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Digital Youth Divas: Exploring Narrative-Driven Curriculum to Spark Middle School Girls' Interest in Computational Activities

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Women use technology to mediate numerous aspects of their professional and personal lives. Yet, few design and create these technologies given that women, especially women of color, are grossly underrepresented in computer science and engineering courses. Decisions about participation in STEM are frequently made prior to high school, and these decisions are impacted by prior experience, interest, and sense of fit with community. Digital Youth Divas is an out-of-school program that uses narrative stories to launch the creation of digital artifacts and support non-dominant middle school girls' STEM interests and identities through virtual and real-world community. In this article, we discuss the framework of the Digital Youth Divas environment, including our approach to blending narratives into project-based design challenges through on- and offline

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mechanisms. Results from our pilot year, including the co-design process with the middle school participants, suggest that our narrative-centered, blended learning program design sparks non-dominant girls' interests in STEM activities and disciplinary identification, and has the potential to mediate girls' sense of STEM agency, identities, and interests.

INTRODUCTION

Most women use technology as a critical mediator of their professional and personal lives, yet few are involved in designing and creating computational devices and programs. Although science, technology, engineering, and math (STEM) career opportunities have increased over the past decade, the majority of young women pursue non-STEM fields of study, with disparities being even greater for women from nondominant communities (e.g., Corbett & Hill, 2015; DuBow, 2011; Klawe, Whitney, & Simard, 2009). Participation rates on Advanced Placement computer science exams, a gateway to college-level courses, likewise reveal stark race and gender contrasts: Recent studies found that less than 20% of test takers were female, and approximately 11% were boys and girls of a nondominant ethnicity (College Board, 2014; Ericson, 2014). In fact, despite doing well in STEM classes early on, many girls (but not all; see Allen & Eisenhart, 2017/this issue) eventually take on an anti-STEM identity that persists throughout life (see Hill, Corbett, & St Rose, 2010). These large-scale disparities reflect widespread racial and gender imbalances in learning opportunities within formal and informal STEM learning environments as well as the underlying, persistent systemic social and economic inequities that create such imbalances in society. In this article, we address inequities and possibilities in STEM learning for non-dominant girls.

Early opportunities to experience and become interested in STEM are not readily available to all students (Goode, 2007; Margolis, Estrella, Goode, Jellison Holme, & Nao, 2008). In particular, nondominant girls and youth from areas of lower socio-economic status have limited access to in- and out-of-school opportunities and resources that have the potential to build their computational fluencies (Goode, 2007; Margolis et al., 2008; Margolis & Fisher, 2002; Warschauer & Matuchniak, 2010; Watkins, 2012). For environments and opportunities that do exist, there are often persistent negative stereotypes about girls and nondominant students' STEM abilities and interests, a lack of a well-developed sense of community and belonging within STEM classrooms and fields, and a population that is predominantly White and male in terms of both who is participating and who is teaching (e.g., Johnson, Brown, Carlone, & Cuevas, 2011; Ko, Kachchaf, Hodari, & Ong, 2014; Malcom, Hall, & Brown, 1976; Margolis et al., 2008; Margolis & Fisher, 2002).

A sense of fit becomes particularly salient in the middle grades, when students begin to have more authority to select what opportunities they participate in and are at a stage of identity development when many are critically concerned with fitting in.

Indeed, it is in the middle grades that nondominant girls show declining STEM interest (Maltese & Tai, 2010; National Science Foundation, 2003a), which suggests that the racialized and gendered realities within STEM learning settings may make it difficult for many nondominant girls to develop a sense of belonging there (e.g., Johnson et al., 2011; Ko et al., 2014; Malcom et al., 1976; Margolis & Fisher, 2002). Decisions about participation in computing and engineering subjects have been related to prior experience, interest, and sense of fit with community (Johnson et al., 2011; Ko et al., 2014; Margolis et al., 2008; Margolis & Fisher, 2002), and such decisions are frequently established prior to high school (Ainley, Hidi, & Berndorff, 2002; Hulleman & Harackiewicz, 2009; Renninger, Nieswandt, & Hidi, 2015; Tai, Qi Liu, Maltese, & Fan, 2006). A growing body of research suggests that the perceptions and positioning of learners have implications for their participation and that the development of learner identities should be a focus of educational interventions (e.g., Bell, Tzou, Bricker, & Baines, 2012).

