"Go[ing] Hard…as a Woman of Color": A Case Study Examining Identity Work within a Performative Dance and Computing Learning Environment

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Performing arts computing environments have received little attention in the educational sphere; yet, they offer opportunities for learners to validate their efforts, ideas, and skills through showcasing their work in a public-facing performance. In this work, we explore an out-of-school dance and computing educational program run by the organization, STEM From Dance. The organizational mission is to create an equitable learning experience for young women of color to engage with computing while exposing them to STEM careers. Through an analysis of eleven interviews with youth participants, instructors, and the executive director, we examine how the social, cultural, and political dimensions of the learning environment facilitate identity work in computing and dance. Our findings point to three primary activities used by the organization to promote equity: (1) providing psychological safety through a supportive community environment, (2) meaningfully engaging with learners' social and cultural context through creative work with constructionist artifacts, and (3) actively promoting identity work as women of color in computing and STEM through both artifact work and community events. Applying the constructs of identity and psychological safety we explore the tensions and synergies of designing for equity in this performing arts and computing learning environment. We demonstrate how the seemingly contradictory elements of a high-stakes performance within a novice learning environment provides unique opportunities for supporting young women of color in computing, making them non-negotiable in the organization's efforts to promote equity and inclusion. Our work illustrates how attending closely to the sociocultural dimensions in a constructionist learning environment provides lenses for navigating equity, identity work, and support for inclusive computing.

CCS Concepts: • **Applied computing** → **Interactive learning environments**; *Performing arts*; • **Social and professional topics** → *Cultural characteristics*; *Women*; *Race and ethnicity;*

Additional Key Words and Phrases: Equity, computing education, dance, identity work

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1 INTRODUCTION

Creative computing spaces have opened up opportunities for learners to explore artistic disciplines and practices as they design and express their ideas through diverse media and technologies [4, 17, 30, 48, 76]. Within this ecosystem, performing arts integrate a live public showcase of learners' artistic artifacts, bringing visibility to their work and knowledge in relevant forms that cross disciplinary boundaries. These public performances can serve to stimulate motivation while enabling learners to connect their work to communities outside of the learning environment. This article examines an organization, **STEM From Dance (SFD)**, that teaches computing and dance to empower, educate, and encourage young women of color to participate in STEM and computing. The organization upholds community values and learning goals that have arisen to sustain the unique, supportive, interdisciplinary environment. The work reports a theme shared by every learner and educator we spoke with: The final, hyped, scary-for-some, live performance in front of family and friends, is critical to achieving the organization's mission. We provide contextualized insight into how the sociocultural characteristics of the learning community—including the learners, instructors, activities, and the dance and computing disciplines—create a unique landscape for identity work to support learner growth.

Dance education creates a space for self-expression in ways that stimulate learners to work across their physical, intellectual, and emotional selves [7, 49]. One set of explorations at the intersection of dance and computing involves learners coding avatars to dance, such as in the Dancing Alice and VEnvI virtual environments [54]. DesPortes et al. [20, 21] attempted to close the gap between the dance and the computational artifact by investigating an informal dance computing camp in which learners created and integrated programmable wearables into their clothing as they danced. Bergner et al. [12, 13] took a slightly different approach exploring how computing can add a layer of understanding to learners' dance practice as teachers and students analyzed movement data from their competitive step team. These various approaches have demonstrated that dance provides a breadth of opportunities to develop culturally meaningful computing in which we can authentically engage in dance practices in tandem with computing. However, what has been under-explored in prior work are the values, teaching approaches, and tensions that arise as a consequence of integrating public performance and computing within a constructionist, collaborative, culturally sustaining learning environment. Questions remain regarding how to support learners' growth in a performing-arts computing environment that values both equity and quality in its production of authentic, public-facing artifacts. The distinct challenges of integrating computing into the performing arts point to a need for more specificity in conversations regarding arts and computing, which frequently conflate visual arts, music, theater, and dance.

To further understand the inner-workings of a dance and computing space, we have undertaken a collaborative three year research investigation with a non-profit organization STEM From Dance (SFD). SFD was founded and is led by Yamilée, a Black woman who is a mechanical engineer and a dancer. She created the organization to support other young women of color to grow in their creativity and confidence as they build their STEM knowledge such that they can have *"futures in STEM fields"* if they choose. SFD's unique program design, developed over the past 10 years, has integrated a variety of computing technologies such as Processing [76], where participants program animations as backdrops to the dance performances, EarSketch [30], where learners program the music to their dances, and the Circuit Playground Express [31], where learners create and program wearable electronic components that they integrate into their dances as costumes and props. While computing and STEM are central to the organization's mission, it became clear to us that the organization's work with these young women of color amounted to much more than introducing computing or dance concepts, and that to understand the organization's success, we must

examine the intersections between their efforts to create a supportive culture, and meaningful identity work.

In this article, we share some of our insights from initial interviews that we conducted with Yamilée, the founder and executive director of the organization, and a subset of six instructors and four learners. We examine the ways identity work manifested in learners' and instructors' descriptions of the learning environment and their connection to the characteristics of the learning environment designed by SFD. Through a qualitative analysis of the interviews grounded in our relationships with the organization and our first-hand experience of the program context, we shed light on the following research questions:

- RQ1. What contextual characteristics are important for foregrounding identity within a community of practice and how does this create opportunities for meaningful computing education to follow?
- RQ2. How do the social and cultural constructs within the disciplines of dance and computing impact the ways a constructionist artifact is produced, shared, and valued by learners and educators?
- RQ3. How can the construct of *Psychological Safety* contribute to our understanding of relational resources for supporting identity work and the design of culturally sustaining creative computing environments?

2 BACKGROUND LITERATURE

2.1 Identity Work

2.1.1 Understanding Learning through Identity. Identity is a fluid, multidimensional construct that is a combination of internal and external representations of the self situated within contexts that have social, cultural, and historical characteristics [10, 43]. Our self-representations impact how we engage with and are engaged by people, artifacts, infrastructure, and activities. Therefore, identity is central to how we learn within a given experience or environment.

Lave and Wenger [53] tie learners' identity to participation within a shared community of practice, highlighting the role of the social world in learning [68]. They understand learning as one's change in participation within a community of practice, where learners move from peripheral activities to those more central to the practice as they gain knowledge and skills [53]. Research has continued to examine the relationship between learners' knowledge and understanding of themselves to the ways they participate in learning communities. Gutiérrez and Rogoff [39] advocate for a cultural-historical approach to supporting learners. Their perspective highlights the need to help learners leverage their "repertoires of practice" that they have built through participation across other communities in their lives (i.e., ethnic, national, religious, disciplinary, etc.). Our research also takes this cultural-historical perspective, exploring the interactions between the cultural repertoires of the learners, the SFD community, and the disciplinary contexts of dance and computing.

To do this, we connect to the work examining practice-linked identities, which narrows the focus of identities to those "that people come to take on, construct, and embrace that are linked to participation in particular social and cultural practices" [64]. In this work, researchers distinguish between practices tied to learning—"shifts in use of artifacts (both culture and cognitive) for problem solving, sense making, or performance" [63]—and those tied to identity—"one viewing participation in the practice as an integral part of who one is" [63]. Nasir and Cooks [63] identify three resources learners leveraged in making practice-linked identities available in the learning environment, "material resources (the physical artifacts in the setting), relational resources (interpersonal connections to others in the setting), and ideational resources (ideas about oneself and

one's relationship to and place in the practice and the world, as well as ideas about what is valued and what is good)" [63]. While our work conceptualizes identity beyond just the practice, these three types of resources are useful for drawing our attention to different parts of the learning environment that can be leveraged by learners as they engage in *identity work* in a dance computing context.

Identity work focuses on the processes of a learner self-authoring their identities as they develop new practices within a discipline [18]. It attends to actions taken, relationships formed, and resources leveraged as learners work with and against "historically, culturally, and socially legitimized norms, rules and expectations" (p. 38). Holland and Lachicotte [43] and Barton and Tan [10] highlight how one's positional identity within a social context is tied to power, status, and rank. How one chooses to "accept, engage, resist, or ignore such cues shapes how they develop identity-in-practice and determines the boundaries of their authoring space" [10]. We advocate for the importance of this sociocultural lens to focus on the intersections between the disciplinary practices and the learning community to develop a more nuanced perspective of how learners self-author their identities. The insights from our work demonstrate how this expands our conceptions of supporting minoritized individuals to engage with computing in personally valuable ways.

2.1.2 Identity in Computing Education. Within CS education literature, researchers have pointed to the importance of identity in expanding efforts to broaden participation in computing and the need to focus on practices that learners are engaged in within the learning environment. Mercier et al. [61], for example, showed that while learners typically depicted an experienced computer user as a male, their self-identification was less tied to gender and more closely linked to their confidence, time engaging with computers, and experience teaching others. Shaw and Kafai [83] identify the shift within the computing, equity-oriented literature from static understandings of identity toward a more dynamic view. By focusing on a dynamic view, they advocate for work that takes into consideration the role of narratives, community, and critical engagement with computing and one's relation with it. Foundational work from this perspective has examined how learners can be situated as techno-social change agents within their communities [80], how learners can craft representations of themselves to support their participation with computing [22], how learners can design narratives to expand their understandings of themselves with computing [73], and how learners can bridge their computational knowledge across communities, interests, and expertise [74]. However, Vakil [91] argues that CS education research acknowledges identity as a backdrop but does not sufficiently address how identity work shapes learning processes and trajectories. Our investigation into the SFD learning environment contributes to this gap in the literature by understanding how the cultures and practices within the learning community and disciplines provide resources for identity work. Connecting the practice-linked identity resources laid out by Nasir and Cooks [63]—i.e., the material, relational, and ideational—to their role in identity work within a computing education context. We link these three dimensions to the following background literature sections that are useful in supporting this exploration: (1) we discuss the culturally sustaining pedagogy that provides insight into the ideational resources, (2) the constructionist literature to help conceptualize the material resources, and (3) the literature on psychological safety to situate our understanding of the relational resources.

2.2 Culturally Sustaining Computing

Over the past few decades, several interrelated terms and frameworks have evolved to capture the pursuit of equity and inclusivity in (predominantly Black) multi-cultural classrooms. With respect to computing education, the term culturally responsive computing [26, 50, 79] emerged from seminal work on culturally responsive teaching [36] and culturally relevant pedagogy [51, 52]. The

work has resulted in computing education experiences that build on assets within communities of color. Gaskins [33], for example, developed the construct of *techno-vernacular creativity (TVC)*, which brings attention to how minoritized communities are and have been engaging with technology in ways that are not typically recognized. Her work highlights the ways cultural practices and artifacts, such as hair braiding, music, language, and dance, can be integrated as technological competencies within culturally relevant STEM learning experiences [34, 35]. Similarly, Lachney et al. [50] examine integrating the knowledge and cultural ways of knowing of members within a cosmetology and hairstyling practice as a starting point for learners to develop computing and electronics practices. Our study explores cultural practices, building an understanding surrounding the dance computing context. We draw on the work of culturally sustaining pedagogy that *lovingly* critiques the instantiations of asset-based pedagogies through asking the question *"for what purposes and with what outcomes?"* The work moves us beyond building relevance to communities of color and into a focus on supporting the *sustenance* of communities. Further, it seeks to challenge the deterministic and static view of culture, advocating instead for a perspective that is situated, nuanced, and evolving [2, 3, 70].

