

Applying a Transformative Justice Approach to Encourage the Participation of Black and Latina Girls in Computing

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Global protests and civil unrest in 2020 has renewed the world's interest in addressing injustice due to structural racism and oppression toward Black and Latinx people in all aspects of society, including computing. In this article, we argue that to address and repair the harm created by institutions, policies, and practices that have systematically excluded Black and Latina girls from computer science, an intersectional, transformative justice approach must be taken. Leveraging testimonial authority, we share our past 8 years of experience designing, implementing, and studying Digital Youth Divas, a programmatic and systemic approach to encouraging middle school Black and Latina girls to participate in STEM. Specifically, we propose three principles to counter structural racism and oppression embedded in society and computing education: computing education must (1) address local histories of injustice by engaging community members; (2) counter negative stereotypes perpetuated in computer science by creating inclusive safe spaces and counter-narratives; and (3) build sustainable, computational capacity in communities. To illustrate each principle, we provide specific examples of the harm created by racist policies and systems and their effect on a specific community. We then describe our attempt to create counter structures and the subsequent outcomes for the girls, their families, and the community. This work contributes a framework for STEM and computing educators to integrate transformative justice as a method of repairing the harm that both society and the field of computing has and continues to cause Black and Latinx communities. We urge policy makers, educators, researchers, and community leaders to examine histories of oppression in their communities and to adopt holistic, transformative approaches that counter structural oppression at the individual and system level.

CCS Concepts: • Social and professional topics → Informal education; Computer science education;

Additional Key Words and Phrases: Black, girls, women, Latina, STEM, computing, transformative justice, intersectionality

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1 INTRODUCTION

In 2020, the murders of Black Americans such as George Floyd, Breonna Taylor, and Ahmaud Arbery, as well as increases in hostility toward Black Americans, have led to a major moment of reckoning regarding the history of structural racism, oppression, and injustice in the United States [77]. There has been significant concern and discussion about the role that race plays in negatively impacting the lived experiences of Black people—defined as those from the African diaspora—in every aspect of life. With an intense focus on structural and systemic oppression embedded in a history of racism and white supremacy [43], the scrutiny has sparked an examination of injustice in all areas of society and its impact on racial minorities, including in the field of STEM and computing [10, 36, 74] and **computer science (CS)** education [32, 61, 69].

Although the field of computing has traditionally viewed itself as immune to racism [62], recently several scholars have examined the ways in which social injustice is embedded in the field [10, 36], as well as the violence that Black people, particularly Black women and girls, experience while engaging in computing education [61, 69]. As authors with over 30 years of collective experience engaging Black and Latinx youth in computing, the recent focus on injustice both in society and in computing education has led us to examine and reflect on our approach. Specifically, we ask the following question: How can we take a transformative justice approach to increasing the participation of Black and Latina girls in STEM and computing activities in informal learning environments?

Leveraging *testimonial authority* as a method [12] to share our experience designing, implementing, and studying **Digital Youth Divas (DYD)**, a program designed to encourage Black and Latina middle school girls to participate in STEM, we propose three principles to counter structural racism and oppression in CS and society. We posit that computing education must (1) address local histories of injustice by engaging community members and building collective efficacy; (2) counter negative stereotypes perpetuated in CS and create truly inclusive and safe spaces; and (3) build sustainable, computational capacity in communities. To illustrate each principle, we first present examples of the harm inflicted on Black and Latinx communities by racist policies and structures. We then describe how we designed DYD to act as a transformative *counter-structure* by discussing how specific elements of DYD acknowledge and respond to racial harms the participating girls and their communities have experienced. Last, we describe the outcomes resulting from our counter-structural approach to injustice embedded in society.

In presenting these principles, we argue that programs and culture-focused approaches to increasing the number of Black and Latina girls and women in the computing pipeline, such as culturally relevant pedagogy and safe spaces (e.g., [5]), are important and necessary but not sufficient. Instead, we must expand our efforts beyond the program level and address systemic factors that hinder engagement and exclude Black and Latina girls and women from computing education. A transformative justice approach is needed to make effective and lasting shifts toward a more equitable and just field of computing participation. We must acknowledge the histories of harm and work to hold ourselves—as educators, researchers, computing professionals, academics, and so on—accountable for continuing these harms by working to build structures that counter racist systems and grow capacity for healing.

This work contributes a framework of principles for computing educators to apply a transformative justice approach to addressing inequities of participation among Black and Latina girls and women in computing. We make a call for policy makers, researchers, educators, and community leaders to adopt a transformative justice approach by examining histories of oppression in the communities in which they serve and by addressing and countering policies that support systemic oppression.

2 BACKGROUND

2.1 Intersectionality and Computing Education

Although the term *intersectionality* was first used by Kimberlé Crenshaw [17], the theory and framework can be traced back to (at least) the 19th century from the work of Black, Latina, and Indigenous women [12, 15]. Widely taken up by academics and practitioners and aligning with the history of Black Feminist Thought [12], intersectionality is a framework that seeks to account for the multiple, overlapping, and intersecting elements of people's identities and the ways systemic oppression shifts and changes in interaction with those intersecting identities [13, 14]. The crux of this argument is that inequality occurs and is best understood at the intersection of identities and social factors rather than in separation [15]. For example, oppression toward women and oppression toward Black people do not function independently; these oppressions are changed and amplified in unique ways for Black women, who sit at the intersection of the two identities at a minimum.

Rankin et al. [63] argue that intersectionality is needed in computing, because hegemonic (cultural) power has long impacted who is able to participate fully in computing, whose voices are heard, and how decisions are made in the field. Despite efforts to broaden participation, there is still a need for an intersectional approach to CS education at all levels [63]. A recent narrative study exploring the stories of 11 Black women in the field of computing revealed that each of these women experienced discrimination and isolation throughout the pipeline as a result of their intersecting identities [69]. For example, some of the Black women interviewed reported that their colleagues' expectations for them were either unfairly high or low, but were rarely reasonable. This study suggests mentors throughout the educational pipeline to consider the intersectional experiences of Black women and provide them with strategies for navigating computing spaces that explicitly deny and exclude their multiple identities [69]. The same study [69], as well as another recent study of Black women's lived experiences in CS [61], found that even as Black women entered desirable positions in their fields, they often felt the burden of being one of few, if any, representatives for both their race and gender, leading to more hostile and competitive environments [61, 62, 69]. This line of work also confirms that Black girls' exposure to computing in early grades is still limited, as 8 of the 14 Black women in CS interviewed by Rankin and Thomas [61] did not have formal exposure to programming or computing before college. This finding suggests that recent efforts to broaden participation in computing may still miss groups of learners, particularly those with identities at the intersection of multiple social groups such as Black girls. Thus, an intersectional lens to examine and execute such programs and efforts is crucial.

Another extensive study implemented surveys and focus groups with 93 Black women in computing fields to better understand their intersectional experiences across the educational pipeline and compile suggestions to better support Black women in computing [78]. This work revealed that much work is needed along education and career pathways to support Black women in persisting and succeeding in CS. These needs include making the success of Black women a priority by connecting it to personal and organizational success and developing leaders throughout computing pathways and pipelines who are willing to share in and actively address the struggles of Black

women. A particularly salient need identified in this work is to build specific, cultural, and educational supports for Black women beginning in middle school. For the women in the study, this was tied to the same “only one” phenomenon—that is, the experience of being the only representative for their race and/or gender in a space—and they described this as beginning in advanced classes in middle school and persisting through careers [78]. Again, this speaks to a lack of an intersectional lens in the computing fields that has negative impacts all the way from early grades to late-stage careers. Efforts to utilize an intersectional lens toward computing education support for Black and Latina girls in early grades have found that such learning spaces create environments that lead to rapid movement toward critical computing engagement and disrupting dominant, deficit-oriented narratives [5].