In this article, we describe Digital Youth Divas (DYD), an out-of-school program designed to address issues of prior experience, community, interest, and identity development in computer science and engineering for nondominant middle school girls. In particular, we explore how alternative STEM storylines might provide counternarratives that upend more prevalent, stereotypical, and recognizable storylines that permeate formal and informal learning settings to instead positively influence youth's perceptions of themselves and their abilities as domain-specific learners (Nasir, Snyder, Shah, & Ross, 2012; Varelas, Martin, & Kane, 2013). Building on a 10-year history working with and designing learning opportunities for urban youth (Barron, Gomez, Pinkard, & Martin, 2014), we hypothesize that a narrative-driven, blended (face-to-face and online) learning environment can spark nondominant girls' STEM interests and identities. Using data from the first year of program design and implementation, we examine the intentional design components of the DYD model and focus on two primary research questions: How can narrative stories support engagement and building community within informal STEM learning environments? What program components and practices, including narratives, connect to girls' developing STEM-related interests and identities?

The article has four major sections. First, we outline the theoretical concepts —interest development and identity resources—to ground our narrative-centered, blended learning design. Second, we introduce the DYD program and explain our unique design and the tensions inherent in integrating race and gender counternarratives into e-textile and programming design activities through online and in-person mechanisms. Third, we present methods and qualitative results from a study of our implementation, focusing on how girls identified with the narrative story and took on a designer role in the DYD program. Fourth, we discuss the importance and implications of these findings and ideas for future directions of study and design.

Developing Interest Through Engaging Experiences

Hidi and Renninger (2006) defined interest as a state of heightened affect and a predisposition to reengage a subject based on one's knowledge, value, and feelings about it. They outlined a four-phase continuum of interest development from situational to well-developed interest in which extrinsic motivation is required to spark interest and both extrinsic and intrinsic motivation are necessary for self-sustained participation in STEM activities. For instance, the situational interest of a student may be sparked by the task environment—objects, activities, peers, instructors—yet when these environmental factors are removed, the student may disengage. By contrast, the final phase—a well-developed interest—is typified by one's intrinsic interest and motivation to participate, which may still benefit from extrinsic or environmental motivators (e.g., role models, praise) but does not hinge on them.

Hidi and Renninger's (2006) model is useful for thinking about how to construct a task environment that may spark interest in a novel activity or domain and what may be necessary to shift that initial interest into a longer term interest. At the same time, it is limited in its utility for designing an inclusive learning environment for racially nondominant youth and girls who have historically been marginalized and isolated in STEM. Although their model appreciates that engagement emerges from interaction between individuals and their environment, it does not account for the diversity of people's environment or the sociality of how their participation is influenced by their histories, sense of future, or social or interactional goals that might coincide with or supersede their interest development in a particular domain or topic (Azevedo, 2013). Building on interest development and communities of practice perspectives (e.g., Lave & Wenger, 1991), Azevedo (2013) introduced *lines of practice* to clarify conceptually that the ebbs and flows of interest development reflect the shifts in interaction between one's past, present, and future preferences and the conditions of practice. His conceptualization offers a more nuanced view of environment (including material, communal, status, and access-oriented dimensions) and of an individual's history and preferences that has implications for how to design learning environments that are authentically interest driven.

Research on short-term and long-term interest development (e.g., Azevedo, 2013; Barron et al., 2014; Hidi & Renninger, 2006) reveals the importance of creating a diverse landscape of supportive learning environments in and out of school that afford participants the time, activities, peers, and expectations to explore unfamiliar potential areas of interest. Nonetheless, few STEM learning settings meet these criteria for nondominant girls, and the literature is still unclear about how to develop STEM learning environments that both spark nondominant students' and female students' situational interests and cultivate their well-developed interests and engaged participation. We argue that this is because STEM

learning environments rarely build off of nondominant girls' current interests, nor do they acknowledge or intentionally debunk racialized and gender stereotypes that might alienate nondominant girls from participating in and identifying with STEM. In this work we build on Hidi and Renninger's (2006) model to view interest development and youth participation as linked with identity construction.