We expand on the culturally responsive computing literature by examining how the culture within the learning community intersects with the learners' cultures and disciplinary cultures. We will draw on tenets of culturally responsive computing outlined by Scott et al. [79] (p. 420–421), namely, that "Technology should be a vehicle by which students reflect and demonstrate understanding of their intersectional identities.… Barometers for technological success should consider who creates, for whom, and to what ends." In line with culturally sustaining pedagogy, we explore how the creation process provides opportunities for the learning experience to be additive, sustaining learners' ways of knowing while building their capacities to participate within new communities and with new disciplinary content. We will describe in particular how the cultures within SFD create ideational resources for learners as they reflect on their intersectional identities in a computing context. We examine both its process, i.e., the highly supportive learning environment, and its outputs, i.e., a creative dance performance integrating computing artifacts. The dance performance experience reflects a confluence of ideas from culturally responsive computing and constructionism in which learners engage in identity-building and technological innovation through creating with computing [29]. The work provides insight into how community and disciplinary cultural practices within a constructionist environment lay the ground work for *ideational resources* [63] to enable opportunities for culturally sustaining identity work.

2.3 (Situated) Constructionism

The constructionist theory of learning [1, 40, 69] underscores the importance of externalizing ideas and concepts in a manufactured artifact that is shared with others. In developing the theory in the context of children's computer literacy, Papert [69] was influenced by art classrooms where learners were guided by their own interests, rather than right answers, and were able to build artifacts on their own time frames. An anticipated consequence of this personally meaningful making process is that learners will identify with the knowledge they acquire along the way [77]. Researchers such as Maxwell [59], Pea [72], and Ames [5] have critiqued Papert for the minimal consideration of the social and distributed nature of knowledge within the learning environment. They highlighted the neglect of the educator, the situated nature of the constructionist artifact, and the ways knowledge is distributed across human actors and even non-human objects within the environment. One could argue that these constructs were central to how Papert described constructionism originally; however, their work identifies how the early constructionist work decentralizd the socialcultural aspects of the learning environment.

Recent work has begun to more closely examine the social situativity of the constructionist artifacts within communities. Searle and Kafai [81, 82], for example, identified opportunities for Indigenous boys and girls to connect e-textiles to craft practices within their communities. While the curriculum did not explicitly embed sharing, the researchers identified how the integration of knowledge from the students' families facilitated the e-textiles to become *boundary crossing objects* that connected the students' work and knowledge across their family, friends, and communities in ways that promoted "pride and accomplishment in making something that was valued in the community at large" [82]. Holbert and collaborators [41, 42] similarly discussed the importance that learners placed on sharing with or creating for other children in their community. Thanapornsangsuth and Holbert [90] demonstrate the potential for identity work with these shareable artifacts, finding that children making and sharing technology solutions for other members in their community changed their teachers' and the community members' perceptions of the learners from *mischievous and stubborn* to *competent learners with bright futures*.

Constructionism is implicit in several educational computing environments that promote artistic creation such as Scratch [58] (a blocks-based coding environment for creating interactive multimedia projects), Earsketch [57] (a Python program for developing *studio-quality* music), and danceON [71] (an environment for creating dances with coded animations that leverage body-position data to trigger and control the animations). However, the platforms alone cannot deliver meaningful experiences without attention to the design of learning environments, resources, and educator supports to guide, scope, and scaffold learner's engagement. Some work, such as Bennett et al. [11], looks to more closely tie Indigenous art practices from minoritized communities with computing and math and show how the students gain design agency within their studies. However, there is still a question of how the practices connect to the learners' interests, practices, and identities. As Maxwell [59] argues, the social and cultural contexts of the constructionist artifact are essential to understanding the opportunities for learner's identity development and growth.

We bring this situated-constructionist perspective here to our exploration of the SFD dance-computing community. In particular, we attend to the ways in which a community of practice—shaped by the disciplinary cultures, learner cultures, and organizational cultures—impacts the nature of the constructionist artifact and how it is shared and experienced. We examine the constructionist artifacts as *material resources* [63] created and used by the learners as they engage with their identities.

2.4 Psychological Safety

Psychological safety is a construct that can provide insight into the *relational resources* [63] as learners engage in identity work within the learning community. Edmondson [24] introduced psychological safety in reference to interpersonal risk-taking in workplace teams. Since then, organizational and management researchers have focused on its role in cultivating team environments conducive to collaboration, learning, and productivity [25]. After an internal study by Google found psychological safety to be one of the few distinguishable characteristics of their more successful employee teams, the construct gained widespread attention in the media [23]. Studies of psychological safety have also engaged with inclusivity in the workplace. Singh et al. showed how a nurturing and diverse climate can support racial minorities, resulting in individuals going beyond their outlined roles. Researchers have implicitly and explicitly tied psychological safety to identity based on how it moderates acting in authentic and honest ways and supports growth and change [16, 47, 86]. Indeed, perception of psychological safety includes "a belief that others won't reject people for being themselves, that team members care about and are interested in each other as people" [24]. Insofar as psychological safety frees up individuals to be themselves, it can be important during formative years, not just in professional development. In terms of

fostering psychological safety, prior work points to a few key characteristics of the environment: high quality interpersonal relationships, trust, and leader dynamics. It has been observed that interpersonal relationships not only help develop psychological safety but also develop better within a psychologically safe space [45]. Positive relationships facilitate engagement such as peer-to-peer support [78]. A particularly important dimension of these relationships, trust both promotes information sharing and cooperation and is reinforced by such behaviors [25]. Team leaders have been shown to impact the perception of psychological safety based on how they engage with the team members. For example, Nembhard and Edmondson [65] identified inclusive leaders who *invite* and *appreciate* others' contributions.

Some scholars have pointed to a need for a nuanced understanding of psychological safety as it intersects with race and gender. In an ethnographic study focused on Black adolescent girls, Woodson [93] explored how Black female students used "directness" in different ways, depending on the racial dynamics at play. Drawing on prior organizational studies of Black women [28], Woodson suggested that directness may only sometimes indicate psychological safety, as implied by Edmondson's [24] model. For Black women, at other times it may signify an act of resistance. To that end, Woodson argued that critical race perspectives have much to contribute to efforts toward building psychological safety in educational environments. This view need not conflict with Ladson-Billings [51]'s emphasis on the role that culturally relevant teaching can play in contributing to a psychologically safe environment. However, it can provide important moderating considerations. For example, Scott et al. [79] identified as a key feature of culturally responsive teaching "meaningful and sustainable relationships with students predicated on the notion that they will succeed" (p. 415). Woodson's analysis suggests "meaningful and sustainable" support may not be universal, that knowing how to support girls of color likely requires a deep understanding of their intersectional identities.

In the present study, we will demonstrate how SFD implements the above key tenets of psychological safety through leadership modeling, empathy, and deliberate trust-building efforts. These efforts are understood as particularly important to maintaining a nurturing experience for an underrepresented population of girls of color. Through learner and instructor reflections on the learning environment, we illustrate how these characteristics created *relational resources* [63] for identity work.

3 METHODS

3.1 Learning Context: STEM From Dance

STEM From Dance runs school-based programs throughout the calendar year as well as a standalone summer intensive. All of their programming combines computing and dancing instruction and builds toward a culminating public-facing dance performance. All cohorts have at least one **Dance Instructor (DI)** and one **STEM Instructor (SI)**. Participants typically range from 11–18 years old spanning middle and high school participants and are recruited from schools, community centers, churches, and other community organizations. The size of the cohort of participants can range from a class of 20–30 students to a full summer program of 75–80 participants. In the case of the larger programs, SFD breaks the cohort into smaller groups of 15 participants. Within the classes and the smaller groups there is always both a STEM instructor that leads the computational components and a Dance instructor that leads the movement and choreography components.

3.1.1 Dance Performances. The youth participants engage in two types of dances throughout their time with SFD: larger dances that are shared across an entire cohort of participants—ranging from one class of 20–30 students to a summer program of 75–80 participants—and smaller computing infused dances comprised of about 4–8 participants. The larger dances are generally

choreographed by the SFD instructors and attempt to engage all the students in a cohort. They are intended to get the students working and learning together across the program and are an opportunity for students to hone their dance skills with guided instruction. The smaller dances are developed by learners in groups, incorporating interactive visuals, props, and sometimes music that they design and develop over the course of the educational period in tandem with their choreography. The interactive elements are developed during periods of focused STEM instruction, using open source tools for creative computation such as Processing [76], EarSketch [30], danceON [71], and the Circuit Playground Express [31]. The exact tools can vary across implementations. In each case, there is focused support from instructors and staff, and depending on the context and the amount of time they have with their participants, there is more or less scaffolding.

3.1.2 Organizational Structure. The exact organization of activities varies depending on the context, but consistent across all of their programming, are three main types of activities: Community Building Activities, Dance and Computing Activities, and the Final Performance (Table 1). The flagship summer program lasts two weeks and spans from the morning through the afternoon (5–7hrs/day, depending on the schedule). This program often incorporates all of the components listed in Table 1. The school-based programming is delivered during classes or in an after-school program. The timing is shorter and can vary from one hour to several hours a week, lasting either an entire semester or full year, depending on the school. The schools vary in their expectations and resources, and SFD remains flexible to meet the context in which they bring their programming.

3.1.3 Previous Research Activities. Over the course of our relationship with Yamilée and the STEM From Dance organization, we have engaged in many activities, including observing four two-week summer camp sessions, co-developing danceON [71] (a software in which learners can code animations over their dance videos), developing curricular content for teaching about wearables and the danceON software, conducting a 12-week internship for participants to explore and build with danceON, and creating a two-week supplemental program engaging learners as tutorial builders for SFD as part of their Summer Youth Employment Program. The work in this article is informed by the extended amount of time and collaboration across these activities. While the interviews took place at the beginning of our relationship with the organization, the analysis and understanding of the findings that we report on have been built throughout the course of our three year collaborative investigation.

3.2 Data Collection

To contextualize our understanding of the performative computing environment from the perspectives of the participants and stakeholders, we conducted 11 in-person interviews. We spoke to the founder/**executive director [ED]**, four **STEM instructors [SI]**, two **Dance instructors [DI]**, and four high school **youth participants [YP]** (see Table 2). All research participants were women, with the exception of one STEM instructor (Vlad). Interviewees were identified and contacted through the organization's program director. Interviews were conducted one-on-one with a researcher, except in the case of Alisha and Nyah [YP] who were interviewed together, and scheduled to last one hour. They consisted of a discussion of the interviewee's experiences in SFD programs, their current perspective on those experiences, including what they enjoyed and felt they had learned, and their ideas for how to improve the program. The goal was to explore the sociocultural environment based on the participants' perspectives on their experience.