Intersectionality is not entirely new in computing, although recent critiques raise concerns about how the idea has been taken up. Rankin and Thomas [60] argue that much discussion of intersectionality in the computing fields references the concept in a way that is ahistorical and thus incomplete. Failing to acknowledge the long history of work in this area by Black, Latina, and Native women mirrors a common oversight in computing to fully acknowledge the role of women of color in the foundation of the field. Further, some in the computing fields have dismissed intersectionality as a poor analytic tool [58], misinterpreting the lens as focused on naming identities and categories rather than identifying the ways power plays across and at the intersection of social divisions [60, 66, 76]. To operationalize intersectionality in computing fields, Rankin et al. [63] recommend researchers meaningfully engage with intersectionality as critical theory of understanding that was created outside of computing but informative nonetheless, and ask themselves a series of questions about their research around audience, stakeholders, positionality, and power.

In our current work identifying and addressing harms toward Black and Latina girls in society in general and in STEM and computing education specifically, intersectionality provides a lens for understanding how and why harm is unique and persistent for these girls. By pinpointing where these harms originate and why, we can then make specific moves to address and alleviate them.

2.2 Transformative Justice as a Framework

Transformative justice is a liberatory movement led by communities that have historically experienced systemic oppression and State violence to build practices and structures that respond to harm [21, 41]. Originating from the practices of Native and Indigenous peoples [37], the goal of transformative justice is to address harms that have resulted from discriminatory and oppressive laws, policies, and practices [29, 37, 39, 53]. At its core, transformative justice is an approach that imagines and creates alternative structures and systems that center people, relationships, and communities who have historically been the targets of State violence [39]. By State violence, we refer to the physical, emotional, financial, psychological, and mental harms imposed on individuals and communities through the use of force, intimidation, or structural policies that impede individuals’ and communities’ freedom to thrive and grow [3, 42]. Such violence has been implemented not only by federal, state, and local governments but also by institutions and organizations that historically and/or currently engage in unjust, biased, and discriminatory practices.

As an example, transformative justice is an approach to respond to the criminal justice system, which has disproportionately left Black and Latinx people with harsher sentencing in comparison to white people for the same crimes [3]. The punitive, retributive nature of the criminal justice system is a form of State violence against Black and Latinx individuals, families, and communities [3]. Transformative justice works by understanding and addressing the underlying causes of harmful behavior to heal the individuals and community, but also by changing the systems and conditions that foster harmful behavior (e.g., lack of job opportunities, neighborhood investment, education, mental health services) [21, 41]. Implementations of transformative justice include street outreach

organizations [8] and collectives that practice and teach transformative justice in their communities [1, 21, 29]. Central to transformative justice is the belief that individual healing and justice is inextricably tied to collective liberation [29, 52], and the combination of working at interpersonal and structural levels is why the model is unique and transformative [8, 53]. Thus, transformative justice addresses harm at both the individual and system levels by creating *counter-structures*, community-based alternatives to harmful social and political structures [4, 8, 41].

Principles from transformative justice can be applied to any context where there exists harm caused by systemic oppression. For instance, the field of human-computer interaction has begun to incorporate transformative justice into design values and methods [4, 16, 19]. In our work, we apply the following central tenets of transformative justice to achieve justice within and through CS education: addressing historical and structural causes of harm while also ameliorating the impacts of those harms; taking a community-centered approach that fosters relationships and leverages strengths; building safe spaces with accountability mechanisms; and developing counter-structures to violent, harmful, and oppressive policies and institutions [8, 29, 37, 53]. As STEM and computing researchers and educators who take a transformative justice approach, we seek to create futures where Black, Latinx, Indigenous, and other traditionally excluded groups due to systemic oppression have thriving STEM communities, and we are no longer grappling with a “diversity problem” in STEM fields. To achieve this, we must situate all transformative justice initiatives as owned and controlled by communities impacted by harm. There is no specific model or formula for transformative justice; instead, each iteration is unique, because it is applied to each community depending on their particular local histories, strengths, challenges, and goals [8, 29, 52].

3 POSITIONALITY STATEMENT

Following the methodology of *standpoint theory* [34], we include a statement of standpoint of the authors. We are six women with collectively more than three decades of designing educational programs and technologies to support Black and Latinx youth engagement in STEM, computing, and digital media. Four of the authors identify as Black, cisgender women, one as an Asian cisgender woman, and one as a white, cisgender woman—all from middle to upper-middle class backgrounds due to socio-economic status and educational attainment. Half of the authors live and work in the community that we engage with in this study; thus, we leverage not only our lived experiences as community residents but also oppression we have personally faced due to gender and sometimes intersectionally race [14, 15] in our computing education, the field of STEM more broadly, and society more generally. Yet, we recognize that our status as cisgender, upper-middle class, and non-disabled people afford us privileges that shape the lenses through which we understand and experience the world.

In this article, we use the term *Black* to inclusively refer to those from the African diaspora—that is, those of Black African descent who live in North and South America, Europe, Australia, and/or Asia. Racial discrimination and structural oppression are global phenomena that not only impact those in the United States but those of African descent more broadly [15]. Furthermore, we do not use the term *underrepresented minority* (URM) to describe groups racialized as non-white because “aggregating groups together based on their low levels of representation, the URM label becomes insensitive to the unique needs and circumstances of its group members” [74]. Therefore, we use the term *Black* to describe those who identify as being of Black African descent and the term *Latino/a/x* to describe those who identify from Latin American or Hispanic origins. When speaking specifically of those who identify as girls of Latin American descent in our program, we use the term *Latina*, but when speaking generally about the need for STEM opportunities for youth of Latin American descent or describing our participants’ families, we use the term *Latinx* to be

inclusive of the entire gender spectrum [49]. We focus specifically on Black girls and Latinas based on the interest, lived experiences, and the expertise of our larger team, as well as the focus of our community partners, organizations, and leaders.

4 METHODS

4.1 Context: DYD

Launched in 2013, DYD is an out-of-school program created to engage middle school girls, specifically Black and Latina girls, in design-based engineering and CS activities launched through non-stereotypical narrative stories [57]. Since its inception, DYD has had more than 500 girls participate and has trained more than 40 high school, undergraduate, and graduate students to be near-peer mentors. The program encourages girls to develop STEM identities by participating in face-to-face and online spaces to design, create, and re-imagine everyday artifacts (jewelry, hair accessories, music) and activities (dancing and talking to friends) through circuitry, coding, design, and fabrication, as well as non-technical skills such as collaboration and critique. It is designed to bridge connections between girls' existing interests and STEM using an interconnected framework of project-based activities, narrative stories, and an online social networking platform. Integral to DYD is a community of peers and mentors who play a critical role in leading activities involving hands-on learning experiences, building social relationships, and providing encouragement to girls to persist in STEM.

After several years of researching, designing, and developing DYD across diverse urban and suburban cities in the Midwest [24, 26, 57, 64], our focus has widened beyond program design to attend to the broader learning ecosystem and infrastructure. Based on work from scholars such as Gloria Ladson-Billings [44, 45] and Carol Lee [47], and our experience co-designing the program with Black and Latina girls, our early efforts focused on designing a culturally relevant curriculum that debunks stereotypes and that is relevant and meaningful to our target populations. Additionally, since culturally relevant pedagogy requires that learners have opportunities to practice critical consciousness and to question social norms and values [44], we designed DYD specifically to provide such opportunities and to support Black and Latina girls in describing their identities and futures [57, 64]. After achieving our goal of providing high-quality, culturally relevant STEM opportunities to Black and Latina girls, we began to focus our efforts on the importance of adult support, where we co-designed activities and a network for family engagement that intentionally includes parents and caring adults [51]. Feedback from participants parents and caring adults led to expanding our attention to organizations and infrastructures, leading us to take a transformative justice approach to our work—addressing the immediate harms of discrimination in CS while also building counter-structures to address root causes of harm. As evidenced by the history of DYD, we view both culturally relevant pedagogy and transformative justice as necessary, although meant to support work at different scales. Although culturally relevant pedagogy allowed us to design at a classroom scale, transformative justice supports our current work of designing a community ecosystem of youth program providers who are committed to creating welcoming environments for Black and Latina girls. Therefore, DYD consists of youth and parent and caring adult programming, as well as training and partnerships with mentors, program providers, city agencies (e.g., library and parks), and school districts.

