STEM people' as individuals who do or use STEM as part of their daily lives or professions. Professions that students mostly associated with STEM people were teachers and scientists, however, survey responses ranged from bankers to CNAs. Typically, students did not consider race in their conceptualization of STEM people, however, they did more frequently include the age of who they believed to be STEM people and white-dominated professions. The students who considered age viewed STEM people as adults. There were also students who believed that neither age or race was a factor in who belongs in STEM, stating that anyone or everyone can be someone who belongs in STEM. Black youth's perspective of who mostly fits the description of a STEM person (older, professional, and sometimes race-determined) did not necessarily align with how they might describe themselves. Continuing to frame student responses with findings from Dorph et al. (2018), it is important to consider how students' opportunities to participate in STEM and see non-professional STEM people shapes students' participation as legitimate.

When prompted for their happiest STEM memories, some students described moments where they described feeling happy or had fun. Students described their happiest memories around STEM as involving an activity, project, or experiment done in school. Students mentioned participating in science experiments, science projects, and even a science fair most often. Student responses mirror with previous research (Dorph et al., 2018) that finds students reported more favorably about STEM learning experiences that they enjoy and that are engaging. Other students described their happiest memories in STEM to be moments where they felt successful in STEM, like earning a high score on an assessment or answering questions correctly. When prompted for their least happiest STEM memories, students most frequently described moments that involved mathematics. Students cited other moments in classrooms that were their least happiest memories like being given too much work, having to take assessments, or being restricted from going outside due to class behavior. Student responses highlight tension between the way Black youth would like to learn STEM and how it is mostly offered in their schools. Black youth's reports of feeling least happy when engaging in routine class practices opens conversations about how students can feel best supported in their learning and their participation in STEM through activities that more align with their learning preferences.

Black youth responses for how they reimagine STEM classrooms in the future are framed by findings from Basu and Barton (2007) who found students' reimaginings of the future in relation to STEM to involve more than potential careers. Black youth reimagined STEM classrooms in the future to include learning that incorporates their personal interests. Students' collages featured trees and scenes from nature, with some students describing a love for the outdoors. Also, students reimagine STEM spaces that included their interests and topics they want to know more about. For example, student collages included futuristic vehicles, buildings,

and technology. Students' collages also included their interest in STEM to include addressing pollution and animal conservation. In alignment with Brussels and Barton (2007), Black youth reimagined STEM in the future to include themselves and possible solutions to issues they see in the present day. For example, students from Tasha and Cindy's classes included images of pollution and climate change in their future imaginings of STEM.

Face to findings mostly included responses from the student participants in the study. However, it was important to acknowledge the lack of responses from some students in regards to questions that asked youth to deeply reflect on their STEM experiences or questions that ask them to think about their emotions as they relate to STEM. Although many students answered survey questions concerning emotions, responding that they felt happiness, joy, and also frustration with STEM, some students declined to answer, or revealed that they do not have feelings in relation to STEM. Because STEM is often viewed as neutral, apolitical (Gutstein, 2006), and emotionless (Ahmed, 2014), students' hesitant to respond to emotional based questions could be linked to neutrality associated with traditional STEM domains. Another possibility is whiteness and still classrooms and surveillance culture impacting students' comfort level to openly discuss their emotions in relation to STEM.

Finally, reauthoring conversations mostly took place with the Black Joy Group members who had time and agency to reflect on past experiences involving STEM and their STEM development. In doing this, members of the Black Joy Group identified moments where a positive STEM experience was transformative in how they view themselves as STEM learners. Although the Black Joy Group intended to do a similar reflection process to reauthor with Black youth, there was not enough time in the study for all Black youth to feel comfortable reflecting on STEM experiences and the emotions associated with them.

Chapter 5. Discussion

Black Joy Group

This study was driven by a desire to gain a deeper understanding of the emotions and experiences of Black youth as they navigate STEM spaces, which have historically been unwelcoming and difficult for them to thrive in. The Black Joy Group came to this work with the intention of shifting from countering deficit and dominant narratives to better recognizing Black Finesse and joy. Ultimately, the Black Joy Group aimed to decenter whiteness and the white gaze from discussions about Black youth and their relationship with STEM. The Black Joy Group utilized counter narratives and the sharing of their own moments of STEM reauthoring to frame the way they negotiated their STEM identities over time.

Participants reframed their past experiences as STEM learners, and Black youth's current experiences with STEM through the lens of Black Finesse (Mackey, 2020). From this perspective, the women and Black youth in this study were able to be perceived from an asset-based perspective which affirmed and legitimized their STEM participation. Despite whiteness and negative experiences in STEM spaces, the women in the study still identified moments of reauthoring through positive moments in STEM. Examples of positive STEM reauthoring were identified as situations where Black Joy Members got to exercise agency in STEM spaces, build on cultural practices, and feel joy. With the goal of facilitating similar moments of reauthoring for Black youth, the women in this study reimagined STEM classrooms as more welcoming and more joyous spaces for Black youth. They reimagine STEM learning that better *sees* students and provides them the opportunity to exercise their agency to reauthor through moments of joy and affirmation. Although reauthoring was the desire for Black youth, the Black Joy Group also recognized STEM as a political system (Bullock, 2019) that Black and Brown youth and also

educators learn to navigate. To support youth and educators in prioritizing joy, the Black Joy Group reimagined STEM spaces that celebrate students' Finesse and frame their STEM navigation from asset-based perspectives

Why Black Joy?

The members of the Black Joy Group chose to center Black joy due to how Black youth's joy is often invisibilized or misinterpreted, especially within white-dominated contexts. This study intentionally centered joy, responding to calls to continue gaining understanding of positive racialized emotions (Bonilla-silva, 2019; Tichavakunda, 2021), and also, as a way to challenge dominant deficit narratives that persist about Black youth. Additionally, this study centered race and Blackness to directly challenge salient narratives of STEM as non-racist and apolitical (Gutstein, 2006). This study sought to better understand how the experiences of Black youth shape their identities (Rowley et al, 1998), and more specifically, how their experiences shapes their identities in relation to STEM (Martin, 2012; Gholson & Robinson, 2019; Morton & Parsons, 208; Morton, Gee & Woodson, 2020). Ultimately the goal of this research was to better understand how Black joy can be noticed and interpreted in ways that counter dominant narratives of Black youth.