Supporting Participation and Interest Through Identity Construction

Recent literature in STEM education suggests that interest development, particularly for marginalized and stereotyped youth, is not simply an individual accomplishment or a discrete activity but a social and interactional process that is often mediated by how students perceive the valued ways of knowing and being of a given practice or discipline in relation to the ways of knowing and being with which they already identify (Bang & Medin, 2010; Varelas et al., 2013). The limited interventions that do exist frequently attend to how racialized, gendered stereotypes limit these girls' participation, interests, and identities in STEM. Indeed, recent interventions such as CompuGirls, Black Girls CODE, and Techbridge offer nonisolating, identity-rich learning spaces for nondominant girls to experience and participate in rich STEM activities (e.g., Mosatche, Matloff-Nieves, Kekelis, & Lawner, 2013; Scott, Sheridan, & Clark, 2015; Scott & White, 2013). These interventions are built on an understanding of the racialized and gendered nature of learning and participation, particularly within domains of knowledge like STEM that are privileged in society. This work suggests that to support interest development, it is important to understand the types of racial and disciplinary identities that are also being negotiated.

Many inclusive STEM learning spaces are characterizable by their efforts to broaden participation in computing and technology by targeting racially diverse students, by including racially diverse role models or instructors, and by both acknowledging students' intersectional and multiple identities and dispelling stereotypes that may constrain students' willingness to participate (Margolis et al., 2008; Margolis & Fisher, 2002; Scott et al., 2015). Although these interventions may eventually become "affinity spaces" or "a place or set of places where people affiliate with others based primarily on shared activities, interests, and goals, not [only] shared race, class culture, ethnicity, or gender" (Gee, 2004, p. 67), there is an awareness that it is necessary to create learning environments that overcome the various and distinct design challenges of sparking racially nondominant girls' interest in STEM.

First, designers have to mitigate stereotypes and nondominant girls' concerns about fit and/or marginalization within STEM. Second, these environments must create learning experiences that engage these youth in high-quality STEM activities that spark their participation and STEM interests. Third, to deepen nondominant girls' STEM interests, designers have to develop ways to keep

these girls engaged in STEM activities beyond the narrow physical and temporal confines of the intervention. This requires considering their broader learning interests and ecologies and exploring mediums that can be exploited for continued engagement. Finally, to monitor interest development, designers should develop fading environmental scaffolds that initially serve as motivators but decrease over time as the girls' levels of participation and interests deepen.

Using Narratives to Address Stereotypes and Spark Interest

Educational designers have begun to examine the affordances of narrative-centered learning environments for educational purposes and relative to STEM (Baker & Leary, 1995; Dickey, 2011; Grimaldi, Fokkinga, & Ocnarescu, 2013; Ketelhut, 2007; Lloyd, 2000; Pruitt & Adlin, 2006; Rowe et al., 2009; Squire, 2006). Although the use of counternarratives has been found to increase girls' engagement and retention of interest in STEM fields (Baker & Leary, 1995; National Science Foundation, 2003b), less is known about the design features of narrative-centered learning environments that might support interest development for nondominant girls.

Our approach is based on an understanding that while individual youth may gain interest in a topic or domain, interest development occurs alongside processes of learning and participation. Indeed, these processes are mediated by social others and students' perceptions of what ways of being and knowing are valued for that domain and whether those perceptions align with who youth see or foresee themselves to be (Bang & Medin, 2010). Likewise, we view learning environments as spaces in which participants' social roles and identities, and perceptions about them, influence their own participation and often dictate how they are positioned relative to participation (Cole, 1996; Gutierrez & Rogoff, 2003; Lave & Wenger, 1991; Lee, 1997; Wenger, 1998; Wortham, 2006).

Learning-in-practice views argue that learning is determined by shifts in one's participation (i.e., practices, use of artifacts) and that learning is intertwined with identity formation as one's continuing participation in a practice or a particular domain becomes integral to who one is (e.g., Lee, 1995, 1997; Nasir & Hand, 2008; Varelas et al., 2013). In order to see how interest, participation, and identity processes co-occur in DYD, we draw on the framework of Nasir and Cooks (2009) to outline three types of identity resources—ideational, relational, and material—that are made available in learning environments. *Ideational resources* are the ideas that are offered up in the discourse and interactions in the specific learning setting about what is valued and who one is and can be. *Relational resources* are the ways in which the relationships with others in the setting, such as peers, mentors, and instructors, provide people with information about who they are (and are not) and the types of identities they support. Finally, *material resources* are the ways in which artifacts and other physically tangible objects (e.g., curriculum) in the setting tell people about who they are and who they can be (Nasir & Cooks, 2009). These resources accumulate over time in ways that can

positively or negatively influence youth's participation, identity, and learning trajectories relative to a practice or set of practices that constitute an activity or discipline.