It is important to note that we intentionally decided that the DYD curriculum will not explicitly name and discuss historical harms caused by CS education, the tech industry, and society during our program in an effort to provide safe spaces for Black and Latina girls where they can just be children rather than engage in adultification [23] by reminding them of societal harms and potentially causing more trauma. Instead, we seek to create counterspaces [56], where girls are made

to feel safe and comfortable so they can start discussions about harms and negative stereotypes if they wish, but they do not feel forced to do so. In the past, for example, DYD girls decided to build a tool using sensors to help those who are visually impaired cross the street. This project emerged from a discussion where the girls stated that they witnessed the difficulties as a result of the lack of auditory pedestrian street crossing systems in their neighborhood. The project stemmed from the city's lack of investment in their neighborhood to install more expensive auditory pedestrian crossing systems, thereby making those who are visually impaired less safe. The girls decided to use the STEM skills they learned in DYD to address the harm. Thus, we designed DYD as a program that allows girls to take an activist stance in their projects if desired and to engage in discussions about harms with program mentors and leaders, but they are not required to do so.

For more than 8 years, DYD has been implemented in several different neighborhoods and surrounding suburbs of a large Midwest U.S. city in various configurations (e.g., afterschool, Saturday, summer, online program). Although the program has been offered in different geographical areas over the years, a consistent goal has been to engage middle-school-age Black and Latina girls in STEM and computing. In this work, we focus our discussion on one mid-sized, suburban city, which we refer to by the pseudonym Graceland. Graceland is a racially diverse city with a population of roughly 70,000 residents, where 60% identify as white (non-Hispanic and/or Latino/a/x), 17% Black, 12% Hispanic or Latino/a/x, and 10% Asian. As another testament to its diversity, nearly 20% of residents have foreign-born parents. Roughly half of housing is owner occupied, the average household income is roughly \$78,000, and educational attainment is relatively high with at least 65% of residents having a bachelor's degree. At the time of this writing, DYD has been operating in Graceland for 5 years with programming extending from November to May during the school year, in 6-week camps held in the summer, and in pop-up sessions hosted throughout the year.

There are three main reasons we focus specifically on Graceland as an example of applying a transformative justice approach: (1) the population and size of Graceland is more similar (and therefore perhaps more relevant) for those implementing computing education in other mid-sized suburban and rural areas; (2) the harms that have historically and currently happen in Graceland are similar to many other cities of its size (as well as smaller and larger places); and (3) particularly in recent years, the city of Graceland has demonstrated a willingness to combat racial inequity and has attempted to address historical injustices through several policies and programs. Thus, it is an example of a relatively progressive city in terms of its stance on racial injustice, although issues of structural oppression persist.

4.2 Our Approach

In this article, we apply autoethnography [31] as a method for describing our experiences creating DYD as an attempt to counter structural oppression that has negatively impacted Black and Latinx youth, families, and communities. Our description of our experiences engaging in resistance to injustices faced by Black and Latinx communities aligns with Black Feminist Thought and intersectionality [12, 14]. Specifically, we engage in (1) self-reflection and acknowledgement of the systems that perpetuate the oppression of Black and Latinx communities, as well as our own privilege as scholars who work within these systems of oppression [14], and (2) resistance to combat and counter ongoing racism, discrimination, and oppression of Black people in the United States at the hands of organizations, institutions, and other entities that uphold white supremacy and whiteness, aligning with Black women and their allies who have historically engaged in resistance [12].

Aligned with standpoint epistemology, we leverage the validity of "one's own experiences" as knowledge, truth, and an illustration of data through *testimonial authority* [14]. Testimonial authority is the ability and right for those who have been traditionally ignored, disbelieved, and/or

dismissed to share their autoethnographic lived experiences as epistemic agency [14]. “Testimonial authority within a given interpretive community rests on the ability of a person both to speak and to be heard . . . But it also rests on interactions among listeners who decide the degree to which the testimony put forward fits within the epistemological rules of the community” [14, p. 132]. In other words, the computing education community has the ability to accept or deny our testimonies of designing justice-oriented computing environments; however, to deny these testimonies is a form of epistemic violence, a method of silencing marginalized groups [22]. Specifically, we engage in testimonial authority by reflecting on issues related to designing, implementing, and researching DYD in Graceland, as well as articulating how our long-term research and design effort developed to increasingly attend to structural oppression. Our reflections and testimonies shared in this work stem not only from our own experiences as members of the research team but are supplemented with additional data sources gathered over the years such as pre- and post- surveys from parents and youth, interviews with families and mentors, observations and field notes from the program sessions and family events, and log data from our online learning platform.

5 PRINCIPLES

In this section, we present three principles for leveraging transformative justice as a framework to design computing education experiences for those who have been excluded by structural oppression. For each principle, we first describe the harms caused by historical and current policies, institutions, and practices that create power structures that prevent equitable access and participation to educational opportunities broadly and to STEM and computing education specifically [4, 28]. Next, we describe ways in which we attempt to address those harms. Last, we describe the result of implementing counter-structures and how they contribute to the larger goal of resisting systemic oppression and transforming participation in STEM and computing.

5.1 Principle 1. Computing Education Must Address Local Histories of Injustice by Engaging Community Members and Building Collective Efficacy

5.1.1 *Harm.* Any step toward equity for Black youth in Graceland must begin with an acknowledgment of the specific wrongs that have caused and perpetuated inequity. In the historically Black area of Graceland, where most Black residents live and where we held DYD, the harms are evident and result from unjust practices perpetuated by federal and local governments. For example, most Black residents currently live in one area of the city due to policies that intentionally created housing segregation using a number of official and unofficial practices. Between 1910 and 1970, the Black residents were almost entirely limited to purchasing homes in one area of the city (delimited as a regional “ward”) [73]. As a result, by 1940, 95% of the residents in the ward identified as Black. Mechanisms of structural oppression ranged from unofficial realtor practices that steered Black people away from purchasing in other wards to banks that refused to lend to qualified Black families seeking to purchase in white wards [73]. Furthermore, local “Improvement Associations” pooled funds to purchase homes in white areas that were at risk of being purchased by a Black family, a tactic to maintain segregation [65]. Any attempt by a Black family to try to circumvent these policies and practices by pushing to live in another area of the city were met with retaliation including (but not limited to) physical violence from white residents, loss of jobs, and/or repercussions to Black business owners (e.g., burning down businesses, lack of patronage). As with all cities that experienced redlining (i.e., racial discrimination in investment and lending practices in Black areas while simultaneously pushing capital, city services, and infrastructure investments in majority white areas), residents of Graceland are still feeling the negative impacts (e.g., concentrated poverty, high unemployment) of such policies that have created harms that are yet to be corrected [2].