Black joy remains under-researched as it relates to Black people in a higher education context (Tichavakunda, 2021). Black joy is also under-researched in the context of Black youth and their STEM identity development. We centered Black joy intentionally and as counternarrative (Solórzano & Yosso, 2002) to the hyper-fixation on Black pain, trauma, and the perceived shortcomings of Black people that pervade media (Boaler, 1999; Kaplan, 2005; Rothe, 2011) and deficit-perspectives of research about Black youth's learning. In our discussions about Black joy, the Black Joy Group acknowledged the historical and systemic harm experienced by

Black people to help conceptualize and notice how tension lands on Black and Brown bodies (Mendoza et al., 2021). The work of this study did not seek to resolve racism or anti-Blackness that show up in STEM classrooms (Coles, 2020), but to better understand it and use that knowledge towards improving Black youth's learning experiences. At the same time, the Black Joy Group made a conscious effort to prioritize the joy of *freedom* (Love, 2019; Adams, 2022) which is also experienced by Black people. While it was important to recognize the unique, racialized and political challenges of Black youth navigating STEM, the Black Joy Group recognized that these challenges are not the only aspects of the Black learning experience. Participants' and their retellings of their STEM experiences help represent a spectrum of perspectives and narratives of what STEM means in their lives and how it has shaped their identities.

Critical Race Theory is an essential part of supporting students in expressing Black joy and understanding the importance of expressing Black joy and a white-dominated space such as STEM by helping students develop a critical consciousness that allows them to better navigate the racist history and structure of STEM that does not fully value or validate their ways of knowing and learning. Further, Black joy may be utilized in critical race theory to help keep the focus on the joy and well-being of Black youth as they develop a critical consciousness to better understand the racist systems they navigate. Although beneficial and necessary, Black youths' critical development through CRT can entrust the responsibility (Anderson, 2004) of calling out racial injustice on the marginalized groups that have been historically subjugated by whiteness. Incorporating Black joy in CRT is a call to continue decentering whiteness by freeing Black youth from the need to challenge it.

Capitalist Narratives of STEM

The Black Joy Group's conceptualization of STEM learning that best serves and encourages Black youth mirrored Worsley and Roby's (2021) conceptualization of Black joy in STEM as a community and for the purpose of celebrating joy. Our conceptualization of what STEM should be was often in contention with more dominant perspectives of the purpose of STEM as a capitalist venture that commodifies Black learners and their talents (Martin, Price, & Moore, 2019). Members of the Black Joy Group expressed frustration with some of the more salient and opportunistic narratives of STEM, its purposes, and its perceived value within society. Participants like Jayla noticed that STEM is more increasingly framed as a vehicle to set youth apart and to set them up financially. Her perspective of working in philanthropic spaces provides her the opportunity to notice the way the narrative of STEM continues to shift with the needs and demands of society. Similarly, I highlighted how STEM success and talent continues to be framed almost like a type of currency exchanged for access to prestigious and financially viable STEM careers and fields that have historically been mostly white and male. Through shifting narratives of what STEM is for we hoped to continue shifting student and educator perspectives from a "learn-to-earn" perspective that attracts Black and Latinx students into STEM schools to pursue STEM careers in the interest of "racial capitalism" (Morales-Doyle & Gutstein, 2019).

As teachers and researchers, it is also important to understand and interrogate our role in perpetuating capitalistic, opportunistic perspectives of successful STEM learning and whiteness which assigns status and monetary value to STEM. For example, in a meeting, Tasha expressed a desire to support students in outwardly expressing their Black joy in schools through dance and rap in between classes. However, in the same statement, Tasha expressed a desire to support

students to take school rules and responsibilities more seriously by arriving to class on time. In this instance, Tasha acknowledged her role in constraining her student's Black joy by insisting they comply with school rules and meet the expectations set for them to check their Black joy at the door before coming to class. Both the students and Tasha were under an obligation to perform and comply with the expectations set for them by schools to achieve the goal of creating an appropriate learning environment. This took precedence over prioritizing students and Tasha's joy in that moment.

Another example of the difficulty of extricating joyous STEM from its constraints came from Black Joy meetings where we discussed the amount of freedom that would be required for Black youth to define and own STEM on their own terms. Conversations would be moving towards liberatory frameworks of STEM learning for Black youth, however, always present in the conversation were the limitations of these frameworks in the face of whiteness and opportunism which encourage students to learn to successfully navigate STEM for the purpose of joining the workforce and making a life for themselves in the future. Receiving a ‘good’ education, being a ‘good’ student, and later living a good life are inextricably linked through capitalism, making it difficult to extricate STEM from whiteness as we were able to extricate Black joy from whiteness. In response to Martin, Price, and Moore (2019) who call for liberatory mathematics extricated from whiteness, the Black Joy Group strived to humanize Black learners and their experiences as narratives that exist separate from whiteness and capitalism. The Black Joy Group found it important to continue presenting students with ways to see STEM and utilize it in ways that are not connected to gain. By doing this, we continue to shift narratives of STEM that create a clearer vision of what and who STEM is for.

Black Youth

The Black Joy Group co-constructed and designed survey questions for Black youth. In doing so, the participants of the Black Joy Group aimed to better understand how Black youth perceive STEM and STEM narratives. And most importantly, how Black youth see themselves within the narrative of STEM, And how their experiences within STEM classrooms shape their self-perception.

Student Perceptions of STEM

STEM for Black youth in this study extended beyond the type of STEM learning that is typically presented to Black youth in schools (Anyon, 1981; 1997). Most Black youth recognized STEM as either science, technology, engineering, and mathematics, however they saw themselves as STEM people outside of traditional STEM domains. For example, Black youth included themselves in collages featuring activities they do that involve STEM such as mechanics and being outdoors. Students also described STEM and STEM careers as a discipline learned and done in schools and laboratories for careers, but they also viewed STEM as happening outside of schooling and professional contexts. For example, a student mentioned that they use math generally to 'get around', and another student who mentioned activities she does at home like tracking how long she sleeps. STEM is not a foreign idea to students, and students expressed traditional ideas about it, while at the same time locating it in their personal lives. This has the potential to disrupt ultimately shaping STEM narratives, who is considered to be a STEM person and which types of STEM are viewed as 'real' STEM. Legitimate STEM participation for students is usually mediated through their participation in higher-level, rigorous STEM courses. Shifting narratives of what types of STEM count as legitimate has the potential to challenge STEM gatekeeping strategies associated with higher-level STEM courses that are mostly white

and male (Heubert & Hauser, 1999). Challenging perceptions of what counts as STEM and who counts as a STEM person continues to challenge narratives about who belongs in STEM and why (Roby & Calabrese, 2019; Vakil & Ayers, 2019).

STEM from Black youth's perspective includes joy through their interests and passions like building things, and creating art as a means to learn more about the world around them. However, students indicated points of frustration due to a misalignment between the joyous STEM learning that they prefer, and the more traditional STEM that they typically engage in while in school. Many of their reimaginings of STEM in the future involved combining STEM and their interests, like going outdoors to learn about biology through nature. The Black Joy group theorized Black joy as being a sense of freedom and liberation (Golden & Utah, 2015; Adams, 2022). Their perception of what makes STEM joyous is supported by students' desire to engage in STEM outside of the confinement of their typical STEM classrooms which they spend most of their time learning in.