All interviews used a semi-structured approach in which researchers followed a script and added followup questions based on participant responses. We prepared three separate scripts for the executive director, instructors, and youth. All scripts began with a warm-up in which we asked

Table 1. Representative SFD Activities

Community Building	**Descriptions**
Speaker Series	Professionals across STEM and artistic disciplines share their experience working in various companies and various roles. They then engage in a question-and-answer session with the participants.
STEM Workplace Visits	Participants visit STEM workplaces to tour facilities and talk with STEM professionals about their jobs.
Community Norm Setting	Facilitated by instructors but driven by participants, the cohorts outline norms and behaviors they want in the environment to make it a comfortable place for everyone.
Affirmations	The cohort recites affirmations together that are often led by one of the participants.
Activities and Games	Participants choose additional fun activities to engage in. Some are related to further exploration of dance and computing topics, while others are designed for participants to get to know one another and the instructors while having fun.
Downtime	Time allocated for participants to spend time with each other; usually built into breaks and lunchtime.
Dance and Computing	**Descriptions**
Tech Sessions	Time dedicated to learning about and creating with the technology that will be integrated with dance. It is typically led by a STEM instructor with a Dance instructor participating in the activities.
Dance Sessions	Time dedicated to learning pre-choreographed dances that span their whole cohort, learning about various types of dance, and creating and teaching their own choreography to other participants. It is typically led by a Dance instructor with a STEM instructor participating in the activities.
Tech and Dance Sessions	As the program progresses there is less of a separation between the tech and dance sessions as students students connect across the disciplines to develop their final performance. The sessions are often merged and there are also extra office hours held by the instructors to facilitate the development of the projects.
Final Performance	The performance is a celebration of all the hard work the participants have engaged in over the course of the project. It is an event with an MC that integrates performances of the participants' final projects, award ceremonies that recognize the work and accomplishments of several of the young women, various speakers including Yamilée[ED], SFD alumni, and additional STEM and dance professionals. The event is attended by the participants, their friends and family, and depending on the context, even their school classmates.

the participant to introduce themselves and describe how they arrived at STEM From Dance, or in the case of the executive director, how she developed the idea for it. From there, questions diverged across participant groups. We asked the executive director to give an overview of the organization and its goals, to describe how its offerings and technologies have changed over the years, and to indicate the decision-making processes that guide ongoing developments. Instructors were asked to describe positive and negative interactions with learners as they taught their specialty (Dance or

Table 2. Participants and Roles

Role		Pseudonym(s)
Executive Director	[ED]	Yamilée
STEM Instructors	[SI]	Andrea, Nadia, Selena, Vlad
Dance Instructors	[DI]	Nichole, Tiana
Youth Participants	[YP]	Alisha, Celeste, Nyah, Shania

STEM), their experience partnering with an instructor with a different specialty, how they guided and facilitated student projects, and their ideas to improve their learning environment or STEM From Dance as a whole. Finally, learners were asked to describe their experience participating in SFD, the project(s) that they had worked on, including how they collaborated with others, and whether there were other things about computing or dance that they wish they had learned about. As described below, our understanding of STEM From Dance is informed by these interviews as well as by first-hand observations of the learning environment and co-development of curricular material over the course of two years.

3.3 Thematic Analysis of Interviews

The coding and analysis of the interviews was conducted by four researchers using an iterative, six-phase thematic coding process outlined by Braun and Clarke [14, 15]: (1) familiarizing oneself with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing potential themes, (5) defining and naming themes, and (6) producing the report. We entered the analysis interested in understanding the successes and challenges of creating a dance and computing learning environment for young women of color. Specifically, this structure was intended to provide us with themes that could contribute to understanding of how participants and instructors situated themselves within their experience in STEM From Dance.

We began by familiarizing ourselves with the data by listening to the audio recordings and correcting errors in the machine-generated transcriptions. Then each researcher was assigned 2–3 interviews to highlight and comment on. At least two researchers inductively coded each interview and then exchanged transcripts to code additional excerpts and comment on the excerpts previously identified. Through several iterations and discussions, we found commonalities between comments and labels written independently by researchers and refined our ideas into an initial codebook, loading the transcripts onto Dedoose (a collaborative, qualitative coding software[1]) to apply codes across the data. We identified 12 codes for instructors and students (i.e., "Funds of Knowledge," "Supportive Community," and "First Experience") and four codes specific to instructors depicting how they engaged with students and consciously altered their classrooms (i.e., "Asset/Deficit" and "Speculative"). We then conducted another iterative process refining our codes. The five major themes depicted below in our Findings section emerged from our discussion.

3.3.1 Establishing Validity and Credibility. During our coding process, we set out to achieve consensus rather than *inter-rater reliability (IRR)*. IRR has shown to be useful for demonstrating that codes are standardized, not overly subjective, and valid such they they convey an agreed-upon property of the data [60, 89]. However, our goal in this study was not to report themes that can be generalized across contexts or be objectively applied or validated. Rather, our identification of themes was in search of a thick description [37] of SFD experiences, situated within the broader context of the organization and the landscape of equity in computing [55, 60] to share insights

[1] https://www.dedoose.com.

that may transfer across contexts. We apply an interpretivist framing [62] that acknowledges our positionality within the work. Our findings incorporate our understanding of the organization, its members, and the young women they serve based on two years of participating and collaborating with STEM From Dance. To address issues of validity and credibility within our research methods, we used established techniques such as triangulation, prolonged engagement, and member checks [55, 56, 60]. The work presented in this article focuses on the interview data, but the findings have been triangulated with data sources across our research activities, including written observation notes of the summer program, notes from planning sessions with Yamilée, and notes from the weekly research meetings with the organizational leads of SFD.

4 FINDINGS

The thematic analysis yielded five high-level themes that were identified across the interviews:

(1) ***Development and realization of a safe and supportive community*** - Identifies the ways in which the community was caring and supportive of the youth participants and their growth through design decisions made by SFD, the ways the instructors supported the participants, and the ways in which the participants supported one another.
(2) ***Culture in the learning environment*** - Focuses on the moments identified when youth participants brought themes or topics that they found meaningful into the work they did, when they were able to build on their cultural resources or prior knowledge, and when they were able to connect with communities outside SFD.
(3) ***Importance of constructionist artifacts and processes*** - Outlines the ways in which the youth participants or instructors identified the importance of what they or others created or could create, the significance of the production process, and the tensions that arose out of the sense of importance ascribed to the artifacts.
(4) ***Identity and interest in relation to computing, STEM, and dance*** - Outlines youth participant and instructor reflections on identity and interests, shifts in knowledge, perspective, or confidence over the course of programming, and sense of ownership over work created or role assumed in the creative process.
(5) ***Exposure and representation in computing and STEM fields*** - Outlines the ways in which youth participants were exposed to STEM fields and built their conceptions of what it means to participate in STEM fields as an underrepresented minority.

In the following sections, we focus on a descriptive account of the key characteristics of the learning environment using quotations from the interviews to illustrate our findings, and where applicable, we triangulate with observations and notes from our time working with SFD. We organize findings into three sections: developing a safe and supportive learning environment (theme 1), cultural and social context of constructionism (themes 2 and 3), and identity and growth within and beyond computing (themes 4 and 5).

4.1 Developing a Safe and Supportive Learning Environment

SFD was designed to promote a safe space for young women of color to engage with computing. As Yamilée, the executive director [ED], explained, "we prioritize creating a sense of…culture and an environment that I think the girls really respond well to…One girl described it as *warm*." Andrea, a STEM instructor [SI], identified how learners, "build up and kind of find…a safe place in the class." Instructors saw SFD as not only a learning experience but also an important community within the young women's lives. Serena [SI] felt that the most important part of the program was that it served as a "support group" for the young women. Similarly, Nichole [DI] described the most significant impact of SFD on youth participants as,

> "I think having supportive women in their lives, 'cause we were consistent.... There was one school that we worked at...all the students in that school had been like expelled or suspended like multiple times. So it was like, they're in gangs. Most of the girls had children. There was like...a lot of trauma. And it was really hard to get their trust.... And so that type of environment, it was like, it was all about trust, like getting these people to know even if they didn't learn anything in class because the whole time we spent like doing behavior management by the end, like when we walked in they're like running to hug us or like I just felt like they knew that we have their backs and like their best interest at heart."

We identified three characteristics of the organization that led to cultivating a safe and supportive environment for learners: instructor dispositions, explicit design decisions for fostering community, and readiness to adapt activities to serve immediate needs.

4.1.1 Instructor Dispositions. The instructors nurtured psychological safety through their empathy with the youth participants and their acknowledged role in both easing the pain and modeling productive risk-taking. All of the female instructors we spoke to identified their own past difficulties navigating computing culture and concepts and showed empathetic responses to what younger learners might be going through on this journey. As Andrea [SI] stated, "I kind of always wanted to, you know, make things easier for the kids because for me it was difficult." Serena [SI] explained, "So like my first computer science class, I freaked out and I did badly.... I almost didn't do computer science because that experience—it's a very painful experience for me.... So I hope that because they have a group of people rooting for them, like really believing they can do this, they might pursue it if they want to." Nadia [SI] recalled a childhood dream to make digital tap shoes, but was, "not brought into the robotics class probably like the boys." The instructors had distinct memories that had emotional implications that shaped their approach towards teaching.

While the female STEM instructors recalled painful experiences and feeling outsider status, the one male instructor notably did not. Instead, when prompted to think about difficulties and challenges, Vlad [SI] focused on learner engagement during STEM instruction, "The biggest challenge was getting them really involved and excited with a tech aspect and keeping them, keeping their interest at a peak instead of their interest dropping." To be clear, Vlad was wholly supportive and invested in the success of his learners; however, he did not position himself as someone who related to their experiences.

Instructors' own identification with respect to specializing in dance or technology impacted how they engaged with learners and led to opportunities for modeling and reassurance. For example, Nichole [DI] identified how as a dance instructor she was learning to code along with the participants, "So I thought that was really cool, to be able to share that with them and also to help take that fear from them. Like, 'Hey, I'm an adult and I don't know either and I'm learning with you...' So I think for some students it was...reassuring." Similarly, Serena [SI] said, "I think joining the students this year while they dance helps because I'm not a dancer so they can see somebody that's not a dancer but still is doing it and messes up just like they mess up and it's okay." We saw this take place within our observations when Vlad [SI] was leading the students through exercises and the Dance Instructor would ask questions and identify when she was stuck. There was a point in the session when the whole group was helping to debug the dance instructors' code for her programmable wearable microcontroller.

4.1.2 Fostering Community. SFD treats community building as a central goal of program design that seemed to facilitate psychological safety through developing an orientation towards: building trust, cultivating existing ties, and creating new ones through social activities. As Yamilée [ED]

stated, "We try to encourage the relationships between the adults and [learners] where we convey like a level of trust to them." That trust was articulated by the learners, as when Nyah [YP], endearingly but smiling in jest, referred to an instructor as "an angel" guiding them through their learning. Relationship building occurred outside of project time, as Alisha [YP] recalled, "they actually infuse more fun aspects like…to create better bonds…it was weird, but like everybody became friends in the three-week span, which is different because I'm not really used to that. I'm not really used to opening up to people." Explicit practices meant to foster community were also embedded. For example, Yamilée explained how they facilitate community norm setting through community agreements used within cohorts, "at the beginning of making the groups, they make these agreements together. So it's like, 'Hey, we're not going to tell you everything that you need to do. You know what you want from your group, say it' and they agree. They signed to it." In the sessions, we observed the activity was always highly collaborative with the facilitator encouraging input from multiple students (i.e., calling on participants who had not contributed yet), while also encouraging iteration on ideas to refine one person's idea into an agreement others were happy with. Some example agreements we saw were, "always be creative" and "don't put others down." These types of activities ensure the culture is not exclusively defined by SFD and integrates the youth's voices.