Restricted to living in one ward, Black residents experienced separate treatment that was by no means equal and that still has effects today. The majority Black ward is currently the only ward in the city without a neighborhood school; it was closed in 1979. Ever since, Black youth who live in the ward are divided up by street blocks and bussed to predominantly white schools, which fulfills the technical goals of school desegregation but creates a fractured Black community that lacks the same social capital of white neighborhoods with local schools. Bussing creates a set of circumstances where kids cannot participate in afterschool activities held at the school, because they have to get on the bus to return home as soon as school ends—unless their parents can provide alternative transportation options, which can be difficult. Furthermore, without a neighborhood school, there is dearth of informal educational spaces in which Black youth can engage in out-of-school activities in their neighborhoods, a critical part of youth interest exploration [46, 50]. Citing budget restrictions, the city neglected and disinvested from the building that was formerly the ward's neighborhood elementary school. The city then sold the building to a social service, non-profit organization that, despite well intentions, has been unable to maintain the building due to costs. Currently, the former school building is for sale, which if sold will displace several community organizations that are tenants and that serve the community. Community residents have been vocal about wanting to be a part of the decision-making process in regard to the sale of the building, citing the historical and current importance of the building. City officials and the school district have indicated that philanthropic organizations should cover the cost of maintaining the building and that Black youth should be able to commute to other areas of the city to access spaces for informal learning opportunities, a task that white youth and families living in other areas are not expected to do.

Another detrimental result of bussing and school closure is that the social networks between youth and caring adults in the community are fractured, because children are distributed across more than six different primary and middle schools. This structural configuration has weakened the social cohesion among residents of the predominantly Black ward as compared to other wards. Graceland is known as a place where people move specifically to raise a family. The networks surrounding one's immediate community and children's school are the building blocks for becoming aware of learning opportunities, supporting youth development, and building social capital and collective efficacy that can be used to advocate for youth. As we led the DYD work in Graceland, it was critical to acknowledge the history of housing segregation, disinvestment, school closures, and bussing as injustices that these communities and families still face and to develop DYD as a sustainable program and community in itself that acknowledges and attempts to repair the harms.

5.1.2 Counter-Structures. Understanding the history of harms due to the local school closure, bussing, and disinvestment, we attempted to design three different aspects of DYD to counter such harms. First, we worked with local residents to identify the ideal location for DYD to make it accessible for our target population. Second, we worked to build a community with social capital among families and with community-based informal learning providers. Last, we invested in Graceland's majority Black ward, which had experienced the highest levels of disinvestment, by hiring local small businesses to host and cater our events and becoming paying tenants of learning spaces that the city had disinvested from.

Location was one of the fundamental decisions that we considered when initiating DYD in Graceland. Even as Graceland's majority Black ward lies less than a mile from our academic institution, it was critical that the program have a home base within the community we desired to serve. The legacy of bussing means that youth that live in the majority Black ward are consistently forced to operate in predominantly white communities, leading them perhaps to feel like outsiders given that other youth who attend their schools and afterschool program actually

live in the area. Although we had the option to use the free space at our academic institution to host DYD (and could have justified it as an opportunity for youth to be on a college campus), we ultimately did not host our program at the institution because such a decision would re-create the same structures of oppression that the girls and their families face on a daily basis, causing more harm). To create a sense of ownership of the DYD program, we knew that it had to exist within the community that the girls lived in, knew, and loved.

Other critical strategies in our DYD approach were to (1) implement our **Caring Adult Network (CAN)**, making DYD a family STEM program with the goal of connecting parents who may live on the same block but do not know each other because of racist bussing policies that have fractured the community, (2) have a community-based recruitment effort to engage traditionally excluded Black and Latinx parents and caring adults (i.e., Black immigrants, Spanish-speaking families), and (3) create a monthly social hour for Black professionals in the community to strengthen their collective efficacy. To implement these methods to engage community members, we hired a **Community Relations and Engagement Manager (CREM)**. Our CREM was a Black woman who lived in Graceland and who had children who were enrolled in the local school district. The role of the CREM was to foster relationships with the parents and caring adults, understand the challenges they face, and to build relationships between our academic institution and the local Black community. She helped bridge the experiences of caring adults and youth by engaging adults during pick-up and drop-off before and after youth program sessions, learning about the family structures of the participants, and serving as a consistent, guiding presence in the program. By living and working in the Graceland community and drawing on her community engagement expertise to know when and how to ask questions, the CREM served as an asset to community members not only in the context of this project, but in other areas of local life as well. As a paid, full-time member of our team, our CREM played a vital role in our decisions about DYD and research including co-authoring research publications about her strategies and experiences [25].

In an attempt to counter the local policies, which have resulted in youth and families who are disconnected from each other and limited in their ability to share learning opportunities, we developed CAN with several goals in mind. One goal was to create a space for the CAN community to have a voice in the program design and experience (for both the girls and themselves). Therefore, the CREM facilitated workshops and events with parents to solicit their feedback on the location of the program, as well as how DYD and CAN should be organized, specifically how best to engage parents as equal partners in the work of creating a sustainable informal STEM learning community. Without parent feedback, we recognized that it was unlikely that we would meet their collective needs, and we were likely to reinforce the oppression that prior programs and organizations (intentionally or unintentionally) created.

Another goal was to leverage CAN to take a community-based approach to recruitment efforts. In addition to the feedback workshops, the CREM led our recruitment efforts, which ranged from working with local business owners, churches, schools, local organizations, and community leaders to invite girls and families to participate. We worked directly with community leaders with strong ties to immigrant groups to host special events and invite those who may not speak English or who did not know the purpose of out-of-school learning activities. Parents from Haiti, the Caribbean, and various countries in Africa and South America participated in these events. Living in the community and having an understanding of all the nuanced segments of the Black and Latinx community allowed the CREM to recruit using methods that appealed to families who are many times marginalized and/or ignored. For example, working with a local Latinx business owner, who was also a prominent member of a local Catholic church, the CREM co-organized a recruitment event targeting local immigrant families that was facilitated entirely in Spanish.

The DYD team and the CREM also held various educational and social events with families to build social capital among the parents as a part of CAN. These events ranged in topics from educational STEM and identity workshops to fun, adult-only social hours. The educational workshops, for example, were led by one of the lead researchers, a Black woman who lives in Graceland with her spouse and children. Workshop topics engaged parents and caring adults in table discussions about the support roles they play in their child's learning, as well as the impact of their girls' intersectional identities and the impact it may have on their experiences in society and in STEM. The educational workshops always ended with a showcase, where DYD girls showed off their projects to the parents and caring adults in CAN. This gave parents an opportunity to give the girls feedback and get to know both the youth and their families. The social hours were informal events where parents enjoyed a night without children. At one CAN social event, for example, a DJ played music while parents and caring adults ate dinner and made chocolate with a local chocolatier to take home for Valentine's Day. We provided childcare, movies, STEM activities, and dinner for any children the parents wanted to bring as to not burden parents with having to make the choice between the cost of a babysitter or to attend the social event. Last, we made sure there were enough to-go plates for parents who needed to take food home for other loved ones or for the next day. We held all workshops and events in Graceland's majority Black ward, making participation easier for parents who desired to attend but did not have transportation. CAN parent leadership set the time and day of the events and gave feedback on the planning of such events. As a deliberate attempt to counter the impact of the social fracturing experienced by bussing, the working and social events provided a pathway for caring adults to get to know each other, bond, and create strong social ties and social networks that would be critical for sharing information as the kids continued in DYD and beyond. This was a deliberate effort to counteract the effects of bussing on the community.