Research on the intertwining processes of learning and identity also indicates that particular *storylines*, or stereotypical narratives that are discursively reproduced, are prevalent within society and learning settings. These storylines narrate how youth perceive themselves and their abilities, particularly in domains like STEM (Allen & Eisenhart, 2017/this issue; Varelas et al., 2013), and have implications for the types of identities youth are afforded access to within learning environments (Nasir et al., 2012; Varelas et al., 2013). Storylines are powerful because they define the parameters of a single identity construct (e.g., racial identity, learner identity) *and* shape how that identity is viewed in relation to an individual's other real or perceived identities (Givens, Nasir, Ross, & McKinney de Royston, 2016; Nasir, 2011). This is because identities operate functionally in sets, such that one aspect of one's identity has implications for other aspects. For example, stereotypes about scientists or techies often evoke a cluster of identities (including White, male, nerdy, good at science) while excluding others (like stylish, popular, or artistic). Well-known persons like Steve Jobs, Bill Gates, and Bill Nye become static, one-dimensional representations of who is assumed to be interested in or good at science or technology (Visintainer, 2015). Yet these stereotypical *identity constellations* do not reflect intragroup or intraperson diversity *and* seemingly foreclose the possibility that alternative identity constellations exist or can be developed (Givens et al., 2016).

THE DYD PROGRAM MODEL

DYD is an out-of-school program developed to engage middle school girls in design-based engineering and computer science activities, with a special focus on recruiting and retaining girls from underrepresented urban communities, especially girls who have not expressed interest in STEM. The program environment addresses the previously outlined design challenges using the DYD situational framework: a narrative storyline that is based on nonstereotypical characters, in-person activities led by racially diverse female mentors and involving interactions with racially diverse female peers, and an online platform that extends beyond the confines of in-person activities. This framework builds on 10 years of design-based implementation and research in formal and informal youth learning environments across Chicago by the Digital Youth Network (DYN), founded by the lead author.

DYD is a 2-year program sequence that is scaffolded to offer girls increasing levels of expertise, creative freedom, and learning opportunities as designers, programmers, electrical engineers, and computer scientists. The first year, organized to spark an initial first stage of interest (Hidi & Renninger, 2006), relies heavily on the situational components of the project-based curriculum, narrative stories, online platform, and

mentors. The final year, by contrast, is driven by the individual youth learner's interests and project design ideas. In this article, we focus on the first year of the program, designed to bridge connections between girls' existing interests and STEM using the DYD situational framework. This interconnected framework is integrative in its design and delivery, and it is mediated by intentional instructional and social practices. Here we describe the four primary components of the framework, highlighting the design and interaction features intended to debunk adverse racialized and gendered stereotypes and expose youth to a myriad of computational practices as technological creators and designers to support youth identification with computing and engineering topics.

Project-Based Curriculum

Research suggests that project-based curriculum intentionally positions girls as creators and designers through the making and creating activities they engage in that support youth in developing STEM-linked interests and identities (e.g., Barron & Martin, 2016; Barron, Wise, & Martin, 2013; Blikstein, 2013; Vossoughi & Bevan, 2014). Given that many engineering and computational making domains remain male dominated (e.g., Blickenstaff, 2005; College Board, 2014; Ericson, 2014), the DYD project-based curriculum is designed to counter these trends by inviting participation from nondominant, female youth. The modular curriculum is clustered into three project families (e-fashion, e-paper, and e-dance) that interweave computational and digital literacies through the development of creative artifacts. Girls who participate in DYD transform everyday items (e.g., hair ornaments, bracelets, and greeting cards) and practices (e.g., dancing) into unique, personalized objects and experiences through the integration of circuitry, fabrication, programming, and design.

The e-paper and e-fashion work builds on the *Grinding New Lenses* e-craft series developed by Kylie Peppler and colleagues (Peppler, Gresalfi, Tekinbas, & Santo, 2014), and the e-dance unit utilizes Virtual Environment Interactions, an introductory programming platform developed by Shaundra Daily and colleagues (Daily et al., 2014). Each curricular unit promotes independent work and problem solving through complex design projects that are broken down into smaller activities (see Figure 1). Each project is accompanied by learning resources such as how-to guides, troubleshooting tips, and related extension activities. Activities are designed to support community development (e.g., showcase events) and identity reflection (e.g., video diaries).