Closing interviews from the Black Joy Group expressed a similar desire for the future to include more relevant and exciting opportunities for Black youth to explore and engage in STEM, and most importantly to see themselves represented in it.

Connecting Emotions and STEM

Students reported their happiest STEM memories as moments when they were actively engaged and included in STEM that interested them. For example, students wrote about experiments they have done in science classes and hands-on projects they participated in. Students who shared their happiest STEM memories wrote more and in greater detail when describing these moments. Also, their written responses often included sketches depicting these happy moments. When asked about their least happiest STEM memories, students who answered

pointed to traditional classroom practices and activities like doing classwork, or taking tests. Students did not seem to be as open to providing responses to this question, or to the prompt asking students to reflect on how STEM makes them feel. When students did respond to this prompt, they did not include accompanying drawings.

Viewing STEM as a political system (Bullock, 2019) gives insight into the systemic issues that Black and Brown students face, particularly in spaces like STEM classrooms where some of the youth's least happiest STEM memories occurred. Within the political system of STEM, students' behavior and their expectations to be successful STEM learners takes priority and act as distractors from schools attending to students' happiness first and foremost. For example a student cited their least happiest memory by associating poor classroom behavior with punishment, writing, "When something bad happen and you can't go outside no more". It does not detail what 'something bad' means, however common classroom management tactics involve withholding fun and joyous activities like being able to be outdoors. This cause and effect relationship between classroom behavior and Black youths' joy is exacerbated by Black youth being subject to heavy surveillance within schools.

The Black Joy group often reflected on the societal constraints that may contribute to Black youth feeling more guarded and less comfortable talking in depth about their experiences in STEM classrooms. For example, surveillance, compliance, and anti-Blackness in STEM could be contributing factors to students' vulnerability in discussing when they felt the happiest doing STEM, as opposed to students not answering as frequently or as detailed when thinking back on their least happiest and happiest memories. Additional factors that may have contributed to students' difference in comfort level regarding their sentiments about STEM is that students are probably not often asked about their perspectives on STEM. Although US students spend a

significant amount of time learning STEM subjects throughout their schooling years, their attendance in these classes are often required for promotion and college prep tracks (Heubert & Hauser, 1999), so they likely are not often asked about their perspectives on STEM and their uses for it. Also, students were surveyed in their mathematics classrooms with their teachers in the room for most of the time. Although the teachers were not overly-involved in the reauthoring sessions with Black youth, they did manage classroom behavior as necessary for a few students. Discussions during Black Joy Group meetings often referred back to the almost ever-presence of surveillance of Black and Brown people, and even surveillance of the self. Even in the case of this study aimed at decentering the white gaze and white standards of expectation, these joy-constraining factors could not be completely removed from the youths' counterspace.

Reauthoring Towards Black Joy

The goal of this research was to support Black youths' reauthoring of STEM narratives. Although the study was co-designed to allow opportunities for Black youth to reauthor and negotiate their identities in STEM, the Black Joy Group found that reauthoring cannot be facilitated in short stints. Reauthoring with Black youth also requires relationship building that extends beyond a few classroom visits. Inviting students to exercise agency in moments of reauthoring also involves providing counterspaces where students feel comfortable pushing on dominant narratives.

Even given an opportunity to participate in a counterspace with a Black STEM expert asking them about their experiences as Black youth in STEM, STEM, as a set of dominant practices associated with whiteness and emotionally-neutral, proved difficult to overcome. Counterspaces have been found to be potential sites of Black joy often providing refuge, cultural celebration, and support (Solórzano et al., 2000). Unlike out-of-school or other non-traditional

sites for youth STEM activity (Pinkard et al., 2017; Tanksley, 2019), classroom learning is often a site of whiteness and surveillance under a veil of color blind neutrality. Reauthoring in STEM spaces should push against stereotypes and beliefs of STEM being rigid and emotionless. In addition to students having the opportunity to be involved in STEM communities as STEM people. Black youth should also have the opportunity to explore a spectrum of their emotions as they navigate STEM spaces and negotiate their identities within them.

Reauthoring STEM Narratives

Although the aims of this study set out to support students in reauthoring STEM narratives and narratives of the self, the Black Joy Group realized through discussions of our own reauthored narratives over time the Black youth who participated in this study may not be fully prepared to engage in reauthoring in the way we initially intended. In my positionality section, I discussed instances in my own learning and teaching trajectories where, over time, I had the opportunity to develop a STEM identity. My experience aligned with other members' experiences, like Leah who shared how her participation in her high school's Stream Team helped strengthen a weakening connection to science. Another example of a reauthored STEM narrative was Tasha, who in interviews cited her trials of success and failures in an engineering class being essential to building confidence with the subject. In each of these instances of reauthoring, moments of success and also failure characterized their relationships and identities within STEM. This is not something we felt could be achieved with Black youth in this study in the short time I visited them in their classrooms. Instead, we wanted to focus our framework on supporting Black joy in STEM spaces by first supporting students in their navigation of STEM spaces and underlying systems (Du Bois, 1903; Anzaldúa, 1999; Mackey, 2020). Drawing on critical frameworks to make visible invisibilized systems that Black youth navigate, this study

shifted its aim to better understand how youth are experiencing STEM learning and STEM classrooms, and how Black youth are constructing and reconciling their identities as STEM learners.

In order for students or educators of Black youth to reauthor, I suggest setting up students and teachers with a foundation of understanding how invisible racialized systems operate in schools and STEM classrooms. The Black Joy Group theorized that having a solid foundation to think broadly about the types of STEM classrooms students need to feel supported and successful is important in helping cultivate joyous STEM classrooms where narratives about Black youth can continue to be shifted towards more asset-based perspectives.

Limitations of the Study

This study, as originally conceived, involved working with Black and Brown youth in a digital counterspace around their interests in pursuing STEM pathways. The study which was co-designed with teachers, community educators, and scholars, provided an opportunity to explore reauthoring for Black youth. The Black Joy Group was not originally part of this dissertation, so finding connection between it and the student study required consistent reflection to ensure I was staying within the scope of the Black Joy Groups' vision to better understand how Black joy can be better supported in STEM spaces.

This study was conducted during the Covid pandemic. The Black Joy Group met virtually, however, attendance was not consistent for all members. Additionally, restrictions for schools during the pandemic meant that I only visited one classroom face-to-face for a couple of days. I met with students from the second class virtually.

Lastly, the participants in this study that made up the Black Joy Group each have experience conducting or engaging in equity-centered research. The expertise of the women of

color in this study was crucial to co-designing and framing this research from an asset-based perspective of Black youth. Future iterations of studies concerning supporting reauthoring and Black joy should also include white teachers as they are more likely to be educators of Black youth.