Besides fostering community from within, SFD also integrates with and recruits from community organizations such as churches and under-resourced schools. Shania [YP] described being recruited during a praise dance practice at church and volunteering because she liked math. Because of the targeted community outreach, existing friend groups regularly enroll together. Celeste [YP], discussed the effect of having her friends in the program, "I'm kind of shy and like not super outgoing, so that was scary, but I had my friends there who were also part of the church dance so that kind of helped me, they kind of pushed me to step out of my comfort zone."

Aside from designed activities and external networks, community emerged through learners' own unstructured peer interactions. Nyah recounted being the one girl with coding experience among a bunch of dancers, "so I took the lead in the class because I had experience in AP Computer Science.… I remember there was a time where the class was not understanding the instructor, and I was able to break it down so that all of us could understand. Because I was at the point where I didn't understand anything to where I actually did good in my exam, so I was able to speak in like…from student to student to teacher to teacher, if that makes sense." Nyah was able to draw on her own experiences learning the material, which facilitated her in taking a leadership role as she helped to break down the material for the other participants.

4.1.3 Maintaining the Safe Space. While the organization and instructors prepared in advance to create a safe space, interpersonal conflicts would occasionally arise. Maintenance and regulation of psychological safety involved both instructor and learner initiatives. Serena [SI] described her experience protecting youth from harassment while being careful not to stigmatize,

> "the instructor has to step in and, you know, make sure that even though you're giving each other constructive criticism [it] has to be constructive.… We usually will point out the behavior that's wrong, but we'll do it in a way that's not like embarrassing them or be like, '…I understand why you're criticizing [Hanna], but you know, [Hanna] is trying her best. Like you are not perfect as well and you know, you have also been unfocused and you've also made mistakes.' So you know, you kind of have to tone it back."

Learners recognized the importance of the supportive culture and the need to protect it. Celeste [YP] reflected, "I feel like this whole program is built up on building people up and I just think

that's so amazing, but it really sucks when you get those few, two or three people, that's just kind of negative." While learners had conflict and tensions they also were able to work through some of them themselves. The following quote from Celeste [YP] demonstrates how an aesthetic disagreement about choreography was resolved with a focus on making all of the dancers feel comfortable.

> "Since we didn't sit down to assign what certain people would do, there would be a slight conflict on which move we would do for this specific dance. So let's say I made a part of the song, a choreo for the part of the song and somebody else kind of did it as well. They would want to do their move, and I want to do my move. And you got to find a compromise, which is difficult.... I think mine is really good and she thinks hers is really good, so we have to find a nice compromise where both ideas can be showcased and not, you know, overseen.... We just talked basically and just saw which ones felt more natural, I guess. So whoever thought my move was harder, if there was more people thinking that mine was hard, we would just go with the easiest one. So everyone felt comfortable or the majority felt comfortable."

Psychological safety was supported by an awareness of the need to self-regulate to support all participants especially those struggling. Compromise was discussed not as transactional (i.e., this for that) but as decisions made to minimize discomfort.

4.2 Cultural and Social Context of Constructionism

Instructors and learners both emphasized the cultural and personal significance of the computational artifacts they worked on. Shania [YP] emphatically recalled, "I think it's pretty fun, especially the results. I love the results. I cannot stress enough how much I love the results." She contrasted her prior experiences using an educational coding environment with making interactive props in the form of a crown and a staff (stick) for a SFD performance,

> "I was taking coding class in my freshman year of high school and at first it was kind of okay, but after a while I started losing interest. When I got into [SFD] I still didn't really like it. But at the end of it I actually started to like it because, I like what the results was way better. Because, at school we used a coding website. It's a dog named Karel,[2] and you have to code it and make her do a flip, and it's not really as interesting as making something up, making a crown, making a stick."

Shania's reflection illustrates how the constructionist artifacts only become a material resource for identity work once they had personal value. This demonstrates a need to understand the sociocultural nuance within constructionist experiences.

Nadia [SI] distinctly gendered her perspective of the importance of the dance performance,

> "Women, I think more so than men, just culturally have a project-based-outcome desire. You know, you will learn the thing if you are trying to create the end result, more so than just getting the answer right. So getting to the end of your math problem and the answer is 4.2 isn't exciting but getting to the end of your code problem and you've made something that you feel is aesthetically beautiful or expresses yourself is a reason to get through the hard stuff."

In the following sections, we demonstrate how the participants depicted the dance projects as meaningful not just because they were creating artifacts, but because the artifacts were authentic

[2] https://codehs.com/info/curriculum/introkarel.

to learner interests and values because of the social and cultural contexts in which the artifacts were situated.

4.2.1 Culture and Meaning Embedded in Dances. The importance of the computing and dance artifact produced during SFD programs goes beyond the desire for a project-based outcome. It was frequently invoked as an opportunity for learners to bring meaning and culture into their work with STEM. Yamilée [ED] reflected on her desire to approach dance authentically,

> "There's something about this performance space that allows the two [computing and dance] to exist. And I wanted the dance to feel like dance, not like, you know, like the 'dance your PhD'…. That's cool, but for like a 13 year old child, you know, like dancing the DNA helix may not be that cool looking, you know?… I wanted it to feel like what dance looks like to them."

Dance has cultural roots for many of the participants and integrates across various communities in their lives, from their neighborhoods, to churches, to dance and cheer teams. Nyah [YP] explained her connection to dance and how it was integral to her cultural repertoires [39] that she integrated into the learning experience,

> "Dancing's like how I express myself. Because like growing up we used to have things they call block parties…. I used to do this thing called *getting lite*, it's like a [neighborhood name] thing where you just move your shoulders and get lite with your feet…. No one in the program knew how to do that, so I taught like my whole entire cohort how to get lite."

Serena [SI] described how one group of learners brought in their own style of dance combining Hip Hop with a Caribbean-style dance, adding, "It was cool to see them take what we've taught them, but also incorporate something that they have been growing up with."

Dance not only makes a connection to one's culture through music and movement, it is also a contemporary art form that engages with evolving social issues. SFD learners had the opportunity to design choreography around themes that were important to them. Shania [YP] discussed her cohort's dance on the theme of police brutality,

> "We tried to emphasize certain words that would make the audience feel things. So in the beginning 'Just Friends' is like a hard bass and it's kind of scary. So we put words like 'breathe,' 'relax,' 'calm down.' Because in that part of the dance I started as the Black person and I'm getting pulled over. So it's like breathe, relax, all of that. And then towards the end it was names of Black people that have passed away because of police brutality."

In our time working with SFD we have seen participants engage with a range of self-identified themes for their dances from sociopolitical themes such as the Black Lives Matter movement, to social themes of self-empowerment and women empowerment, to themes that were commentary on some of the social pressures participants experienced, like the pressure to look good on social media. The culture and values integrated across the disciplines and learners became ideational resources [63] that were important and emphasized by both the instructors and learners.

4.2.2 Social Context for Constructionist Artifact. The public-facing element of the final performance is key to the SFD learning environment, as Yamilée [ED] explained, "...exemplifying our whole point that STEM is relevant to you and it can be something that can help you because you just made this dance performance that's really cool and you're excited to show it to your friends."

Learners depicted the performance as an important shared experience and a major motivator as they expanded their practices within computing. Shania [YP] said the most fun part of the program was, "the last day when everybody came together and we saw everybody's end result and everybody's hard work paid off. And it was a really good bonding moment. Everybody was cheering each other on." Similarly, Alisha [YP] stated that the performance, "was the funnest part because we got to exchange our personalities with each other," and Celeste remembered: "I loved my dance. I feel like I was really confident and it really showcased all of our talents and we worked really hard on it." The final performances that we observed were full of positive peer and instructor support with participants providing individual and team shout-outs offering their congratulations, commenting on how good the dances were, and highlighting particular aspects of the dances that they appreciated.

Serena [SI] reflected on how the performance served as a way to focus and motivate the learners around a shared goal, "When we tell them that there's only three weeks left.... Oh like they were operating at 20%, but then when they get to that last, um, three weeks, they're like catching up to the 80% that they've been hiding from us." The participants recognize the importance of getting to the finish line with their final projects.

4.2.3 Tensions of the Public Performance. The instructors and learners identified not only the benefits of this public performance, but also the tensions that arose because of it. Tiana [DI] reflected, "Some people are really shy and once you tell them, 'Oh, we're going to perform in front of your friends and family,' uh, they're like, 'wait, hold on. I didn't know you were going that far!"'

Participants identified ways in which clever integration of technology and specific instructional strategies helped learners navigate the emotional challenges of the performance. For example, Nyah reflected on her team's decision to wear LED masks (before the pandemic): "we chose the mask because there were these two dancers that always had masks on. They never danced with their faces showing, and that helped us cover our weird facial expressions and to calm down nerves. Because you know when you're dancing you get nervous, like watching the crowd, and like making like weird faces, so the mask was to like um kind of like hide that and like just show the beauty of technology." Participants are embodying their constructionist artifacts, and the clothing choices provide another layer of control in how participants were able to do that. In this case, the mask acted as a barrier to the audience helping to subside their fears and hiding their faces, which they no longer had to focus on the presentation of during their performance.

Nichole [DI] discussed one of her strategies for helping learners overcome performance anxiety.

> "We did this activity where we had them anonymously write down fears about the stage.... And then, they put it in a hat and I read all of them out loud and they started to hear that there were like duplicates of the same thing over and over again. We had this clique group that was like super popular. They were like the best dancers. It was really interesting to hear that just about everyone was talking about the nervousness of messing up on stage, of looking like a fool, of someone making fun of them. It was like all the same. And I was like, 'do you see how we all are feeling the same things?"'

The instructors' sensitivity and empathy for the participants' fear of failure meant that they were able to devise ways to help them navigate their fears by bringing it to the forefront. The community that they built together enabled the participants to safely share their fears and see the similarities between them.

Serena [SI] noted the stakes of failure,

> "that's really their first experience with a project and like computer science. And so they want it to go well and I think rightfully so because their parents and their friends

> are seeing them. So it's a lot of, can be a lot of pressure for them to do well.… If the performance doesn't go well, then it's really disappointing for them…why would they come back next semester and then go through that pain again?"

The performance has a strong sociocultural value within the learning environment, which then creates an environment in which failure and the idea of failure become more pronounced and impactful for learners. Going back to the youth participant's example of Karel the dog, if Karel is not able to do a flip it's not a big deal because Karel did not mean much to the student; however, if the performance does not go well it is a big deal because not only is the learner more invested in the outcome, but the outcome is public. Nadia [SI] seemed to go even further than Serena in expressing concern about the stakes of the final performance:

> "I think that it's important to have the space to fail, but not have it be a part of your finished project that you then have to go and perform in front of your peers in three weeks. And if you don't get that new skill perfected in time, you're going to fail on the big thing. That's the thing that's scary to me because these girls, they're performing in front of other classes, and their boyfriend is out there, and they're nervous. These are such high-stakes social situations. So yeah, you don't want to be the one whose thing doesn't light up because you didn't learn how to solder."