Narratives

In the DYD model, narratives are used to motivate participation and interest, launch project activities, and explicitly connect girls to a larger (albeit fictional) community of racially diverse female computational makers. The DYD narratives were co-designed

FIGURE 1 Youth participants working on the artistic and circuitry design of their e-cuff project.

by the team and middle school girls in the program (described in more detail later in this article) and written by professional children's authors. The narrative centers on a group of students in a parallel middle school DYD club. Each narrative episode is aligned with a curricular unit (e-fashion, e-paper, e-dance) and focuses on a different character in the fictional club. Narrative episodes are made up of multiple chapters, with each chapter scaffolding project activities within the curricular unit. In each chapter, the main character encounters a situation, challenge, or design-thinking prompt that requires the creation of a physical artifact or written solution. The characters work together through projects, often relying on one another for support or competing with one another as they navigate academic, technical, and social issues that impede their project's progress and their sense of well-being. The action takes place within the context of relatable middle school settings and experiences, including classrooms, cafeterias, libraries, computer labs, and school dances. To support multiple learning modalities and varied opportunities for exploration and connection, the text of the narratives is available through the online platform and in hard copy, and dramatic animations of selected segments of the narratives are also available in the platform.

The narratives encourage interest and engagement through elements of contemporary young adult fiction (mystery, clues, social and emotional issues) that elicit youth curiosity (e.g., Dickey, 2011; Malone, 1981). At the level of week-to-week implementation, these stories provide girls with an unfolding incentive to initiate and continue participation, as their work and progress drives the unlocking of subsequent chapters and allows them to follow the thread to a conclusion. As material and ideational resources, these stories offer alternative storylines about race, gender, and computing that deviate from dominant stereotypes. The main characters are middle school girls with a variety of racial and ethnic backgrounds, skills, interests, and technological experiences who, like the DYD participants, are similarly engaged in computational activities and challenges that shift over time. Characters are designed to present diverse representations of intersectional realities, identity possibilities, and stylistic nuances rather than stereotypical tropes (e.g., the nerdy programmer, the stylish girly girl, the athletic tomboy) as a way to ideationally position participants as capable of being interested in and succeeding in STEM irrespective of their perceived identities or identity constellations. Likewise, character body types are meant to reflect the diversity of heights, weights, and physical features (eye color, hair length and type) of adolescent girls. Nonstereotypical combinations of character interests, appearances, and storylines are designed to mirror the complexity of middle school girls' multiple identities, potential STEM interests, and social realities within schools.

Project activities are purposefully embedded in the stories to connect the fictional and real worlds. Girls are assigned projects that mirror those in the narratives, and technical language is used throughout the stories. This contextual project placement builds on work that has found that clearly communicated work and concepts can be relayed through project narratives (e.g., Putnam, 2010) in

FIGURE 2   A screenshot from a Digital Youth Divas narrative video showing a character holding her paper prototype for the e-cuff design project.

ways that allow users to apply the rules of their own existence in relatable worlds to figure out solutions (Dickey, 2011). In the animations, illustrations are embedded with visual representations of the projects and processes students work through in the face-to-face environment (see Figure 2).

Prompts for projects are launched from within the narratives, as are invitations for showcase opportunities such as competitions, positioning participants as creators and contributors in part of a larger community of digital makers (Barron et al., 2014; Martin, Barron, Austin, & Pinkard, 2009). For example, in one episode the girls in the narrative come up with the idea for a project that is then passed on to the girls in the program. The following excerpt reveals how the narrative blends the third-person fictional DYD story with a second-person STEM activity prompt:

> "Duh!" Sylvia pointed at her conductivity kit. "What if we could make the flowers light up? It would be a really cool effect, and everyone could see them." "Yes!" Roshonna grinned. "That's an amazing idea. How do we figure out how to get the lights to work?" She asked. "You guys focus on refining the design. Leave the lights to me," Sylvia grinned. "Alrighty then," Roshonna clapped her hands. "Let's get to work!"
>
> Now it's your turn: Use a 3 V battery to light 1 LED; Create a series circuit using 1 LED, a 3 V battery and alligator clips; Continue to add LEDs and alligator clips to create a series circuit; Use aluminum foil as a switch to turn your series circuit on and off.