Chapter 6. Conclusion

Analysis of the data collected in Phase 1 addresses research question one, *How do participants in an educational counterspace reimagine STEM education that centers Black joy?* To investigate this, participants co-designed an online counterspace for theorizing and conceptualizing Black joy as it exists in a STEM context regarding Black youth. In this online counterspace, participants processed their thinking and feeling through embodied noticing and the use of body mapping and collaging. Participants drew on their personal experiences as youths developing a STEM identity and also, their experiences working with Black learners. The Black Joy Group defined and theorized Black joy by making distinctions between 1) *happiness,* delight from the material or external, 2) *joy,* delight originating internally or from the soul, and 3) *Black joy*, delight originating internally or from the soul that is also free from judgment and/or constraint. From this perspective, Black joy was theorized to already be experienced by Black youth. It is also characterized as being nuanced and multifaceted with a network of support like family, friends, community, and artistic pursuits and expression that support students in manifesting their joy. Further, participants described Black joy as a state of being that is political in nature because of the way it can be noticed and interpreted when experienced within a Black body. Because Black joy can be perceived negatively, particularly when viewed through the white gaze, participants conceptualize Black joy as existing independently, not in opposition to whiteness or other systems of oppression.

Participants recognized Black joy as being constrained by outside oppressive factors pervasive in schools. Participants named racism, whiteness, gatekeeping, capitalism, and surveillance as the main constraints to Black joy in a STEM context. Their experiences as STEM learners and their experiences working with Black youth informed their perspectives of the ways

Black youth need to navigate these constraining factors in order to seek and experience joy in ways that white students' joy is not subject to. In their personal STEM narratives, each participant included instances where they felt connected to STEM in meaningful and joyful ways. However, those instances of connection and joy were often infringed upon by one or more of these constraining factors. From this perspective, the main goals of STEM are not to foster love, joy, and appreciation for STEM for Black learners. Participants perceived STEM learning and the navigation it requires as more of a hazing process where only the people who have the resources, access, and privilege to withstand the gatekeeping are included in its narrative.

Participants recognize that various stakeholders may be complicit or directly involved in maintaining STEM as a predominantly white, western institution. To this end, these stakeholders continue to construct and perpetuate salient STEM narratives that perceive Black youth through a deficit lens. Participants aim to challenge the current narrative by developing a framework to better support educators and Black youth in shaping STEM spaces to be more inviting and welcoming to Black youth and their joy.

Reimagined narratives of what STEM is like, who STEM is for, and what STEM can be used for include less traditional models of schooling like being inside classrooms sitting in desks, memorization, the focus on performance and testing, and surveilling people or compliance with white, colonial standards of what it means to learn and do in STEM spaces. Reimagined narratives challenge the factors that constrain joy and Black joy in STEM spaces, making it more difficult for students to continue feeling welcome and some spaces and welcome to bring their whole selves into STEM spaces.

The Black mathematics students in this study conceptualize STEM as something that is done in the context of schooling, but also, they conceptualize STEM as a tool to innovate or

address world issues like pollution and climate change. Despite most students' associations of STEM being linked to their experiences in classrooms and in schools, student participants described a wide scope of the activities and practices that they believe characterize STEM. Student participants identified dancing, making music, wildlife, engineering, architecture, banking, baking, and other capacities that STEM plays a large part. When asked about the type of people who utilize STEM, students listed more stereotypical roles and careers like teachers, doctors, nurses, scientists.

When describing their experiences learning and doing STEM, students drew on memories where they felt most or least connected to STEM. Examples of some of these memories include science and mathematics projects, classroom and home experiments, and having the opportunity to engage with STEM outdoors in nature. In surveys, where students were asked to describe their happiest memories involving STEM, students described instances where they were successful on an assessment, or instances where they got to incorporate their interests into their learning and learn something new. For students' least happiest memories, they referred to instances when they felt unsuccessful on an assessment or felt disinterested in instances where their interests were not related to what was being taught. Students wrote and illustrated more when providing information about their happiest moments which were more inclusive of their vision of what STEM comprises.

Practice Implications

Findings from this study call for teachers of all races to be equipped with the tools to better notice, interpret, and appreciate Black joy in STEM classrooms. By being equipped with the tools to facilitate joyous learning for Black youth, teachers may be better prepared to challenge white standards of appropriateness that often constrain Black joy in schools. Findings

from the two educators in the Black Joy Group speak to the challenges and the pressure to meet Western expectations and to perform in schools. Dominant norms that prioritize performance in schools are pervasive in schools where Black educators may creatively subvert (Gutiérrez, 2016) these norms in favor of prioritizing Black joy for their students and also for themselves. Decentering white, western norms in STEM classrooms poses a real risk for educators, especially given the recent political climate, tensions around race and culture, a lack of diversity in the field, and leadership issues all leading to high rates of Black teacher turnover (White 2016; 2018). Black educators need support from administrators and most importantly, policy makers to shift priority to cultivating spaces of joy and affirmation for Black teachers and Black youth.

In addition to challenging white standards of appropriateness and behavior, findings from this study have implications for teachers challenging dominant narratives of STEM from opportunistic, capitalist perspectives. The intentional framing of STEM beyond financial gain and status can provide students the freedom to engage with STEM intrinsically and strictly for the joy of it. Further, broadening the purposes of STEM may support Black youth in broadening their scope of STEM and who counts as a STEM person. To make Black joy more visible in culturally sustaining STEM classrooms, educators and scholars could focus on facilitating STEM learning that affirms Black youth and their joy by naming their participation and their joy as valid STEM learning both in and out of schooling contexts. By including youth and their STEM practices in the narrative of STEM, students are able to frame their identities and relationship with STEM as legitimate.

Theoretical Implications

Student participants in this study were recruited due to their enrollment in the mathematics classrooms of two Black educators who were part of this study. Their students

complete surveys and collages about their experiences about STEM as a discipline, however, future research should include Black youth enrolled in classes of other STEM disciplines or informal STEM learning spaces. Additionally, this study only featured Black youth from a middle school classroom and a high school mathematics classroom. Future researchers looking to gain more insight into the experiences of Black youth in STEM classrooms should include younger students' perspectives of STEM.

Centering reauthoring in STEM identity development should include interdisciplinary practices and domains to expand what has been traditionally defined as STEM. In the process of investigating reauthoring for Black youth, the Black Joy Group drew on non-traditional methodology and firming methodology to better access aspects of their identities and relation to STEM that were best explained through interdisciplinary work. To facilitate reauthoring for Black youth, educators should look to literacy and other creative outlets that students may have more experience in expressing themselves through. Reflection through writing and creating art may better support students in talking more openly and comfortably about their STEM experiences.