Lastly, we focused on investing in the community we served. For example, we became tenants in the neglected former school building. Our rent went to building maintenance and improvements, which we witnessed in less than a year of us being tenants in the space. Having a major institution hold programming in the building signaled an invitation to other organizations to also become tenants and host programming there. Perhaps an effect of our presence (i.e., as a major university renting space), we witnessed the tenancy rate in the building increase during our tenure in the building, including our university committing to a lease that ran beyond our grant cycle so other faculty could situate their programs within the space. Furthermore, all the events were catered by local Black- and Latinx-owned restaurants. For instance, at the chocolate social hour, a local Chilean restaurant catered the food and the chocolatier was a licensed Black woman from Graceland, who also became a tenant in the same building to support her catering small business. We also hired local high school and college students from Graceland to provide on-site childcare and STEM activities for the youth that attended the event with their parents and caring adults. Although these may seem like small efforts, they were duly noted by the community and local businesses appreciated the support and advertising (e.g., several parents asked the chocolatier if she hosted birthday parties and other events).

5.1.3 Outcomes for Principles 1. As stated earlier, our tenant occupancy in the disinvested former school building as a higher education institution may have lent legitimacy to the building, which had been neglected by the city. After our first year in the building, we saw modifications in the building maintenance, upgrades, and additional tenants moved in who also provided out-of-school learning opportunities to youth in the community. Thus, although our academic institution has historically caused harm (e.g., being a whites-only institution until the early 1920s), we leveraged its reputation to increase investment in the community. This allowed parents to

drop off their youth of all ages for programming at one location in their neighborhood—that is, middle school girls could attend DYD and their siblings who may have other interests or who may not fall into our target demographic could also access quality informal learning programs by other community partners.

As a result of the location and recruitment efforts, the program participation was very high, with more than 45 girls regularly participating in the weekly program in the first year and more than 85 signing up in the subsequent year. More than 85% of parents and caring adults participated in at least one of the CAN workshops, and more than 70% participated in two or more workshops or events. Those who did not participate cited conflicts with work and other obligations as reasons they were unable to participate, but most said they planned to participate in the future. Given that we are committed to closing the gap in the social network that was created by bussing, we documented bonds being built across families in the program as a result of CAN. For example, we observed parents whose children attended the same school and/or different schools exchange phone numbers after the girls shared the importance of their new friendships with their parents as well as parents sharing information about other opportunities or ways to navigate the school district politics. The social networking opportunities created by CAN is a direct counter to the loss of numerous opportunities parents would have to interact with each other if they walked their children to and from a neighborhood elementary school, attended PTA meetings all at the same school, or simply met because their children were in the same classes. The youth showcases that caring adults attended allowed the DYD and CAN participants to normalize celebrating Black and Latinx excellence and hard work and having a community rally around their achievements.

5.2 Principle 2. Computing Education Practices Must Counter Negative Stereotypes Perpetuated in Computer Science and Create Truly Inclusive, Safe Spaces

5.2.1 *Harm.* Most approaches to computing education describe the potential benefits of the field without acknowledging the harm that computing has caused and the gatekeeping that excludes certain people from participating and engaging in the computing. In Graceland, the evidence of exclusionary practices are visible in the fact that (1) the local district high school offers **Advanced Placement (AP)** courses in CS, but there are few, if any, Black students enrolled in the course despite strong interest in primary and middle school; (2) the high school CS clubs, even those specifically for girls, have nearly zero participation from Black and Latina girls; and (3) Black youth are disciplined through school suspension at disproportionately higher rates as compared to other groups of students.

Unlike many schools, Graceland has a large number of honors and AP courses in which students can enroll. The advantage of taking AP courses is that if students score a 3 or higher on the exam, they receive college credit for taking the course, potentially saving them thousands of dollars on college tuition. Such savings could be incredibly important for people whose families were discriminated against and excluded from the opportunity to build generational wealth, particularly Black Americans who have a significant wealth gap to this day as a result of laws and policies prohibiting their acquisition of wealth [42]. Furthermore, taking AP courses such as CS can signal to college admissions that students are prepared to enter and be successful in CS at the college level, and perhaps worthy of scholarships based on merit. However, at **Graceland High School (GHS)**, there are disproportionately fewer Black and Latinx students enrolled in AP courses. An internal study found that white students who do not qualify to take advanced courses typically have parents who successfully advocate for their placement in advanced courses. Many times, parents advise other parents about the process (i.e., what they can do to get their student placed in advanced courses); however, with the lack of social capital in the only majority Black ward, information on how to navigate the school system (and leverage parent advocacy) is somewhat

hidden. Furthermore, the few Black and Latinx GHS students enrolled in AP courses report feeling isolated in class and therefore not motivated to do well in the course or on the exam.¹ Roughly 50% of Black students achieved a 3 or higher compared to more than 80% of white students in 2018. Feelings of not belonging is strongly felt in the AP CS courses as well, particularly because of the lack of representation (i.e., seeing people who look like them as teachers, mentors, and peers).

Informal spaces that are designed to support girls in CS many times exclude the intersectional identities of Black and Latina girls as evidenced by the fact that the girls-only GHS CS afterschool club had few Black and Latina girls. Other STEM and computing out-of-school programs in Graceland have also reached out to our team about the lack of diverse women in their programs—many times asking us for help with recruitment. There may be several reasons for the lack of a sense of belonging in learning environments in school and out of school. To address the lack of inclusive spaces, we must acknowledge the harm caused by bussing Black youth to different predominately white and affluent schools. Predominantly white learning environments are often perceived as hostile by Black students [33, 55, 79], and Black girls and women experience saturated violence on a daily basis in such spaces, particularly in computing [61, 62, 69]. Although our goal is to encourage middle school girls to participate in computing even being a part of DYD, we recognize the harms that they have likely experienced on a daily basis, interacting mostly with people who do not look like them and perhaps feeling like they do not quite fit in [62].

Similarly, there are pervasive stereotypes of who belongs in computing and who does not, with those having intersectional identities of being both Black and/or Latina and girls as not belonging either [40]. Many of these narratives are pushed by society and culture; however, much of it manifests in the lived experience of youth. Black and Latinx children, and girls in particular, are not always afforded the space to be young, with society often viewing them as older than their white counterparts [23, 30]. Additionally, Black girls are increasingly sexualized, including facing harsher punishment as compared to their white peers for wearing certain types of clothes or behaving in a certain manner [23]. This plays out on the local stage in the types of disciplinary action given but also in computing (e.g., searching for Black girls on Google brought up pornographic images of Black women until recently [54]). This stereotype results in the harm of increased discipline for Black and Latina girls, which happens in Graceland where Black and Latinx youth are more heavily disciplined than other students. For instance, Black students make up only 27% of the student population of GHS but represented 54% of the suspensions in 2019. Witnessing the criminality and sexual objectification of Black and brown bodies on a daily basis through harsher reprimands for Black and Latinx students as compared to their white counterparts feeds into stereotypes that Black and Latinx students are not worthy of education and that they do not belong in computing. This has a detrimental impact on students' self-image, as well as the perceptions their white peers, teachers, and administrators have of them. Therefore, the result of these harms perpetuate false narratives, even among teachers who have the power to encourage students to participate in computing and communicate who fits into computing education or education more broadly.

5.2.2 Example of Counter-Structure. To repair the harm that the lack of representation and sense of not belonging in advanced computing courses in school and STEM programs out of school cause, and to counter harmful negative narratives about Black and Latinx people, DYD aims to provide an inclusive space for Black and Latina girls to grow and affirm their racial, gender, STEM, and other identities. We do this by (1) allowing the girls to redesign their own physical space so that it is a comfortable place for them to engage in STEM and computing education; (2) intentionally recruiting Black and Latina students to create a strong peer cohort, as well as hiring mentors

¹Citation is not included here to maintain anonymity of the city.

that reflect the DYD participants; and (3) creating a “Divas Circle,” a safe place for girls to share their thoughts, experiences, and questions about anything including identity without fear of being reprimanded or offending others.