Here, Nadia [SI] explicitly points out this tension of having a learning environment that should support imperfections and failures and these same imperfections and failures then being tied to a high-stakes performance. The requirements of support that instructors provide to get participants to the finish line become even more critical to the success of SFD. To mitigate risk while respecting learner ideas, instructors take projects brainstormed by learners, attempt to scope and concretize them, and present them back to learners as options. As Vlad [SI] noted, "we as instructors at the end of the day go over which projects are feasible to do with the tech that we have and then we gear them towards that."

While it is not the norm, when needed, SFD instructors will step in to complete work. Yamilée [ED] described an instance in which, "one of the groups went to make these flames that had lights and the instructor ended up doing like 90% of it because they just didn't have the time and the focus to do it in the sessions." In the eyes of Yamilée, the stakes of major failure in a live performance outweigh the benefits of learning a hard lesson about focusing during class, a perspective that is consistent with her mission to create an identity-affirming experience for students. Failure has an additional concern for Yamilée [ED], as was indicative from her reflection on what makes a dance performance "unsuccessful." She states,

> "I mean, first thing that comes to mind: Tech's not working, because that's the whole point of our existence right—it's that integration of tech into dance—and so when the tech doesn't work, it's just such a bummer because that's the expectation that people have when they see it. And, also for the girls it's important because we're trying to convince them that they can do tech."

Yamilée [ED] recognizes the impact of failure for the young women, as well as sees it as negatively reflecting the organization's ability to carry out on their promise of connecting the technology to the dance. This is a central concern to Yamilée, since this is one of the main defining characteristics of their organization. Generally, the instructors are there to provide just-in-time help so learners aren't spinning their wheels on a problem without guidance. The instructors often work with participants to think through their complex problems and solve them while leaving the majority of the work and direction up to the participants.

4.3 Identity and Growth within and beyond Computing

In addition to supporting the development of culturally and socially situated artifacts, SFD supports the identity and growth of their participants through building their conceptions of what it means to participate in STEM fields as an underrepresented minority and explicitly focuses on cultivating their participants' confidence.

4.3.1 Engaging with Under-representation in Computing & STEM. SFD communicates its mission statement, regarding under-representation in STEM and computing, to learners at the beginning of their programs. For example, in the summer camp's welcome ceremony, Yamilée [ED] shared her personal story about how she entered engineering and why she created the organization to support young women of color in STEM fields. The summer program also features a daily speaker series in which STEM professionals, who are often women and people of color, share their work and experiences in their field. The narratives highlight the reality of the difficulties that underrepresented individuals often face and the success of overcoming them through perseverance and community support. Learners also take field trips to various STEM organizations where they interact with professionals in their workplace. Alisha [YP] and Nyah [YP] explained the impacts of these visits,

> Alisha: "I was actually able to see like in the companies how there was a majority of men and a few women."
>
> Nyah: "And lack of people of color. Yeah, it was mainly like white people, Asians, men…"
>
> Researcher: "How did it feel going on those visits?…"
>
> Nyah: "After the visit, it pushed me to like actually go hard for STEM as a woman of color. Because like I'm from the quote un-quote the hood, so like my friends outside the school, they don't know about computer science.… I went harder for computer science than I ever did before, and I didn't really care for it but after that I was like, actually I should take more time with STEM and try to do it in college maybe…"
>
> Alisha: "For me, it made me feel, I guess, empowered. Because adding on to what she was saying, in [city name] there's a big education gap between people of color and Caucasian and Asians, because we all end up going to different schools with different curriculums, and usually the one that people of color go to—they don't have the best curriculum, so their graduations are pretty low, so that just empowered me—how computer science could open pathways for people."

The participants connected their experience seeing underrepresentation in the workplace to their understanding of systemic issues in the world and the implications of gender and race. As Alisha [YP] further reflects,

> "that's also a big part of being in a patriarchal society, like it's kind of easier for a woman to downgrade each other, degrade each other, than just like push each other forward. So like SFD really taught us that in certain fields we have to work together in order to make impact, and be courageous, and show grit, and just persevere through any other gender norms you face or racial norms you face."

Serena [SI] noted that the learner perspective is also shaped by seeing a preponderance of women in instructional roles: "So they also have the STEM instructor be an example for them as far as like, Oh, okay, so women currently are pursuing computer science."

All interviewees noted multifaceted transformations and growth that occurred through participating in a SFD program. Yamilée [ED] identified how the organization is not designed just to cultivate engineers.

> "We want some percentage to actually go to some kind of post-secondary education for STEM, to graduate with a degree and/or to have some kind of STEM-related job.… Not STEM-related but like a job that relies on a STEM skillset. So it may not be an engineer, but it could be, like the technical staff of Lincoln Center, who are, you know, doing work that uses STEM skills to put on a production."

SFD's program design engages with learners' understanding of how STEM can be applied, through its intersection with the arts, thus broadening their perspectives of STEM identity. Serena [SI] recalled,

> "Seeing them understand that you can combine STEM with other things is also cool because a lot of them think that STEM is something that you learn in school and then you just leave it at school. Like there's no like application for STEM or it's like what, like men in white coats are doing in like the laboratory."

The sociocultural context of the constructionist environment was about more than just what students were doing in the learning experience, but how they were connecting it to their view of computing in the real-world.

4.3.2 Confronting Issues of Confidence. Interviewees emphasized the role that confidence and mindset play for learners in deciding whether to pursue further STEM participation. Andrea [SI] reflected that confidence was a greater hurdle than learning and knowledge, "It's not that they don't know, it's just they are like, 'I, I'm scared.'.… I feel that like maybe, um, self doubts. It's a big, big challenge for them."

The goal of fostering confidence was also seen within the organizational structures. For example, SFD organized participants into cohorts with empowering nouns—i.e., Tenacity, Confidence, Persistence, and so on. The goal being for learners to identify with and embody these qualities within their time in SFD. In our observations, the instructors promoted participants' confidence in various ways, such as giving students leadership positions, calling out participants' persistence and successes to make them more visible, and focusing their time and attention on participants who are struggling to help them navigate failures. They even gave awards during the final performance to participants who persisted through challenges.

Instructors were particularly sensitive to changes in confidence levels in their interviews. Vlad [SI] recounted a specific change in a learner, "The whole two weeks she was quiet for the camp. Like, and then the last week when it came to projects she was so into it. It was a shock to see [her] talking and contributing ideas and giving suggestions…that was really cool." Serena [SI] remarked on how changes in confidence, even incremental changes, are an essential goal of the program, "Maybe not all the girls will come out wanting to be scientists, but that wasn't the point anyways. It was just to show them that they could if they wanted to."

Yamilée [ED] recounted that challenges developing confidence were exactly why she started SFD at the intersection of computing and dance,

> "I started to think about [SFD] because of how much mindset is a barrier.… I just wanted to change that mindset. And that's what got me thinking about dance. Because when you dance, you have the sense of possibility and kind of like a fearlessness, you know, to perform in front of an audience takes a lot of courage. And, and I was doing

that since I was like four years old every year. And I know that has some influence on my ability to persevere in difficult situations."

The impact of dance on learners' sense of self was also noted by other instructors, as Serena [SI] stated, "with dance, I think they start to gain ownership over themselves in a way that like other subjects can't teach them. Like dance is such a nice discipline because it gives them…like the physical confidence, like the confidence in their body." These performative computing spaces are special in how the learner is situated within the constructionist artifact, such that they are embodying the successes and at times also the failures of what they created.

5 DISCUSSION

What distinguishes SFD as an interesting case is not that it is an after-school program designed to teach computing. Nor even that it is a program emphasizing equity and targeted at girls of color. As a creative computing opportunity, it is in good company. In choosing to focus on performing arts, perhaps, it becomes perhaps a rarer example. High-stakes outcomes for computing experiences exist elsewhere, notably in competitions like First Robotics. However, SFD offers a unique blend of high-stakes, public-facing performance with a target population facing an upstream current of domain under-representation, marginalization, inexperience, and, subsequently, lower degrees of self-identification. Why would an organization that recognizes the need and challenges of their outreach mission—and deliberately cultivates psychological safety—simultaneously insist on a high-stakes final performance or even a performative medium in general? We now turn to a discussion of some of the distinctive aspects of SFD as an organization navigating tensions of its own design to create an effective environment for identity work.

5.1 Cultivating Space for Relational Resources

Nasir and Cooks [63]'s work defines *relational resources* as "the positive relationships with others in the context that can increase connection to the practice" [63]. In the SFD learning environment, the relational resources were the foundation of the culturally sustaining experiences and the types of identity work that it enabled. In our findings, we saw several ways in which SFD created a psychologically safe space that was reciprocally related to relationship formation—i.e., psychological safety was both caused by and created opportunities for relationship formation. In line with prior work by Schulte et al. [78], social support was central to the development of psychologically safe spaces. Most work in the *Culturally Responsive Computing (CRC)* literature attends to aspects of the social environment—such as Scott and White [80]'s theme of promoting *People Before Technology (PBT)*, Clark and Sheridan [19]'s focus on peer-mentorship, and Pinkard et al. [73]'s integration of STEM mentors. Not only are these types of resources seen as important for practice-linked identities, but if we think beyond the practice to culturally sustaining pedagogy, the relational resources in our work have been centralized by SFD to promote sustenance of communities [2, 3, 70]—specifically those marginalized by computing fields.

5.1.1 Instructor-Participant Relationships. Our findings highlight how relationships stemmed from the trust that was cultivated between the instructors and learners through the organizational structures and the orientations of the instructors. Trust was noted to be particularly important in our findings, because the learners are predominantly young women of color, many who are engaging with computing for the first time, and some who lack other safe spaces and communities in their lives. Trust has been noted as a requirement for psychological safety [25] and as a key characteristic in creating a communication structure in which "ideas can be explored, and mistakes can be made safely" [32]. The CRC literature acknowledges the importance of instructor-learner relationships especially when it comes to engaging in justice- and equity-oriented discussions [6];

however, there are not always clear directions for how to do this. Our findings suggest that empathy and humility were central to supporting development of this trust.

The instructors demonstrated empathetic dispositions when it came to supporting learners in navigating the challenges and failures that come along with learning computing. Their dedication was first to the learner and second to the material that was being learned. This impacted the types of activities they engaged in and their orientation towards struggling participants as they helped mediate intense emotional responses around failure. The participants we interviewed recognized the instructors' and organization's efforts in creating a supportive and trusting environment and reflected on its importance during the interviews. Our case-study had several alignments with the care ethics literature, in which the learners in SFD were not just *cared about* by the instructors and organization, but they were *cared for* [66, 67]. Importantly, this was both intentional and recognized by the learners. We believe that the CRC literature might leverage the work within care ethics that draws attention to the social dynamics involved in creating relational support in a learning experience—specifically how "care, attention, empathy, response, reciprocity, and receptivity" [67] are fostered and emerge in the learning environment. Using these as additional supports in the CRC literature can draw a greater focus to the development of culturally sustaining experiences in which the instructors' relationships with the learners can reach beyond the learning environment and "enhance the likelihood that their students will live in and promote a public climate in which caring relations will continue to flourish" [66].