Lastly, theoretical implications from this study find that embodied activity supports deeper and more nuanced conceptualizations of Black Joy and its constraints in STEM classrooms. This study benefited from leaning into embodied learning as an intentional methodology to elicit not only participants' thoughts and perspectives, but to also think deeply about how those perceptions weigh on the body, and how they potentially land on Black and Brown Youth and STEM classrooms as they navigate societal constraints that hinder Black Joy. STEM education researchers concerned with critical pedagogies need to more deeply theorize

reasons why Black joy remains invisible in conversations about Black youth and their relationship with STEM.

References

Adams, J. D. (2022). Manifesting Black Joy in science learning. Cultural Studies of Science Education, 17(1), 199-209.

Adichie, C. 2009. "The Danger of a Single Story." TED Global Talks. Retrieved December 17, 2017http://www.ted.com/talks/chimamanda_adichie_the_danger_of_a_single_story.html

Alim, H. S., & Paris, D. (2017). What is culturally sustaining pedagogy and why does it matter. Culturally sustaining pedagogies: Teaching and learning for justice in a changing world, 1, 24.

Anderson, J. D. (1990). A Tale of Two Browns: Constitutional Equality and Unequal Education. Duke Law Journal, 1990(2), 261-319.

Anderson, J. D. (2004). Crosses to bear and promises to keep. Urban Education, 39(4), 359-373.

Anderson, J. D. (2023). Ex-slaves and the rise of universal education in the South, 1860-1880. Thinking about Black Education: An Interdisciplinary Reader.

Anyon, J. (1981). Social class and school knowledge. Curriculum inquiry, 11(1), 3-42.

Anyon, J. (1997). Ghetto schooling: A political economy of urban educational reform. Teachers College Press.

Anzaldúa, G. (1987). Borderlands/La Frontera: The New Mestiza. Aunt Lute Books.

Ashford, S. N., Wilson, J. A., King, N. S., & Nyachae, T. M. (2017). STEM SISTA Spaces. Emerging Issues and Trends in Education, 3.

Au, Wayne. 2015. High-Stakes Testing: A Tool for White Supremacy for Over 100 Years. In Bree Picower and Edwin Mayorga (Eds), What's Race Got To Do With It? How Current School Reform Policy Maintains Racial and Economic Inequality. Peter Lang, Inc.

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

Basu, S. J., & Barton, A. C. (2007, January 1). Developing a sustained interest in science among urban minority youth. JOURNAL OF RESEARCH IN SCIENCE TEACHING, 44(3), 466–489.

Battey, D., & Leyva, L. A. (2016). A Framework for Understanding Whiteness in Mathematics Education. Journal of Urban Mathematics Education, 9(2), 49-80.

Bell, D. (2004). Silent covenants: Brown v. Board of Education and the unfulfilled hopes for racial reform. Oxford University Press.

Boaler, J. (1999). Participation, knowledge and beliefs: A community perspective on mathematics learning. Educational studies in mathematics, 40(3), 259-281.

Boatwright, T. (2019). Flux zine: Black queer storytelling. Equity & Excellence in Education, 52(4), 383-395.

Bonilla-Silva, E. (2003). Racial attitudes or racial ideology? An alternative paradigm for examining actors' racial views. Journal of Political Ideologies, 8(1), 63-82.

Braaten, M., & Sheth, M. (2017). Tensions teaching science for equity: Lessons learned from the case of Ms. Dawson. Science Education, 101(1), 134-164.

Brooks, L. B. (2020). Black Joy, Black Love and COVID-19: A Reflection on Self-Care and Community in the Midst of a Pandemic. Journal of Black Sexuality and Relationships, 7(1), 67-72.

C. Bullock, E. (2017). Only STEM can save us? Examining race, place, and STEM education as property. Educational Studies, 53(6), 628-641.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching, 44(8), 1187–1218.

Carter, P. L. (2005). Keepin'it real: School success beyond Black and White. Oxford University Press.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. (1966). Equality of educational opportunity. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Office of Education.

Coles, J. A. (2020). "It's really geniuses that live in the hood": Black urban youth curricular un/makings and centering Blackness in slavery's afterlife. Curriculum Inquiry, 51(1), 35-56.

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. u. Chi. Legal f., 139.

Crenshaw, K. (1990). Mapping the margins: Intersectionality, identity politics, and violence against women of color. Stan. L. Rev., 43, 1241.

Davis, B., Wilkins-Yel, K., & White, F. (2020). Supporting STEM Identity Development Among Women of Color Through Engagement in a Transformative Counterspace.doi:10.1177/0733464808330822

Delgado, R. (1989). Storytelling for oppositionists and others: A plea for narrative. Michigan Law Review, 87(8), 2411-2441.

Dewey, J. (1910). Science as subject-matter and as method. Science, 31(787), 121-127.

Dillard, C. B. (2019). To experience joy: musings on endarkened feminisms, friendship, and scholarship1. International Journal of Qualitative Studies in Education, 32(2), 112-117.

Dorph, Bathgate, Schunn & Cannady (2018) When I grow up: the relationship of science learning activation to STEM career preferences, International Journal of Science Education, 40:9, 1034-1057, DOI: 10.1080/09500693.2017.1360532

Du Bois, W. E. B. (1903). The Souls of Black Folk. Chicago, IL: A. C. McClurg & C

Dumas, M. J., & Nelson, J. D. (2016). (Re) Imagining Black boyhood: Toward a critical framework for educational research. Harvard Educational Review, 86(1), 27-47.

Dumas, M. J., & Ross, K. M. (2016). “Be real black for me” imagining BlackCrit in education. Urban Education, 51(4), 415-442.

Dunn, D. C., Chisholm, A., Spaulding, E., & Love, B. L. (2021). A radical doctrine: Abolitionist education in hard times. Educational Studies, 57(3), 211-223.

Dunn, D., & Love, B. L. (2020). Antiracist language arts pedagogy is incomplete without Black joy. Research in the Teaching of English, 55(2), 190-192.

Erickson, F. (1985). Qualitative methods in research on teaching (pp. 119-62). Institute for Research on Teaching.

Farmer-Hinton, R., Lewis, J., Patton, L., & Rivers, I. (2013). Dear Mr. Kozol.... Four African American women scholars and the re-authoring of savage inequalities. Teachers College Record, 115(5), 1-38.

Flick, U. (Ed.). (2013). The SAGE handbook of qualitative data analysis. Sage.

Flowers III, A. M., & Banda, R. (2016). Cultivating science identity through sources of self-efficacy. Journal for Multicultural Education.

Freiler, T. J. (2008). Learning through the Body. New directions for adult and continuing education, 119, 37-47.

Gholson, M. L. (2016). Clean corners and algebra: A critical examination of the constructed invisibility of black girls and women in mathematics. Journal of Negro Education, 85(3), 290-301.

Gholson, M. L., & Robinson, D. D. (2019). Restoring mathematics identities of Black learners: A curricular approach. Theory Into Practice, 58(4), 347-358.