One of the first activities we organized involved having DYD girls reimagine and redesign the physical space where the program was held. Our goal was to allow the girls to create a space that they could truly call their own, to build camaraderie and feelings of sisterhood through shared team work, and to remind the girls that the ideas, thoughts, imaginations, and futures of Black and Latina girls matter and that they have the power to manifest those futures. We gave DYD participants tools, materials, and training to engage in the redesign project. They leveraged their skills in STEM to both design and complete the transformation of the space. Having a space that they envisioned and designed to meet their needs for unstructured social time, the girls were able to inhabit an identity that contrasts society’s constructs of Black and Latina girls and women—which at best erase them from academic spaces, and at worst sexualize, criminalize, and degrade them [7, 61, 72]. Enabling the girls to redesign the room in which they spend time with their cohort creating, tinkering, and making STEM-based activities, as well as socializing and building strong bonds with their peers and mentors, allowed us to address harm caused by gendered racism through physical space created by, for, and with Black and Latina girls.

To further address negative stereotypes that are perpetuated by the lack of diverse representation and inclusive environments in computing, we co-created stories with girls that included diverse characters to launch the STEM projects [24, 26, 57]. Specifically, we worked with girls to co-design stories that were then written by a Black woman who is a popular young adult author. The narratives debunked stereotypes of Black and Latina girls, as well as others who are marginalized in computing. The main storyline centered around a fictional DYD program, where the characters in the stories had STEM superpowers (e.g., design, coding, making, engineering, robotics) and faced issues that the girls in the real-world DYD program had to solve through the in-person STEM projects. Moreover, additional issues around identity and personal challenges that girls faced in the real world were embedded into the stories to provide space to discuss what the characters were going through and how that may or may not relate to the girls’ lived experience (e.g., bullying, discrimination, friendship fallouts). The characters’ intersectional backgrounds ranged in diversity in terms of their racial and ethnic identities, family structures, body type, disability status, and so on. During the co-design process, the importance of not leaving anyone out was evident given that the girls sometimes felt excluded in their lived experience at school, in books and movies, and at out-of-school programs [24, 26]. We formatted the stories into printed books, audio podcasts, and animated videos to launch the STEM-based projects.

In addition, we hired high school and college mentors who reflected the diversity of DYD girls. The instructors and researchers who interacted with the DYD girls were all women of color—many of them who studied or worked in STEM fields and/or women who leveraged STEM in other fields of study (e.g., health, modeling, entrepreneurship). By hiring mentors from the high school, 2-year and 4-year colleges, and graduate schools, we created a pipeline of Black and Latina women for DYD girls to look up to and interact with on a regular basis. Thus, all DYD participants had the opportunity to engage with high school, community college, and university student mentors. Graduate students and faculty of color were typically research assistants or program leads but were available and present at many of the DYD sessions, which provided a lens through which the girls could understand what STEM looks like in an academic career. Access to a network of women with ample opportunities for social interaction ensured that DYD participants could always seek and share information with people who not only looked like them but also were at different stages in their computing careers. Parents and community members of color were also brought in to showcase their STEM-focused careers and skills. Our approach to

mentorship, although challenging to implement, was important to counter negative stereotypes by demonstrating to DYD girls that Black and Latina women in STEM are everywhere, even as they may seem invisible or hidden in society's depictions of STEM-focused individuals. The relationships girls developed with peers and mentors who shared their intersectional identities fostered trust and strong bonds that persisted throughout the program; even after the program ended, some mentors still kept in touch with the girls and their families.

Further, DYD worked to create a safe, social space (the "Divas Circle"), where girls can reflect on their identities and lived experiences, discuss thoughts and challenges, and bond with other girls who looked like them. Mentors led the discussions and created rules for interactions that allowed everyone to use their voice, to engage in respectful and thoughtful dialogue, and to push girls to think critically about stereotypes and their role in debunking societal myths about Black and Latinx people. For example, when a conversation emerged about Rosie the Riveter as the girls looked for images of influential female figures in history for an etching design STEM project, mentors instinctively embarked on an in-depth conversation with girls about the exclusion of Black women throughout the history of computing and engineering [40]. This story highlights why computing education must counter harmful societal narratives in a meaningful way, where honest conversations can be had in safe spaces and without the wrath of and/or offense to white people [18].

5.2.3 Outcomes for Principle 2. We saw positive outcomes from the structures we established to counter negative stereotypes perpetuated in computing. Specifically, the space redesign was very successful. Girls personalized the walls with their names and other things that related to their personal identities. They felt more connected to the space as a result and found it a comfortable place to lounge, complete with hanging chairs and couches—providing a space that they felt comfortable tinkering in. We created several programs to support more formal scheduled programming and opened up the space for girls to "hang out" and explore STEM activities on their own time. The peer and mentor network was extremely strong with 92% of girls reporting by the end of DYD that their mentors cared or strongly cared about them. Continuing girls sought to be paired with girls they met in the program in the previous year, suggesting that girls also formed relationships and bonds with their peers that persisted beyond the program. The Divas Circle was also very successful in that girls explored their thoughts and feelings about various identity-related issues. We found that girls who were older (i.e., 7th to 8th grade) had deeper and more reflective conversations, whereas younger DYD participants engaged with the topics surrounding identity at a more surface level, exploring and discussing these issues sometimes for the first time. Oppressive structures are upheld by oppressive narratives, and therefore the counter-narratives that the girls and mentors developed in DYD are a critical component of building transformative structures that center healing and justice.

5.3 Principle 3. Computing Education Must Build Sustainable, Computational Capacity in Communities

5.3.1 Harm. As many tout computing careers as an opportunity for Black and Latinx youth to enter a well-paid field, there is a lack of acknowledgment of the hostile experiences that such groups face while pursuing careers in computing, particularly Black women [61, 69]. We bear witness to harms in computing and in society that hinder building the computational capacity necessary to sustainably increase the number of Black, Native, and Latina women in the field of computing, such as (1) the lack of representation in computing education and work environments, which many times results Black and Latina women experiencing violence and trauma; (2) ignoring the systemic oppression that the field of computing is complicit in and the impact that it has on

people of color (e.g., its impact on the gentrification that Black people experience in Graceland, oppressive computing outcomes due to predictive policing); and (3) the discussion about, but lack of commitment to, building a sustainable pipeline beyond one-off computing education programs.

Although women in general are underrepresented in the tech industry, women of color are more likely than white women to leave their jobs, citing “unfairness” as a core reason for leaving a tech position (36% vs. 28%) [68]. Additionally, one-third of women of color report being passed over for a promotion, which is higher than any other group [68]. Despite these realities, a false narrative of the computing field as being a meritocracy in which race does not impact outcomes continues to be perpetuated, which in turn actively dismisses the lived experiences of Black and Latinx women in the industry. Such thinking leads to misguided recruitment and STEM program interventions that fail to address the biased practices that exist within organizations [68]. Examples of such behavior begin in computing education spaces [62] and are found in examples where youth in GHS have repeatedly described their experiences of being overlooked, ignored, and mistreated as reasons they do not enroll in or drop out of CS courses.²

In addition to the violence experienced in computing, innovations in CS have caused job losses for low-wage laborers like taxi drivers and hotel workers as the gig economy favors workers who have their own assets (e.g., cars and homes) with which they provide services. This made redundant the typical taxi driver who could have rented a cab from a fleet, creating a lower barrier to entry. Black and brown workers are disproportionately left behind when industries have a major tech pivot [67]. The CS field also fuels gentrification, the economic displacement of lower-income, often racialized residents by high-wage employees at tech companies. In Graceland, gentrification is pushing Black residents out as real estate prices skyrocket, causing property taxes to escalate as well. Many of the remaining Black fixed-income seniors eventually find themselves unable to afford their home expenses, causing them to sell to more affluent buyers. Gentrification is made worse due to the increase of white people in tech fields moving to Graceland to raise their families. Black residents dropped from 22.5% of the total population in the 2000 census to 16.6% in Graceland based on the American Community Survey in 2019, all while home prices in the area experienced a 48.5% increase from 2000 to 2020 [11]. In particular, the majority Black ward lost 37.5% of its Black residents from 2000 to 2020 [11].