Trust was also supported through instructors' demonstration of humility, which created a safe space to ask questions, not know something, and encounter failure. In computing education, there is a prevalence of *defensive climates* in which competitive demonstration of knowledge often hinders the development of collaborative and supportive experiences for minoritized learners [8, 9]. In this environment, relational resources that can facilitate productive social experiences become even more important. Walters and Diab [92] has identified how *humility* in leaders—i.e., acknowledging limitations and mistakes—can lead to greater psychological safety, enabling individuals within the group to be able to "act without fear" and engage more fully in their work. The structure of SFD embeds opportunities for humility by having separate designated dance and STEM instructors who can then learn each other's discipline along with the youth participants. Within this performative, constructionist learning environment the social artifacts—i.e., the dances and wearables—were highly visible, which made making mistakes (and not knowing something more generally) also highly visible. When this visibility was leveraged by the instructors to demonstrate their own lack of knowledge, it set a precedent for being able to make mistakes, while also becoming a point of engagement for participants to learn with, and at times, also teach the instructors.

5.1.2 Peer Relationships. Scott et al. [79] highlight the importance of learners forming relationships with one another in their definition of CRC. In our work, the interviews demonstrated how the youth participants were able to become friends with other participants within the learning environment, which seemed to be the result of four organizational decisions: instantiation of a cohort model that grouped a subset of participants together, the requirement to engage in collaborative construction of dances, the allocated community-building time outside of the computing and dance activities, and the recruitment strategies focused on leveraging existing relational resources from other environments by recruiting groups of participants from community spaces. The interviews highlighted how the relationships translated to supportive behaviors between participants for facilitating identity work, such as choosing dance moves that everyone would feel *comfortable* with and navigating conflict based on their understanding of the other person. Further, the youth participants felt comfortable serving as intermediaries between the instructor and other participants to help explain concepts that their peers were struggling with. Mentorship has strong roots in how the

CRC model has evolved [79, 85], and we similarly saw the affordances of students taking on leadership roles. Our findings demonstrate that the interdisciplinary dance computing environment enabled participants to leverage their various expertise and funds of knowledge [38] to contribute to the learning environment. Similar to DesPortes et al. [21], we found the group project created space for many types of knowledge contributions, which can have a positive impact on learners' identity work across disciplines [18]. We saw this manifest in the learning context as participants took advantage of the opportunity to teach one another. In line with Mercier et al. [61], we found that this stimulated opportunities for learners to identify with computing [61]. Learners reflected on the effectiveness of both teaching and learning from their peers. Our work points to how the relational resource between students helped to make this happen. These relational resources then fed into the ways the material resources were engaged in within the community of learners.

5.2 Structuring Material Resources for Positive Social Interdependence

The essence of SFD is embedded in how the material resources of dance and computing are organized and shared throughout the learning experience. Material resources involve "the way in which the physical environment, its organization, and the artifacts in it support one's sense of connection to the practice" [63]. As a constructionist environment, it is not surprising that these are central to what makes the learning experience effective. However, as we saw with Shania's juxtaposition of her experience in SFD with her experience using Karel the dog,[3] not all constructionist environments have the same value for all learners. The organization of the material resources were all in service to the development of dances that would exist within the high-stakes performance. The material resources that we identified in our findings included the physical movements, the clothing worn and modified, the technology in the dances, the tools supporting the development of the dances, and the music. Importantly, these material resources were organized within the structure of group dances situating them as collaborative objects. We saw how these material resources developed a social structure that was supported by the relational resources rather than emulating an individualistic hacker culture identified by Ames [5].

However, as noted by the instructors, while dances were collaborative, there was still an individual nature to the artifacts in how they were distributed. Each participant, regardless of prior experience or confidence, must get up and dance on stage with the material components of their creation. In dances that integrated physical computing, the technology is also individually allocated with every student wearing their own outfit featuring electronics assembled and coded collaboratively by their team. This collaborative yet individual nature creates a *positive social interdependence* with the work of the individual supporting a collective goal [46]. We saw this in how the students were helping each other to figure out and learn about the different components with each other. Yoder [94] identified how cooperative learning theory could be incorporated into the design of dance experiences to facilitate effective collaborative learning experiences. However, there is still little work investigating the opportunities for positive social interdependence. In our work, the potential for positive social interdependence is particularly notable because of the high-stakes nature of the final performance which prompts even more attention to the success of the group. This impacted the organization of the material resources both in how they were constructed and how risks of failure were mitigated. The live performance is frequently cited as a point of pressure by learners and instructors, as no one wants to fail (technologically or artistically) in a public-facing setting. Youth participants, for example, edited the dance moves—i.e., making sure everyone could do the dances—even if it meant making the dances easier and less complex. Instructors designed instruction to help learners succeed in groups, assisted with planning and scoping the material

[3] https://codehs.com/info/curriculum/introkarel.

resources that go into the final artifacts, and in some cases completed or fixed projects to make them performance-ready. In the constructionist computing and the CRC literature, focusing on positive social interdependence could stimulate new ways to conceptualize organization around the material resources in the environment to drive and reinforce the relational resources for supportive interactions.

5.3 Social, Political, and Cultural Dimensions of Ideational Resources

Nasir and Cooks [63] identify ideational resources as a broad range of individually held ideas encompassing, "the ideas about oneself and one's relationship to and place in the practice and the world, as well as ideas about what is valued or good." In SFD, the ideational resources spanned the ways learners engaged in their sociopolitical identities within the learning environment to the final performance and how it was socially and culturally situated to develop learners' identities with computing and dance.

5.3.1 Sociopolitical Ideational Resources. As evidenced by our findings, learners regularly engaged with sociopolitical structures in the performances they create and in how they reflect on what it means to participate in computing as an underrepresented minority. Vakil [91] conceptualizes justice-oriented approaches to computing education in which he advocates giving attention to learners' political identities and creating opportunities to encounter power and inequities as part of the learning experience. But this leaves the question of: What supports are necessary for facilitating this work? In Ashcraft et al. [6]'s study, they center the importance of engaging in identity work that spans discussions of race, gender, and social inequities as part of what facilitates the students to assume the role of a technosocial change agent. They identified how "shifting the spotlight" to various dimensions of identity and equity served to provide multiple entry ways into discussions and how it could be useful for not perpetuating helplessness when focusing on marginalization. In our work, we saw other strategies that built awareness and resilience. Visiting STEM workplaces enabled participants to see underrepresentation for themselves, while narratives shared by visiting STEM professionals served as exemplars of overcoming challenges. Prior work has illustrated the power of narratives that challenge stereotypical depictions of participants from minoritized demographics such as Pinkard et al. [73] and Shaw et al. [84]. In our work, SFD used the examples and narratives as a foundation to discuss practices that support community resilience as minoritized learners. Specifically, they taught about the importance of solidarity, community, and supporting each other within the program and beyond. The power of these ideational resources was evidenced through how the participants' sociopolitical perspectives of themselves shifted as they reflected on what it meant to be a woman of color in STEM and their role in supporting one another to succeed. The participants describe their intentions to translate these perspectives outside of the learning environment. Resilience in computer science is often looked at from the angle of the individual who must be resilient (i.e., Reference [75]) or in identifying what facilitates resiliency in learners (i.e., Reference [27]). Our work points to the potential for thinking about developing learners' practices that support community resilience as ways to eventually shift inequitable structures within the discipline.

5.3.2 Authenticity of Dance and the High-stakes Final Performance. Yamilée [ED] was adamant about engaging with dance deeply and authentically from the perspectives of the participants—i.e., it needs to look and feel like dance to them. SFD strategically recruits in community spaces that engage participants with cultural ties to dance. The performance and practice sessions then serve as ideational resources that provide opportunities to forefront participants' cultures and identities within a space that also integrates computing. Participants' funds of knowledge are valued in the learning environment as they are able to introduce their cultural dance expertise into the

creative process, e.g., as Nyah [YP] taught her peers *getting lite*, a movement she learned in neighborhood block parties. While not all participants have expertise in dance, as a performative art form, dance also embeds participants' expertise. Similar to how Solomon et al. [88] identified an embodied physics dance as an ideational resource to think through physics concepts, the dances in SFD became ways for participants to explore the ideas, ideals, narratives, and aesthetics that they integrate within their performances. Shania, for example, reflected on coding text to help the audience connect to a performance on police brutality. This demonstrates an interplay between creative technology and learners' intersectional identity [79].

In alignment with the practice of dance, there is a public final performance that becomes an artifact that receives significant consideration from Yamilée, instructors, and participants. Similar to Nasir and Cooks [63] where the track & field event in which one competed in was an ideational resource that solidified one's standing within the discipline—i.e., someone who competed in hurdles became a hurdler—in SFD the final performance also solidified the youth participants' standing as dancers, computer scientists, and engineers, as they demonstrated their skills across the disciplines. The participants' readiness and ability to overcome this task of designing, constructing, and performing publicly with technological artifacts led to their transformation in their relationship to dance and computing, a goal of CRC [79]. SFD performances created a space for dance computing artifacts to transcend the learning environment. As in other constructionist environments (i.e., Reference [77]) the final artifact becomes a motivating factor for the learners to pursue technical knowledge. Instructors highlighted how participants ramped up their productivity, bringing the additional "80%" of their energy in the weeks leading up to the performance.

What we found special about SFD's constructionist environment is the way they amplify how the constructionist artifact is socially situated such that it can become an immense ideational resource. Instructors and learners reflected on how the performances reached participants' communities, families, and friends. Coupled with the ways learners saw these computing artifacts as representations of themselves, their ideas, and their ability to do computing, the environment creates a unique opportunity for their identity trajectory to shift across communities and spaces in their lives similar to Calabrese Barton et al. [18]. The performance thus also became a risk, because if failure occurred, that too would be amplified. Our work sheds light on this underexplored tension in constructionist environments inherent in their instantiation—i.e., social artifacts can facilitate attention to both success and failure. The risk was seen as worthy by SFD because of the power of a successful performance for solidifying the experience, the learners' knowledge and skills, the collaborative and supportive relationships, and the demonstration of confidence and *fearlessness* through participants' successful traversal.

5.4 Implications for Future Computing Education

Three main contributions in this work add to our understanding of teaching and learning computing. First, the case study provides insight into the ways designers can center identity in the design of a computing learning environment to open up opportunities for personally meaningful education. While previous work has pointed the the importance of identity, we demonstrate how SFD created specific ways for learners to engage with their socio-political identities that should be incorporated into broadening participation efforts. Further, by exploring dance and computing, our case study illustrated the opportunities for identity work that are unique to performative computing spaces. Second, we highlight how the intersections between dance as a performance discipline and computing as an artifact-driven discipline can have unique social and cultural implications for how constructionist artifacts are produced, shared, and valued. These in turn affect the types of identity work and engagement with computing that are possible as the learners create their dances and share them with a broader audience. Last, we identify how psychological safety can

be a helpful construct for designing inclusive and supportive learning environments. Examining the learning environment from the lens of psychological safety highlighted important characteristics for equity and enabled us to explore how it was received and reciprocated by the learners and instructors. Computing education could benefit from operationalizing this construct within the design and development of inclusive learning spaces to forefront empathy and care for minoritized learners engaging in computing.