Gholson, M. L., & Wilkes, C. E. (2017). (Mis) taken identities: Reclaiming identities of the "collective Black" in mathematics education research through an exercise in Black specificity. Review of Research in Education, 41(1), 228-252.

Gibson, C. (1995). Critical thinking: Implications for instruction.

Given, L. M. (2008). The SAGE encyclopedia of qualitative research methods (Vols. 1-0). Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781412963909

Golden, E. N., & Utah, A. (2015). Getting to joy: Emergence [s] & experimentation/s. Obsidian, 41(1/2), 14-18.

Graven, M. (2012). Changing the story: Teacher education through re-authoring their narratives. In Routledge international handbook of teacher and school development (pp. 127-138). Routledge.

Grossman, J. M., & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. Urban Education, 49(6), 698-727.

Gutiérrez, K. D., & Calabrese Barton, A. (2015). The possibilities and limits of the structure–agency dialectic in advancing science for all. Journal of Research in Science Teaching, 52(4), 574-583.

Gutiérrez, R. (2016). Strategies for creative insubordination in mathematics teaching. Special Issue Mathematics Education: Through the Lens of Social Justice, 7(1), 52-62.

Gutiérrez, R. (2017). Why mathematics (education) was late to the backlash party: The need for a revolution. Journal of Urban Mathematics Education, 10(2).

Hale, J. E. (2001). Learning while Black : creating educational excellence for African American children / Janice E. Hale. Johns Hopkins University Press.

Hannah-Jones, N. (2021). The 1619 project: A new origin story. One World.

Hanson, S. (2008). Swimming against the tide: African American girls and science education. Temple University Press.

Harper, A., & Kayumova, S. (2022). Invisible multilingual Black and Brown girls: Raciolinguistic narratives of identity in science education. Journal of Research in Science Teaching.

Harper, R. P., Weston, T. J., & Seymour, E. (2019). Student responses to problematic STEM teaching methods. Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education, 149-195.

Harris, C. I. (1993). Whiteness as property. Harvard law review, 1707-1791.

Hoffman, K. M., Trawalter, S., Axt, J. R., & Oliver, M. N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. Proceedings of the National Academy of Sciences, 113(16), 4296-4301.

Howard, T. C. (2013). How does it feel to be a problem? Black male students, schools, and learning in enhancing the knowledge base to disrupt deficit frameworks. Review of Research in Education, 37(1), 54-86.

Howard, T. C., Flennaugh, T. K., & Terry Sr, C. L. (2012). Black males, social imagery, and the disruption of pathological identities: Implications for research and teaching. Educational Foundations, 26, 85-102

Huebert, J. P., & Hauser, R. M. l (1998). High stakes testing for tracking, promotion and graduation.

Hughey, M. W., & Goss, D. R. (2015). A level playing field? Media constructions of athletics, genetics, and race. The ANNALS of the American Academy of Political and Social Science, 661(1), 182-211.

Iceland, J., & Ludwig-Dehm, S. (2019). Black-white differences in happiness, 1972–2014. Social science research, 77, 16-29.

Jackson, P. W. (1992). Conceptions of curriculum and curriculum specialists. In P. Jackson (Ed.), Handbook of research on curriculum: A project of the American Educational Research Association (pp. 3-40). New York: MacMillan.

Jacobs, V. R., & Philipp, R. A. (2010). Mathematics teacher noticing. M. G. Sherin (Ed.). New York, NY: Routledge.

Joseph, N. M., Hailu, M. F., & Matthews, J. S. (2019). Normalizing Black girls' humanity in mathematics classrooms. Harvard Educational Review, 89(1), 132-155.

Kessinger, T. A. (2011). Efforts toward educational reform in the United States since 1958: A review of seven major initiatives. American Educational History Journal, 38(1/2), 263.

Khandkar, S. H. (2009). Open coding. University of Calgary, 23, 2009.

King, N. S. (2017). When teachers get it right: Voices of Black girls' informal STEM learning experiences. Journal of Multicultural Affairs, 2(1), 5.

Labaree, D. F. (1997). Public goods, private goods: The American struggle over educational goals. American educational research journal, 34(1), 39-81.

Lachman, G. (1998). The archaeology of consciousness: An interview with Owen Barfield. In H. Palmer (Ed.), Inner Knowing: Consciousness, creativity, insight and intuition (pp. 8– 13). New York: J. P. Tarcher/Putnam.

Ladson-Billings, G. (1998). Just what is critical race theory and what's it doing in a nice field like education?. International journal of qualitative studies in education, 11(1), 7-24.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in US schools. Educational researcher, 35(7), 3-12.

Lane, T. B. (2016). Research environments as counterspaces? Examining spaces that inhibit and support science identity development for Black students in STEM. Urban Education Research & Policy Annuals, 4(1).

Leonardo, Z. (2009). Race, whiteness, and education. Routledge.

Lindemann, H., & Nelson, H. L. (2001). Damaged identities, narrative repair. Cornell University Press.

Logan, M., & Skamp, K. (2008). Engaging students in science across the primary secondary interface: Listening to the students' voice. Research in science education, 38, 501-527.

López López, L., & Nikey. (2021). 'Black girl magic, y'all can't stand it, y'all can't ban it': Black girl curated curricula unsettling the conventional reason of school. Race Ethnicity and Education, 24(2), 229-244.

Louie, N. L. (2018). Culture and ideology in mathematics teacher noticing. Educational Studies in Mathematics, 97(1), 55-69.

Louie, N., Adiredja, A. P., & Jessup, N. (2021). Teacher noticing from a sociopolitical perspective: the FAIR framework for anti-deficit noticing. ZDM–Mathematics Education, 53(1), 95-107.

Mackey, J. Z. (2020). Black Finesse Amidst the Political Science Paradigm: A Race-Grounded Phenomenology (Doctoral dissertation, University of Denver).

Marshall, J. C., Horton, R., Igo, B. L., & Switzer, D. M. (2009). K-12 science and mathematics teachers' beliefs about and use of inquiry in the classroom. International Journal of Science and Mathematics Education, 7, 575-596.

Martin, D. B. (2009). Researching race in mathematics education. Teachers College Record, 111(2), 295-338.

Martin, D. B. (2012). Learning mathematics while Black. Journal of Educational Foundations, 26(1/2), 47.

Martin, D. B., Price, P. G., & Moore, R. (2019). Refusing systemic violence against Black children: Toward a Black liberatory mathematics education. In Critical race theory in mathematics education (pp. 32-55). Routledge.

Massey, D., & Denton, N. A. (1993). American apartheid: Segregation and the making of the underclass. Harvard university press.

Mathematics Education. Washington, DC: National Academy Press.

McGee, E. O. (2020). Interrogating structural racism in STEM higher education. Educational Researcher, 49(9), 633-644.