Other harms that we must acknowledge that have stemmed from computing include, but are not limited to, the perpetuation of overpolicing in Black and Latinx communities, disparities in criminal sentencing, unfair housing placement policies, and biased lending practices [7, 27, 54]. Technologies such as predictive policing algorithms, which draw from historic crime data and are used to target police resources in areas where crime is *expected* to occur, justify heightened police presence, and can create an expectation that people in the targeted area are more likely to commit a crime [7, 71]. The data that predictive policing technologies draw from has inequities embedded into it because historic (and ongoing) injustices such as disinvestment, neighborhood destabilization (e.g., caused by “urban renewal” projects), and the over-policing and criminalization of Black communities through the “war on drugs” have inflated crime rates in many segregated Black communities [3, 42]. These disparities are then reproduced by policing algorithms that “predict” where a crime might occur and target police in Black communities, fueling mass incarceration. Algorithmic systems such as predictive policing are often turned to as a means to mitigate human bias and are mistakenly seen as an “objective” way to make decisions with great human impact, such as setting bail or prison sentences, determining a person’s welfare benefits or if they can keep custody of their child, or whether a person is eligible for public housing or a loan [27]. These systems operate without accountability structures or means of recourse, and the data they use

²Citation is not included to maintain anonymity of the city.

is shaped by historical oppression and skewed by inequities (e.g., credit scores, zip codes, incarceration history), which are in turn reinforced by such systems. On the surface, these societal transgressions may seem far removed from the DYD program, but they provide a view into how CS amplifies racial inequities and harmful narratives [70] that the girls in our program experience and that we attempt to resist. Furthermore, this pattern of amplification points to the need for computing education to support racialized communities' in building their capacity to sustainably counter the harms caused by computing.

Despite computing causing harm that has lasting effects on Black and Latinx communities, computing education has traditionally focused on skill development rather than enhanced capacity building within Black and Latinx communities. Through our experience living and working in Graceland, we recognize the lack of long-term capacity building and pipeline creation [59]. By capacity building, we refer to the goal of creating cohorts of students and families that are able to engage in STEM and computing beyond one-off initiatives aimed at targeting a few of the "best" or most talented students. A sustainable pipeline would consist of parents and caring adults who are engaged in their youth's STEM and computing education and feel comfortable enough with their own skills to provide support, encouragement, and placement in STEM programs. Furthermore, it would consist of Black and Latinx educators (e.g., mentors, teachers, youth providers) who engage in STEM and computing education and where their presence normalizes the long-term participation of Black and Latinx people in STEM. Last, a healthy pipeline would consist of students who experience formal and informal learning environments that were created for them to thrive (not to simply survive), where they can openly explore their interest as it relates to STEM and non-STEM topics. The latter requires that both the in-school and out-of-school network of STEM program providers work together to engage in the professional development needed to learn how to create inclusive STEM and computing learning spaces. In Graceland (like most other similar cities), there is a lack of initiatives that approach computing education holistically, where parents and mentors are engaged in the long-term success of Black and Latinx students. Given our assessment of living in Graceland, talking to parents, and engaging with in-school and out-of-school STEM learning providers, we recognize the harms that have long-term, negative impacts on Black and Latinx communities and the lack of sustainable, computational capacity within these communities to combat the harms.

5.3.2 Counter-Structure. To build sustainable community capacity, we designed a structure that (1) supported parents and caring adults in building STEM skills and engaging in learning support roles, (2) hired Black and Latinx mentors who reflect the lived experience of girls in DYD, and (3) trained a collective of local STEM learning providers to create inclusive learning environments.

As described earlier, CAN is an example of intentionally created space for parents and caring adults to support their girls' STEM and computing education. In addition to the education workshops, social events, and showcases, CAN participants also gained STEM skills, where we introduced basic engineering and computing skills by allowing them to complete some of the same projects that their girls completed. Many times, the girls would join the workshop toward the end to play the role of "expert," where they helped their parents learn circuitry, coding, and other STEM concepts. This bonding activity built confidence in the youth as they explained to their parents and caring adults why certain things worked the way they did, but also supported parents in completing the projects. Furthermore, we provided parents with specific question prompts in the case that they did not know what to ask their girl about the project. These prompts helped to facilitate conversation beyond "What did you do?" and instead allowed parents to become comfortable asking very specific questions that gave the girls an opportunity to practice describing what they learned in their own words. Last, we created a customized space in our online social

network platform to provide parents access to additional learning resources for themselves, view photos of their youth's completed projects, and register their youth for other programs and activities based on their interests.

We also worked to build community capacity by hiring and training Black and Latinx mentors through a city program to teach girls computational skills, as well as the history of oppression. Our approach to creating a sustainable pipeline was to pay mentors through a city job training program that has been in existence for more than two decades. Although there is a range of types of city jobs, our mentors are hired to lead STEM programming in their neighborhoods, allowing them to gain experience teaching and mentoring. In addition, we worked with local community college administrators to allow high school and community college students the opportunity to accrue free college credits toward a degree and/or a certificate due to their training to be a STEM mentor, which included a focus on socio-emotional learning, trauma training, and skills in various STEM areas. We created a strong mentor pipeline to try to mitigate the harms caused by the lack of representation and commitment to building a sustainable pipeline. By connecting the program to the city's youth jobs program and the local community college, it allows for the pipeline of mentorship to sustain beyond any academic grant cycle or research project, as evidenced by the fact that some of the mentors have been hired through the city and community college program to other out-of-school STEM programs. This supports the representation of Black and Latinx women in programs outside of DYD, which is another method of creating sustainable community STEM programming.

Last, we formed a collective of STEM learning providers from Graceland (i.e., libraries, community centers, STEM advocates, and other community organizations) and have engaged them in regular meetings where we discuss methods on how best to create inclusive, informal STEM learning environments that are welcoming for Black and Latina girls in Graceland. Many of these learning providers have conducted youth programming for decades and have reached out to us to improve their approach to engaging Black and Latinx youth in particular. Bringing these organizations together is critical for identifying and building connections to encourage broad and long-term participation in computing across Graceland. For example, this involves coordinating schedules and content addressed in individual programs and city-level competitions, as well as sharing best practices and challenges. Our goal working with the collective is to work toward creating shared best practices for addressing inequities and creating supportive spaces for Graceland's Black and Latinx youth to flourish in STEM.

5.3.3 Outcomes for Principle 3. As a result of our structures to build sustainable computing capacity in the community, we saw increased parent engagement in the education workshops and social events held by CAN (as described earlier). A large number of parents have requested additional learning resources where they can continue to build their own STEM skills, suggesting the value they see in the CAN. Although adult STEM education is somewhat outside of our project scope, the request has encouraged us to look for ways that we can partner with other organizations that do provide adult education and connect parents to those resources. In addition, we have successfully trained more than 40 high school and college mentors since the creation of DYD, and many have gone on to continue their education in STEM and/or have shared that their STEM confidence and interest has increased as a result of being a mentor. The response from the STEM collective has been that the training has been useful, and there have been additional requests for us to facilitate additional workshops on issues such as ways to create more inclusive online STEM resources and improve youth recruitment—expanding the original set of topics that we planned to address through the collective. This work shows promise for developing communities' computing and relational capacities for creating structures that counter racist and oppressive institutions and policies that are often automated and amplified by technology.