6 RECOVERABILITY

The article was developed through a research collaboration grounded in relationships of individuals from the organization STEM From Dance and our research team. Through our collaborative work together we were able to situate findings from the 11 interviews we conducted with instructors, youth participants, and Yamilée, the executive director, in the broader context of STEM From Dance and our work with them. The detailed account of our methods, including the process through which we built a relationship with the organization, is intended to articulate the framing of the investigation and the approach to implementation to make our processes *recoverable* [44] such that other researchers can understand the frameworks that guided the investigation and the work engaged in by the researchers to reach our findings and conclusions. The intention of the work is to contextualize the learning environment and the participants' experiences in ways that expand how computing education researchers explore design for meaningful engagement and participation of learners within underrepresented demographics in computing.

7 CONCLUSION

Performative artistic computing spaces create a distinguishing tension between the challenges and fears surrounding a final performance, balanced with the potential for a transformative experience overcoming those hurdles and showcasing learners' artifacts, identities, and skills. Combining dance with computing provided an open-ended site for creative collaboration that allowed learners to personally identify with the artifacts they created as they leveraged existing cultural knowledge. Learners were motivated to persist through technological challenges by a desire to deliver a successful public performance. Further, they had opportunities to teach, learn, and gain social capital through meaningful group work as they developed their artifacts. The features of the format also came with the risk of the final performance going poorly and its potential negative impact on confidence and identity work. However, the organizational structure of the SFD community and experience created a psychologically safe environment to mitigate the risks and support learner growth. Performative computing spaces offer an exciting potential that research needs explore further as we expand the ways that youth can engage with their computing identities and expand the ways in which computing spaces develop equitable and inclusive contexts for learning and cultural sustainment.

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REFERENCES

[1] Edith K. Ackermann. 2004. Constructing knowledge and transforming the world. *A Learn. Zone One's Own: Shar. Repres. Flow Collab. Learn. Environ.* 1 (2004), 15–37.

[2] H. Samy Alim and Django Paris. 2017. What is culturally sustaining pedagogy and why does it matter. *Culturally Sustaining Pedagogies: Teaching and Learning for Justice in a Changing World*, Teachers College Press, 1–21.

[3] H. Samy Alim, Django Paris, and Casey Philip Wong. 2020. Culturally sustaining pedagogy: A critical framework for centering communities. In *Handbook of the Cultural Foundations of Learning*. Routledge, 261–276.
[4] Ayana Allen-Handy, Valerie Ifill, Raja Y. Schaar, Michelle Rogers, and Monique Woodard. 2020. *Black Girls STEAMing through Dance: Inspiring STEAM Literacies, STEAM Identities, and Positive Self-concept*. IGI Global.
[5] Morgan G. Ames. 2018. Hackers, computers, and cooperation: A critical history of Logo and constructionist learning. In *Proceedings of the ACM Conference on Human-computer Interaction*. 1–19.
[6] Catherine Ashcraft, Elizabeth K. Eger, and Kimberly A. Scott. 2017. Becoming technosocial change agents: Intersectionality and culturally responsive pedagogies as vital resources for increasing girls' participation in computing. *Anthropol. Educ. Quart.* 48, 3 (2017), 233–251.
[7] Fiona Bannon. 2010. Dance: The possibilities of a discipline. *Res. Dance Educ.* 11, 1 (2010), 49–59.
[8] Lecia Jane Barker, Kathy Garvin-Doxas, and Michele Jackson. 2002. Defensive climate in the computer science classroom. In *Proceedings of the 33rd SIGCSE Technical Symposium on Computer Science Education*. 43–47.
[9] Lecia J. Barker, Melissa O'Neill, and Nida Kazim. 2014. Framing classroom climate for student learning and retention in computer science. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*. 319–324.
[10] Angela Calabrese Barton and Edna Tan. 2010. We be burnin'! Agency, identity, and science learning. *J. Learn. Sci.* 19, 2 (2010), 187–229.
[11] Audrey Bennett, Ron Eglash, Michael Lachney, and William Babbitt. 2016. Design agency: Diversifying computer science at the intersections of creativity and culture. In *Revolutionizing Education through Web-based Instruction*. IGI Global, 35–56.
[12] Yoav Bergner, Shiri Mund, Ofer Chen, and Willie Payne. 2019. First steps in dance data science: Educational design. In *Proceedings of the 6th International Conference on Movement and Computing*. 1–8.
[13] Yoav Bergner, Shiri Mund, Ofer Chen, and Willie Payne. 2020. Leveraging interest-driven embodied practices to build quantitative literacies: A case study using motion and audio capture from dance. *Educ. Technol. Res. Devel.* (2020). DOI: https://doi.org/10.1007/s11423-020-09804-2
[14] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitat. Res. Psychol.* 3, 2 (2006), 77–101.
[15] Virginia Braun and Victoria Clarke. 2012. Thematic analysis. In *APA Handbook of Research Methods in Psychology*, H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, and K. J. Sher (Eds.). Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological, American Psychological Association, 57–71. https://doi.org/10.1037/13620-004
[16] Steven P. Brown and Thomas W. Leigh. 1996. A new look at psychological climate and its relationship to job involvement, effort, and performance. *J. Appl. Psychol.* 81, 4 (1996), 358.
[17] Leah Buechley and Benjamin Mako Hill. 2010. LilyPad in the wild: How hardware's long tail is supporting new engineering and design communities. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems*. 199–207.
[18] Angela Calabrese Barton, Hosun Kang, Edna Tan, Tara B. O'Neill, Juanita Bautista-Guerra, and Caitlin Brecklin. 2013. Crafting a future in science: Tracing middle school girls' identity work over time and space. *Amer. Educ. Res. J.* 50, 1 (2013), 37–75.
[19] Kevin Clark and Kimberly Sheridan. 2010. Game design through mentoring and collaboration. *J. Educ. Multim. Hyperm.* 19, 2 (2010), 125–145.
[20] Kayla DesPortes, Monet Spells, and Betsy DiSalvo. 2016. Interdisciplinary computing and the emergence of boundary objects: A case-study of dance and technology. Singapore: International Society of the Learning Sciences, ACM. https://doi.dx.org/10.22318/icls2016.129
[21] Kayla DesPortes, Monet Spells, and Betsy DiSalvo. 2016. The MoveLab: Developing congruence between students' self-concepts and computing. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education*. 267–272.
[22] Betsy DiSalvo, Mark Guzdial, Amy Bruckman, and Tom McKlin. 2014. Saving face while geeking out: Video game testing as a justification for learning computer science. *J. Learn. Sci.* 23, 3 (2014), 272–315.
[23] Charles Duhigg. 2016. What Google learned from its quest to build the perfect team. Retrieved from https://www.nytimes.com/2016/02/28/magazine/what-google-learned-from-its-quest-to-build-the-perfect-team.html.
[24] Amy C. Edmondson. 1999. Psychological safety and learning behavior in work teams. *Admin. Sci. Quart.* 44 (1999), 350–383.
[25] Amy C. Edmondson and Zhike Lei. 2014. Psychological safety: The history, renaissance, and future of an interpersonal construct. *Annu. Rev. Organ. Psychol. Organ. Behav.* 1, 1 (2014), 23–43.
[26] Ron Eglash, Juan E. Gilbert, and Ellen Foster. 2013. Toward culturally responsive computing education. *Commun. ACM* 56, 7 (2013), 33–36. DOI: https://doi.org/10.1145/2483852.2483864
[27] Alberto Esquinca, Elsa Q. Villa, Elaine Hampton, Martine Ceberio, and Luciene Wandermurem. 2015. Latinas' resilience and persistence in computer science and engineering: Preliminary findings of a qualitative study examining identity and agency. In *Proceedings of the IEEE Frontiers in Education Conference (FIE)*. IEEE, 1–4.

[28] S. Alease Ferguson and Toni C. King. 1996. Bringing organizational behavior and therapy together: Counseling the African American female on "job socialization failure." *Wom. Therap.* 18, 1 (1996), 47–58.
[29] Deborah Ann Fields, Yasmin Kafai, Tomoko Nakajima, Joanna Goode, and Jane Margolis. 2018. Putting making into high school computer science classrooms: Promoting equity in teaching and learning with electronic textiles in exploring computer science. *Equit. Excell. Educ.* 51, 1 (2018), 21–35.
[30] Jason Freeman, Brian Magerko, Tom McKlin, Mike Reilly, Justin Permar, Cameron Summers, and Eric Fruchter. 2014. Engaging underrepresented groups in high school introductory computing through computational remixing with EarSketch. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*. 85–90.
[31] Limor Fried. 2016. Introducing Circuit Playground. Retrieved from https://learn.adafruit.com/introducing-circuit-playground/overview.
[32] Kathy Garvin-Doxas and Lecia J. Barker. 2004. Communication in computer science classrooms: Understanding defensive climates as a means of creating supportive behaviors. *J. Educ. Resour. Comput.* 4, 1 (2004), 2–es.
[33] Nettrice Gaskins. 2014. *Techno-vernacular Creativity, Innovation and Learning in Underrepresented Ethnic Communities of Practice*. Ph.D. Dissertation. Georgia Institute of Technology.
[34] Nettrice Gaskins. 2019. Techno-vernacular creativity and innovation across the African diaspora and global south. *Captiv. Technol.: Race, Carcer. Technosci. Liberat. Imagin. Everyd. Life* (2019), 252–274. https://doi.org/10.1515/9781478004493-014
[35] Nettrice R. Gaskins. 2021. *Techno-vernacular Creativity and Innovation: Culturally Relevant Making Inside and Outside of the Classroom*. The MIT Press.
[36] Geneva Gay. 2002. Preparing for culturally responsive teaching. *J. Teach. Educ.* 53, 2 (2002), 106–116. DOI: https://doi.org/10.1177/0022487102053002003
[37] Clifford Geertz. 1973. Thick description: Toward an interpretive theory of culture. In *Interpretation of Cultures*, Basic Books, 3–30.
[38] Norma González, Luis C. Moll, and Cathy Amanti. 2006. *Funds of Knowledge: Theorizing Practices in Households, Communities, and Classrooms*. Routledge.
[39] Kris D. Gutiérrez and Barbara Rogoff. 2003. Cultural ways of learning: Individual traits or repertoires of practice. *Educ. Res.* 32, 5 (2003), 19–25.
[40] Idit Harel and Seymour Papert. 1991. *Constructionism*. Ablex Publishing.
[41] Nathan Holbert. 2016. Bots for tots: Building inclusive makerspaces by leveraging "ways of knowing." In *Proceedings of the the 15th International Conference on Interaction Design and Children*. 79–88.
[42] Nathan Holbert, Michael Dando, and Isabel Correa. 2020. Afrofuturism as critical constructionist design: Building futures from the past and present. *Learn., Media Technol.* 45, 4 (2020), 328–344. DOI: https://doi.org/10.1080/17439884.2020.1754237
[43] Dorothy C. Holland and William S. Lachicotte. 2001. *Identity and Agency in Cultural Worlds*. Harvard University Press.
[44] Sue Holwell. 2004. Themes, iteration, and recoverability in action research. In *Information Systems Research*. Springer, 353–362.
[45] Sian Hsiang-Te Tsuei, Dongho Lee, Charles Ho, Glenn Regehr, and Laura Nimmon. 2019. Exploring the construct of psychological safety in medical education. *Acad. Med.* 94, 11S (2019), S28–S35.
[46] David W. Johnson and Roger T. Johnson. 2009. An educational psychology success story: Social interdependence theory and cooperative learning. *Educ. Res.* 38, 5 (2009), 365–379.
[47] William A. Kahn. 1990. Psychological conditions of personal engagement and disengagement at work. *Acad. Manag. J.* 33, 4 (1990), 692–724.
[48] Eva-Sophie Katterfeldt, Nadine Dittert, and Heidi Schelhowe. 2015. Designing digital fabrication learning environments for Bildung: Implications from ten years of physical computing workshops. *Int. J. Child-comput. Interact.* 5 (2015), 3–10.
[49] Susan R. Koff. 2000. Toward a definition of dance education. *Childh. Educ.* 77, 1 (2000), 27–32.
[50] Michael Lachney, Audrey G. Bennett, Ron Eglash, Aman Yadav, and Sukanya Moudgalya. 2021. Teaching in an open village: A case study on culturally responsive computing in compulsory education. *Comput. Sci. Educ.* 00, 00 (2021), 1–27. DOI: https://doi.org/10.1080/08993408.2021.1874228
[51] Gloria Ladson-Billings. 1995. Toward a theory of culturally relevant pedagogy. *Amer. Educ. Res. J.* 32, 3 (1995), 465–491. DOI: https://doi.org/10.3102/00028312032003465
[52] Gloria Ladson-Billings. 2014. Culturally relevant pedagogy 2.0: a.k.a. the remix. *Harv. Educ. Rev.* 84, 1 (2014), 76–84.
[53] Jean Lave and Etienne Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press.
[54] Alison E. Leonard, Shaundra B. Daily, Sophie Jörg, and Sabarish V. Babu. 2020. Coding moves: Design and research of teaching computational thinking through dance choreography and virtual interactions. *J. Res. Technol. Educ.* 53, 2 (2020), 1–19.