Meltzer, D. & Otero, V. (2015). A brief history of physics education in the United States, Am. J. Phys, 83, 447-458.

Mendoza, E., Hand, V., van Es, E. A., Hoos, S., & Frierson, M. (2021). 'The ability to lay yourself bare': centering rupture, inherited conversations, and vulnerability in professional development. Professional Development in Education, 47(2-3), 243-256.

Miles, M. L., & Roby, R. S. (2022). Black liberatory science education: positioning Black youth as science learners through recognizing brilliance. Cultural Studies of Science Education, 17(1), 177-198.

Morales-Doyle, D., & Gutstein, E. R. (2019). Racial capitalism and STEM education in Chicago Public Schools. Race Ethnicity and Education, 22(4), 525-544.

Morton, T. R., Gee, D. S., & Woodson, A. N. (2020). Being vs. becoming: Transcending STEM Identity development through Afropessimism, moving toward a Black X consciousness in STEM. The Journal of Negro Education, 88(3), 327–342.

Morton, Terrell R., and Eileen C. Parsons. "# BlackGirlMagic: The identity conceptualization of Black women in undergraduate STEM education." Science Education 102.6 (2018): 1363-1393.

Nasir, N. I. S., & Shah, N. (2011). On defense: African American males making sense of racialized narratives in mathematics education. Journal of African American Males in Education (JAAME), 2(1), 24-45.

National Commission on Excellence in Education. (1983). A nation at risk: The imperative for educational reform. Washington, D.C.: U.S. Government Printing Office.

National Research Council (1989). Everybody Counts: A Report to the Nation of the Future of

Nolan, K. (2011). Police in the hallways: Discipline in an urban high school. U of Minnesota Press.

Oklan, A. M. (2017). Reauthoring Narratives with Alternative Education Students Using Recorded Music Expressive Arts (Doctoral dissertation, Alliant International University).

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. Journal of Research in Science Teaching, 55(2), 206-245.

Ornstein, A. C. (1993). Norm-referenced and criterion-referenced tests: An overview. NASSP Bulletin, 77(555), 28-39.

Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. Educational researcher, 41(3), 93-97.

Paris, D. (2021). Culturally sustaining pedagogies and our futures. In The Educational Forum (Vol. 85, No. 4, pp. 364-376). Routledge.

Patel, L. (2015). Decolonizing educational research: From ownership to answerability. Routledge.

Pinkard, N., Erete, S., Martin, C. K., & McKinney de Royston, M. (2017). Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. Journal of the Learning Sciences, 26(3), 477-516.

Quaye, S. J. (2017). On being an angry Black man. International Journal of Multicultural Education, 19(1), 60-78.

Rendón, L.I., 2009. Sentipensante (sensing/thinking) pedagogy: educating for wholeness, social justice and liberation. Sterling, VA: Stylus Publishing, LLC.

Rice, C., & Mündel, I. (2018). Story-making as methodology: Disrupting dominant stories through multimedia storytelling. Canadian Review of Sociology/Revue canadienne de sociologie, 55(2), 211-231.

Roberts, T., Jackson, C., Mohr-Schroeder, M.J. et al. Students' perceptions of STEM learning after participating in a summer informal learning experience. IJ STEM Ed 5, 35 (2018). https://doi.org/10.1186/s40594-018-0133-4

Rogers, R. H. (2018). Coding and writing analytic memos on qualitative data: A review of johnny saldaña's the coding manual for qualitative researchers. The Qualitative

Report, 23(4), 889-892. Retrieved from https://colorado.idm.oclc.org/login?url=https://www.proquest.com/scholarly-journals/coding-writing-analytic-memos-on-qualitative-data/docview/2036388128/se-2?accountid=14503

Rogers, R. H. (2018). Coding and writing analytic memos on qualitative data: A review of johnny saldaña's the coding manual for qualitative researchers. The Qualitative Report, 23(4), 889-892. Retrieved from https://colorado.idm.oclc.org/login?url=https://www.proquest.com/scholarly-journals/coding-writing-analytic-memos-on-qualitative-data/docview/2036388128/se-2?accountid=14503

Rowley, S. J., Sellers, R. M., Chavous, T. M., & Smith, M. A. (1998). The relationship between racial identity and self-esteem in African American college and high school students. Journal of personality and social psychology, 74(3), 715.

Rudrum, D. (2005). From narrative representation to narrative use: Towards the limits of definition. Narrative, 13(2), 195-204.

Seymour, E., & Hewitt, N. M. (1997). Talking about leaving (Vol. 34). Westview Press, Boulder, CO.

Shah, N., & Coles, J. A. (2020). Preparing teachers to notice race in classrooms: Contextualizing the competencies of preservice teachers with antiracist inclinations. Journal of Teacher Education, 71(5), 584-599.

Solórzano, D. G., & Yosso, T. J. (2002). A critical race counterstory of race, racism, and affirmative action. Equity & Excellence in Education, 35(2), 155-168.

Solórzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, racial microaggressions, and campus racial climate: The experiences of African American college students. Journal of Negro education, 60-73.

Spencer, J. A. (2006). Balancing the equation: African American students' opportunities to learn mathematics with understanding in two central city middle schools. University of California, Los Angeles

Spencer, J. A., & Hand, V. M. (2015). The racialization of mathematics education. The race controversy in American education, 237-258.

Spring, J. (2008). The history and goals of public schooling. Educational Policy, 22(2), 213-235.

Staples, J. M. (2008). Hustle & Flow: A critical student and teacher-generated framework for re-authoring a representation of Black masculinity. Educational Action Research, 16(3), 377-390.

Swart, C. (2013). Re-authoring the world. eBook Partnership.

Swart, Chené. Re-authoring the World : The Narrative Lens and Practices forOrganisations, Communities and Individuals, Knowres Publishing, 2013. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/ucb/detail.action?docID=3544746.

Tanksley, T. C. (2019). Race, education and #BlackLivesMatter: How social media activism shapes the educational experiences of Black college-age women. University of California, Los Angeles.

Tichavakunda, A. A. (2021). Black Joy on White Campuses: Exploring Black Students' Recreation and Celebration at a Historically White Institution. The Review of Higher Education, 44(3), 297-324.

Vakil, S., & Ayers, R. (2019). The racial politics of STEM education in the USA: Interrogations and explorations. Race Ethnicity and Education, 22(4), 449-458.

Valenzuela, C., Mendoza, E., Abad, M. (2019). Critical Embodied Noticing. Paper in AERA Symposium entitled, Critical Participatory and Multisensory Approaches in Mathematics Teacher Noticing. Toronto, Canada.

Van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. Journal of technology and teacher education, 10(4), 571-596.

Verdín, D., Godwin, A., & Ross, M. (2018). STEM roles: How students' ontological perspectives facilitate STEM identities. Journal of Pre-College Engineering Education Research (J-PEER), 8(2), 4.