Online Social Learning Network

The curriculum and the narratives unfold in an online platform in order to immerse the girls in the story and provide additional opportunities to interact with one another outside the face-to-face environment. The DYD platform uses

iRemix, a private online social learning network utilized during face-to-face DYN programs and accessible during out-of-program hours. The site supports youth to post work, receive feedback from mentors and peers, view and critique the work of others, and develop and manage a portfolio of projects (Martin, Nacu, & Pinkard, 2016). The platform was designed to extend access to quality digital learning opportunities for students beyond the confines of a physical program or classroom. The platform thus supports the broader learning ecology of youth across multiple locations, such as home, school, and community (Barron, 2006; Barron & Bell, 2015; Barron et al., 2014), and acts as an affinity space (Gee, 2004) in which participants at different levels of expertise are engaged around common interests and projects.

For the DYD, participation on the site allows girls to build profiles and portfolios of work and to start cultivating a desired social reputation within the private and safe community of digital creators. In turn, they are viewed, critiqued, and positioned by others, gaining recognition both internally and outside the program if they choose to use the online space to showcase their work to family members, relatives, or friends outside the program. This is linked to the conceptualization of identities as being essentially stories about persons (e.g., Sfard & Prusak, 2005) that are a dynamic work in progress that is developed by time, individuals, and social practice (e.g., Holland, 2001). In this way, one can think of the girls constructing their own narratives within the online environment as they follow along with the virtual narrative world.

Distributed Online and Offline Mentors

Nondominant girls, like other learners, are influenced by the actors within a learning environment. Findings from previous work (Barron et al., 2014) highlight the fact that mentors play changing and varied roles that shift according to child, environment, and situation. Successful programs that show promise often are difficult to replicate or scale/spread (Coburn, 2003) because they are reliant on maverick mentors who are difficult to replicate. In addition, a critical issue when delivering STEM content to underrepresented populations compounded by repeating cycles of inequities is that often the best person to impart computational content and assess work is not the same person who can foster a safe and encouraging environment that promotes a sense of fit for the intended audience.

To address these issues, mentorship in the DYD program is distributed online and offline. Each mentor type has overlapping roles to support youth in learning and development, adapted from those found to be critical for developing young people's technological fluency at home, at school, and in the community (Barron et al., 2014; Barron, Martin, Takeuchi, & Fithian, 2009; Ching, Santo, Hoadley, & Peppler, 2015; Martin et al., 2009) and online (Nacu, Martin, Pinkard, & Gray, 2014). Mentors who lead the DYD face-to-face program are not engineers but

share cultural connections with the girls and have gone through curriculum and pedagogical training. These female mentors support and work alongside girls, attending to specific practices during interactions. Mentors encourage participation and completion, troubleshoot work, develop community through discussion and collaboration, orient student goals and monitor progress, create a safe environment, and regularly communicate with families. These practices help mentors model a female engaged in STEM activities and provide insight into potential career pathways. At the same time, adults online, including online mentors and program leads, who have some expertise in the project-based curriculum and computational making activities, offer feedback on submitted work, offer formative troubleshooting guidance on projects and questions, and suggest future work and unlock next steps, allowing girls to level up.

Based on the assumption that learning and identity development requires being in ongoing dialogue with the learner, the program model includes dedicated time for conversation. Unstructured conversation while girls talk among themselves as they work is combined with more structured mentor-prompted activities such as check-ins at the beginning of each session to explore how girls are feeling that day and what is going on in their world and circle time when mentors facilitate discussion with the girls around the identity themes raised through the narratives and showcase work.