[55] Yvonna S. Lincoln and Egon G. Guba. 1985. Naturalistic Inquiry. vol. 75, SAGE Publications.
[56] Yvonna S. Lincoln and Egon G. Guba. 1986. But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. *New Direct. Prog. Eval.* 1986, 30 (1986), 73–84.
[57] Anand Mahadevan, Jason Freeman, Brian Magerko, and Juan Carlos Martinez. 2015. EarSketch: Teaching computational music remixing in an online Web Audio based learning environment. In *Proceedings of the Web Audio Conference*.
[58] John Maloney, Mitchel Resnick, Natalie Rusk, Brian Silverman, and Evelyn Eastmond. 2010. The scratch programming language and environment. *ACM Trans. Comput. Educ.* 10, 4 (2010), 1–15.
[59] John W. Maxwell. 2006. Re-situating constructionism. In *The International Handbook of Virtual Learning Environments*. Springer, 279–298.
[60] Nora McDonald, Sarita Schoenebeck, and Andrea Forte. 2019. Reliability and inter-rater reliability in qualitative research: Norms and guidelines for CSCW and HCI practice. *Proc. ACM on Hum.-comput. Interact.* 3, CSCW (2019), 1–23.
[61] E. M. Mercier, B. Barron, and K. M. O'Connor. 2006. Images of self and others as computer users: The role of gender and experience. *J. Comput. Assist. Learn.* 22, 5 (2006), 335–348. DOI: https://doi.org/10.1111/j.1365-2729.2006.00182.x
[62] Matthew B. Miles and A. Michael Huberman. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*. Sage.
[63] Na'ilah Suad Nasir and Jamal Cooks. 2009. Becoming a hurdler: How learning settings afford identities. *Anthropol. Educ. Quart.* 40, 1 (2009), 41–61. DOI: https://doi.org/10.1111/j.1548-1492.2009.01027.x
[64] Na'ilah Suad Nasir and Victoria Hand. 2008. From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *J. Learn. Sci.* 17, 2 (2008), 143–179.
[65] Ingrid M. Nembhard and Amy C. Edmondson. 2006. Making it safe: The effects of leader inclusiveness and professional status on psychological safety and improvement efforts in health care teams. *J. Organiz. Behav.: Int. J. Industr., Occup. Organiz. Psychol. Behav.* 27, 7 (2006), 941–966.
[66] Nel Noddings. 2012. The caring relation in teaching. *Oxf. Rev. Educ.* 38, 6 (2012), 771–781.
[67] Nel Noddings. 2012. The language of care ethics. *Knowl. Quest* 40, 5 (2012), 52.
[68] Debra Mayes Pane. 2010. Viewing classroom discipline as negotiable social interaction: A communities of practice perspective. *Teach. Teach. Educ.* 26, 1 (2010), 87–97.
[69] Seymour Papert. 1980. *Mindstorms: Children, Computers, and Powerful Ideas*, Basic Books.
[70] Django Paris. 2012. Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educ. Res.* 41, 3 (2012), 93–97. DOI: https://doi.org/10.3102/0013189X12441244
[71] William Christopher Payne, Yoav Bergner, Mary Etta West, Carlie Charp, R. Benjamin Benjamin Shapiro, Danielle Albers Szafir, Edd V. Taylor, and Kayla DesPortes. 2021. danceON: Culturally responsive creative computing. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. 1–16.
[72] Roy D. Pea. 1993. *Practices of Distributed Intelligence and Designs for Education*, Cambridge University Press.
[73] Nichole Pinkard, Sheena Erete, Caitlin K. Martin, and Maxine McKinney de Royston. 2017. Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interest in computational activities. *J. Learn. Sci.* 26, 3 (2017), 477–516. DOI: https://doi.org/10.1080/10508406.2017.1307199
[74] Nichole Pinkard, Caitlin Kennedy Martin, and Sheena Erete. 2020. Equitable approaches: Opportunities for computational thinking with emphasis on creative production and connections to community. *Interact. Learn. Environ.* 28, 3 (2020), 347–361.
[75] Tom Prickett, Julie Walters, Longzhi Yang, Morgan Harvey, and Tom Crick. 2020. Resilience and effective learning in first-year undergraduate computer science. In *Proceedings of the ACM Conference on Innovation and Technology in Computer Science Education*. 19–25.
[76] Casey Reas and Ben Fry. 2007. *Processing: A Programming Handbook for Visual Designers and Artists*. The Mit Press.
[77] Mitchel Resnick and Yasmin B. Kafai. 1996. *Constructionism in Practice: Designing, Thinking, and Learning in a Digital World*. Lawrence Erlbaum Associates.
[78] Mathis Schulte, N. Andrew Cohen, and Katherine J. Klein. 2012. The coevolution of network ties and perceptions of team psychological safety. *Organiz. Sci.* 23, 2 (2012), 564–581.
[79] Kimberly A. Scott, Kimberly M. Sheridan, and Kevin Clark. 2015. Culturally responsive computing: A theory revisited. *Learn., Media Technol.* 40, 4 (2015), 412–436. DOI: https://doi.org/10.1080/17439884.2014.924966
[80] Kimberly A. Scott and Mary Aleta White. 2013. COMPUGIRLS'standpoint: Culturally responsive computing and its effect on girls of color. *Urb. Educ.* 48, 5 (2013), 657–681.
[81] Kristin A. Searle and Yasmin B. Kafai. 2015. Boys' needlework: Understanding gendered and indigenous perspectives on computing and crafting with electronic textiles. In *Proceedings of the Conference on International Computing Education Research*. 31–39.
[82] Kristin A. Searle and Yasmin B. Kafai. 2015. Culturally responsive making with American Indian girls: Bridging the identity gap in crafting and computing with electronic textiles. In *Proceedings of the 3rd Conference on Gender IT*. 9–16.

[83] Mia S. Shaw and Yasmin B. Kafai. 2020. Charting the identity turn in K-12 computer science education: Developing more inclusive learning pathways for identities examining identities-in-computing. *The Interdisciplinarity of the Learning Sciences, 14th International Conference of the Learning Sciences (ICLS) 2020* 1, 2013 (2020), 114–121.
[84] Mia S. Shaw, Yasmin B. Kafai, Yi Zhang, GaYeon Ji, Renato Russo, and Ammarah Aftab. 2021. Connecting with computer science: Two case studies of restorying CS identity with electronic textile quilts. In *Proceedings of the 15th International Conference of the Learning Sciences*. International Society of the Learning Sciences.
[85] Kimberly M. Sheridan, Kevin Clark, and Asia Williams. 2013. Designing games, designing roles: A study of youth agency in an urban informal education program. *Urb. Educ.* 48, 5 (2013), 734–758.
[86] Daniel V. Simonet, Anupama Narayan, and Courtney A. Nelson. 2015. A social-cognitive moderated mediated model of psychological safety and empowerment. *J. Psychol.* 149, 8 (2015), 818–845.
[87] Barjinder Singh, Doan E. Winkel, and T. T. Selvarajan. 2013. Managing diversity at work: Does psychological safety hold the key to racial differences in employee performance? *J. Occupat. Organiz. Psychol.* 86, 2 (2013), 242–263.
[88] Folashadé Solomon, Dionne Champion, Mariah Steele, and Tracey Wright. 2022. Embodied physics: Utilizing dance resources for learning and engagement in STEM. *J. Learn. Sci.* 31, 1 (2022), 1–34.
[89] Steven E. Stemler and Jessica Tsai. 2008. Best practices in interrater reliability: Three common approaches. *Best Pract. Quantit. Meth.* (2008), 29–49. DOI: https://dx.doi.org/10.4135/9781412995627.d5
[90] Sawaros Thanapornsangsuth and Nathan Holbert. 2020. Culturally relevant constructionist design: Exploring the role of community in identity development. *Inf. Learn. Sci.* 121, 11/12 (2020).
[91] Sepehr Vakil. 2018. Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education. *Harv. Educ. Rev.* 88, 1 (2018), 26–52.
[92] Kayla N. Walters and Dalia L. Diab. 2016. Humble leadership: Implications for psychological safety and follower engagement. *J. Leader. Stud.* 10, 2 (2016), 7–18.
[93] Ashley N. Woodson. 2020. Don't let me be misunderstood: Psychological safety, black girls' speech, and black feminist perspectives on directness. *J. Educ. Psychol.* 112, 3 (2020), 567–578. DOI: https://doi.org/10.1037/edu0000458
[94] Linda J. Yoder. 1993. Cooperative learning and dance education. *J. Phys. Educ., Recreat. Dance* 64, 5 (1993), 47–56.

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