Wagner, A. E., & Shahjahan, R. A. (2015). Centering embodied learning in anti-oppressive pedagogy. Teaching in Higher Education, 20(3), 244-254.

Walker, V. S. (2000). Valued Segregated Schools for African American Children in the South, 1935-1969: A Review of Common Themes and Characteristics. Review of Educational Research, 70(3), 253–285. https://doi.org/10.3102/00346543070003253

Warren, B., Vossoughi, S., Rosebery, A. S., Bang, M., & Taylor, E. V. (2020). Multiple Ways of Knowing*: Re-Imagining Disciplinary Learning. In Handbook of the cultural foundations of learning (pp. 277-294). Routledge.

Weil, A. (1954). Mathematical teaching in universities. The American Mathematical Monthly, 61(1), 34-36.

White, T. C. (2016). Teach For America's paradoxical diversity initiative: Race, policy, and Black teacher displacement in urban schools. *Education Policy Analysis Archives*, *24*, 16-16.

White, T. (2018). Teachers of color and urban charter schools: Race, school culture, and teacher turnover in the charter sector. *Journal of Transformative Leadership & Policy Studies*, *7*(1), 27-42.

Williams, B. C. (2018). The pursuit of happiness: Black women, diasporic dreams, and the politics of emotional transnationalism. Duke University Press.

Williams, D. G., & Land, R. R. (2006). Special focus: The legitimation of Black subordination: The impact of color-blind ideology on African American education. The Journal of Negro Education, 579-588.

Williams, K. L., Coles, J. A., & Reynolds, P. (2020). (Re) Creating the Script: A Framework of Agency, Accountability, and Resisting Deficit Depictions of Black Students in P-20 Education. The Journal of Negro Education, 89(3), 249-266.

Willox, C. A., Harper, S. L., Edge, V. L., 'My Word': Storytelling and Digital Media Lab, & Rigolet Inuit Community Government. (2013). Storytelling in a digital age: digital storytelling as an emerging narrative method for preserving and promoting indigenous oral wisdom. Qualitative Research, 13(2), 127-147.

Worsley, T. E., & Roby, R. S. (2021). Fostering Spaces for Black Joy in STEM-Rich Making and Beyond. Journal of Effective Teaching in Higher Education, 4(2), 118-134.

Appendix A

Black Joy Group Baseline Interview Protocol

Thank you for meeting with me today. I want to talk with you and ask you a few questions about STEM narratives and your experiences as a STEM learner. This interview should take about 1 hour and I will record the interview.

Identity Map

With your own materials, or the JamBoard page provided, create an identity map. Describe your ideas about equity through words and/or drawings. Think about the different parts of your identity and try connecting them to other ideas, thoughts or emotions that best describe your experiences. I will ask you to talk to us about whatever you made during the interview.

1. Can you walk me through your identity map?
    a. What did you include or not include?

History and Context of STEM

1. How would you define the purpose(s) of STEM?
    a. Do you make a distinction between STEM as a field of study and the way STEM has been applied to practical applications?
2. Do you think there is more than one way to tell a story about history or past events?

Stereotypes and Narratives

1. How has race shown up for you in STEM spaces?
2. Are there stereotypes about people who are good at STEM subjects/ struggle with STEM subjects?
    a. Do you think there is a relationship between stereotypes and narratives about STEM?
3. How might changing the perspective of the history of STEM change the way we feel about stereotypes and narratives of different groups of people regarding STEM?

Embodied Experiences

1. What is your happiest memory of being in a STEM space? What is your least happiest memory in a STEM space?
    a. How did it feel in your body to experience those two moments?
2. What are some of your favorite things about being in STEM spaces? Are there welcoming rituals or practices that are happening during these moments?
3. How does it feel to imagine STEM spaces that honor and nourish all learners?

Reimagining STEM and STEM Spaces

1. If you could go back to a happy/unhappy memory in a STEM space, what would you change about it?
2. If you were telling or retelling the history of STEM, what or whom would you include or not include?
    a. Do you think your telling of the history of STEM aligns with dominant narratives about where STEM comes from and who it is for?
3. What does STEM look like to you in the future?
    a. What excites you about what STEM could look like in the future?
    b. What might these future spaces look like?

Additional Questions

1. Is there anything else you would like to add or a question you would like to revisit?
2. Do you have any questions for me?

Thank you for your time and for your answers today.

Appendix B

Black Joy Group Closing Interview Protocol

Provide:
-A timeline of the work completed
-Preliminary data from students (collages and student descriptions)

1. I would like to get a sense of how you came to understand the interaction of STEM and Joy. To do this, I invite you to create an image or other representation that illustrates your ideas about STEM, Black youth, STEM Narratives, joy, and the future of STEM.
    a. Can you tell me about what you created?
2. What do you think is the impact of doing work around cultivating joy in STEM spaces?
3. What sort of knowledge do you think teachers need to be able to support students in making STEM spaces joyful spaces?
4. Many students incorporated their personal interests into their STEM collages. How can teachers better encourage Black youth's passions in STEM classrooms?
5. We talked about stereotypes of Black youth. How could Black joy in STEM spaces shift some of those narratives around Black youth?
6. What was missing from this work for you?
7. Where do you think work involving STEM and Black youth should move going forward?
    a. What do you see as the possibilities for this type of work?
8. Is there anything more you'd like to say about participating in this project?

Appendix C

Student Survey Protocol

1. What does STEM look like to you?

   Imagine you are explaining science, technology, engineering, and math to a friend or family member. How would you describe it with words, pictures?

2. What kinds of activities do people do that involve STEM?

   Think about the kinds of jobs, hobbies, and activities you've seen people do that involve science, technology, engineering, and math. How many can you name?

3. When you hear the word STEM, how does it make you feel?

   How does it feel to imagine doing science, technology, engineering, and math? Do you feel emotions? Which ones?

4. What is your happiest memory around STEM? What happened?

   Think of a time when doing STEM felt good or fun.

5. What is your <u>least</u> happiest memory around STEM? What happened?

   Think of a time when doing STEM maybe didn't feel good or fun.

6. What is something that you love to do? Does it involve STEM?

   What are some fun things you like to do that bring you joy?

7. Who belongs in STEM and why?

   When you think about STEM, who do you imagine? What do they look like?

Collage Prompt:
Show what you want STEM to be like in the future?

- What would STEM look like to you?
- How should it feel?
- What sorts of activities would you like to see?

- Are there colors, words, or pictures that match the way STEM should feel?
- *Try to put yourself into the picture. How are you using STEM in this future?

Appendix D

Student Collage Descriptions and Field Notes

Collage #	**Theme of Collage**	**Collage Prompts**
	General Description	*Researcher: "Tell me about your collage"*
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