6 DISCUSSION

As a way to address inequitable participation among Black and Latina girls in STEM informal learning environments, this article presents a set of transformative justice principles we contend must be applied in computing education if we are to make lasting changes. Drawing from our experience designing, implementing, and researching DYD in Graceland, we used our testimonial authority to describe how our understanding of histories of oppression and State violence that have resulted in inequitable outcomes for Black and Latina girls and their families was critical in shaping our approach to STEM and computing education. As the examples of the counter-structures we developed demonstrate, recognizing how Black and Latina girls have experienced harms in computing has informed our decisions at all levels, including curriculum; program design; recruitment; and mentor hiring, training, and development. Outcomes of these counter-structures are encouraging and suggest promising results toward long-term systemic change due to taking a transformative justice approach to computing education.

We did not start the work of building the DYD program in Graceland with the explicit idea of applying transformative justice principles. Our prior phases of work in DYD focused on inclusive curriculum, supporting learning across home, school, and online spaces, and building community among caring adults as ways to encourage girls to develop skills, interests, and experience in computing. In retrospect, when we set the goal of creating a learning ecosystem across Graceland to encourage girls in computing, our centrally held view of youth learning and development as dynamically developing across spaces and over time in interaction with adults [6] required that we attend to the whole city and the social and political structures that shape learning. As we focused our efforts in a new geographical area, our view of how to develop a learning ecosystem led sensibly to attend to the specific realities, needs, and goals of the local communities. For computing educators, our findings suggest that a transformative justice approach is consistent with prevailing theories of learning and research on the gender and racial gaps in computing that emphasize the importance of inclusive environments, supportive relationships, and access to learning opportunities. Key tenets of a transformative justice approach, such as fostering relationships, leveraging strengths, acknowledging local histories and goals, and working at interpersonal and structural levels [4, 19, 35] could therefore be used to extend existing efforts in new ways.

For others who are similarly engaged in efforts to expand who participates in computing, we put forward these principles based on transformative justice, with examples of how they were applied in our local context, to make a loud and resounding call to recognize the ways in which afterschool programs, curriculum design, learning platforms, and in-school efforts are inevitably shaped by structural factors and histories that make it very difficult or impossible to shift patterns of participation in computing. We contend that a sole focus on creating inclusive and welcoming environments and expanding an existing “pipeline” of people on their way to computing careers is not enough. Instead, these efforts should be coupled with other strategic initiatives to create sustainable programs that are situated within the communities they intend to serve and that intentionally attempt to counter historical and current harms caused by unjust policies and practices in society and in computing.

As stated at the beginning of this article, the current historical moment reflects a national reckoning with regard to the injustices Black and Latinx people have faced and continue to face today. Especially now, the computing education field must reflect on the roles we have played and the roles we must play in transforming how young people, particularly young Black and Latina girls, have access to the opportunities, people, and resources they need to become creators and leaders in computing. Although our research team has held the constant goal of encouraging more Black and Latina girls in STEM for many years, more recently we have been able to actively address

injustices that are embedded in community and city-level infrastructures. We view today's cultural moment as an especially ripe opportunity to highlight to our colleagues how an understanding of race, racism, and oppression has driven our work. We call on others working on various aspects of computing education to examine their own practices, assumptions, and knowledge about the harms the young people and families they work with have endured.

6.1 Challenges

What would it mean to heed our call for self-reflection and consideration of transformative justice principles in computer education? We recognize a need for further research and discussion on how they can be applied in practice. Here we point to a few challenges and issues to consider.

First, a fundamental aspect of the transformative justice approach is the recognition and understanding of harms to a particular population in a given community. What does it take to develop this knowledge and understanding in a way that is actionable? For a subset of the authors of this article, we attribute some of our capacity to recognize harms to our positionality as Black women living and working in the communities involved in our research. Having the lived experience of oppression provides a certain standpoint, which affects the ways in which situations are understood, problems are framed, decisions are made, and outcomes are evaluated. Thus, one might argue that to understand past harms and develop counter-structures without causing more harm requires agency and leadership of people who are from the community. Indeed, the transformative justice approach asserts the importance of community initiated and controlled initiatives in building alternative structures [16, 41]. This key tenet of a transformative justice approach thus raises questions about how efforts should be organized and who must be involved to appropriately acknowledge past harms and prevent more harm.

A second challenge involves the creation of counter-structures. Given that this approach must begin with acknowledgment of past harms, where do we begin to determine what counter-structures are needed? For others striving to apply a transformative justice approach, the question of what counter-structures to build has strong implications for our methods of collaboration and relationship building across institutions and communities (e.g., universities and neighborhoods). Community-based approaches for identifying assets [20, 75], framing problems, and developing designs for counter-structures are needed to apply these principles. Beyond collaboration, design, and research methods, further research in computing education is also needed to build a body of knowledge of types of counter-structures and their effectiveness.

A third challenge involves the scale of work inherent in the application of transformative justice principles in computing education. How can we as researchers begin to address structural harms that have been caused by systems and institutions? In addition to addressing histories of harm, the approach requires identifying root causes within social and political structures and working at interpersonal and structural levels. For our research team, it has taken many years of building social capital (e.g., with community members, school leaders, civic leaders, funding agencies), networks, collaborative teams, curriculum, platforms, and experience developing successful learning ecosystems to be able to successfully engage at the city level. We also attribute our ability to operate at various, intersecting levels to the practical matter of seeking multiple sources of grant funding to support long-term efforts. The overall research enterprise is necessarily dynamic because the research is always changing to adapt to the needs and circumstances of the local communities in which we engage.

Finally, we also expect that applying transformative justice principles to address inequities in computing education will create disruptions in existing power dynamics. Holding honest and critical conversations about racist, sexist, and ableist, among other, structures and policies and histories of oppression and harm can be traumatic and difficult. Just as the current historical moment has

put a spotlight on painful histories and persistent patterns of harm across society, people working in computing education need to directly address these issues and work to build new structures.

6.2 Future Directions

Even with the anticipated challenges identified here, this work aims to stake out new territory in the computing education field by demonstrating how histories of harm can and must be attended to in order to eliminate inequities of participation among Black and Latina girls in computing. Rather than constraining ourselves to the effort of expanding a pipeline of participation, a transformative justice approach may lead to building new and more equitable structures. By providing this framework, it is our hope to encourage further efforts to work at interpersonal and structural levels. This may mean further inquiry into the links between histories of harm and present injustices, grant funding calling for research and design aligned with transformative justice, and developing job roles and skills that are needed to work across structures and with communities.

7 CONCLUSION

Transformative justice requires honest discourse about patterns of inequality by race and gender across computing education and the workforce [48] to better equip Black and Latinx youth to navigate exclusionary systems and practices. However, the burden to find solutions to these inequalities lies not with youth, but with the educators, researchers, civic leaders, and others who design and establish systems. A sociocultural perspective of education necessitates that computing educators recognize that the process of learning is inseparable from students' perception of and participation in the learning environment [9, 38]. When STEM and computing education programs fail to create an environment in which youth can see themselves reflected in the mentoring, teaching, and leadership around them, they are less likely to persist, and institutions miss opportunities to repair harms and break cycles of exclusion. When the social and political structures in which youth and their families live create barriers to engaging in a network of support, inequities are perpetuated. In this article, we described DYD, a program that we designed taking an intersectional, transformative justice approach to provide a space for Black and Latina girls to make group connections, feel a sense of deep belonging, and strengthen their racial identity salience while developing a STEM identity. We described counter-structures, our acts of resistance to histories and systems that create and maintain inequalities [12]. As this moment in history highlights structural racism and oppression in all realms of society, computing education must also commit to countering persistent harms, which exclude Black and Latina girls from the field of computing. We charge educators, policy makers, and community leaders to take a transformative justice approach to designing learning experiences to combat historical injustice that oppressed communities have and continue to face.

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