METHODS

This work is grounded in design-based research (Brown, 1992; Collins, 1992; Hoadley, 2002) to understand learning environments in real-world contexts using a process of design, implementation, and iterative refinement. Using narratives as a mechanism for engagement and interest development requires that the narrative-based curriculum resonate with the target population. Thus, we engaged participants as co-designers to inform the design of narrative materials and practices and to explore potential relationships between the narratives and the girls' sense of agency, identity, and interest as related to STEM. Decades of participatory design literature has introduced the notion of involving users throughout the entire design process as equal stakeholders who have a say in the creation of systems and tools (Muller, 2003). Druin and colleagues' framework focuses on co-designing with children (Druin, 2002; Druin et al., 1998). Their work informed our approach to engaging the girls as design partners (who informed our approach to creating the narratives), testers (who provided feedback on the narratives), and users who engaged with the narratives during their experience in the DYD program (Druin, 2002). We used a co-design approach to creating the narratives because it provided a lens into the users and shifted traditional roles of power and positionality (i.e., in which teachers or adults make

the decisions) to instead allow the girls to help craft narratives that best suited their (and their peers') interests.

Program and Participants

The DYD pilot was held as an after-school program at two urban public charter schools once a week for 2 hr from January through May (16 sessions per school) and led by two female African American digital media mentors trained in the curriculum. Both women, one in her 20s and the other in her 30s, had significant experience with and ties to previous DYN youth-serving programs and the local communities served. A group of middle schools on the West and South Sides of Chicago with whom DYN had prior partnerships were considered for the Divas co-design year. To minimize logistical implementation challenges, we intentionally sought to launch the DYD co-design implementation in an environment where we had existing relationships with school personnel and where DYN was recognized as part of the after-school culture. The two schools were selected based on principal interest, space and support staff availability, and student demographics. Both schools had majority nondominant students who resided in underserved neighborhoods, but they were unique in comparison to each other. One school (that we refer to as Cedar Elementary) was predominantly Latino (91%), and the other (Elm Elementary) was predominantly African American (85%). Both schools had a high proportion (more than 89%) of students classified as low income.

Cedar was very invested in technology-driven programming, including a history with DYN programs during out-of-school and in-school time, an after-school digital video club, and a middle school game design elective. Elm did not have the same technology emphasis but had a unique focus on identity development, particularly in its mission of cultural identity through African heritage and history. A total of 17 girls signed up to participate: six at Cedar and 11 at Elm. The girls were representative of the target population of the DYD program. A total of 76% defined themselves as African American (two girls at Cedar and 11 girls at Elm), and 24% defined themselves as Latina (four girls at Cedar and none of the girls at Elm); 24% were from bilingual English–Spanish households. We did not collect data on individual girls' socioeconomic status but instead used their school's demographic data as a proxy.

Data Collection Strategies

Researchers worked closely with mentors to incorporate co-design strategies throughout the sessions at both schools. To capture these moments and to get an understanding of how the program was unfolding on a classroom and

individual level, we conducted in-person observations of the sessions, summaries of online activity, and semistructured interviews with individual girls.

Co-Design Strategies.   Specific co-design activities during the sessions were primarily discussion based, including sessions when adult mentors provided student co-designers with drafts of narratives and prompted conversation for participants to offer feedback on the storylines and character development. Furthermore, mentors regularly led discussions regarding how students connected with characters—in terms of both plausibility (i.e., Did the narratives remind girls of aspects of themselves and their lives?) and interest (i.e., Were the girls interested in what happened in the story?). Mentors also explicitly asked about sensitive topics such as race, ethnicity, and gender issues; in most cases, student discussions regarding these topics were verbose and lively with little probing. Focal questions and timing for specific conversations were coconstructed during regular meetings between the mentors and research team, but the conversations were also organic and emergent within the specific classroom implementations. Mentors reflected on these sessions with researchers, which contributed to decisions for adaptations and revisions of the narrative design and corresponding practices.

Field Observations and Digital Ethnographies.   Members of the four-person research team attended regular sessions at each school (approximately every other week) and recorded observations through field notes, often with embedded photographs. In total, 13 field documents were developed, seven from Elm and six from Cedar, representing 125 pages of typed notes. Two members of the research team also engaged in weekly digital ethnographies (Hine, 2008) to qualitatively document online activity and interactions unfolding on the platform over the course of the study. Twelve digital ethnographies were generated of the DYD iRemix instance (representing activities on the platform for participants of both physical locations) totaling 44 pages of notes. We captured 235 images, representing both photographs of the physical environments and screenshots of the online platform.

Semistructured Interviews.   To learn more about the individual girls in the program, including their prior experiences and ideas for their future, building on the idea that interest and engagement often happen across longer timeframes and confluences of experiences and opportunities (Barron & Bell, 2015), we identified a subset of girls as focal case studies representing higher and lower prior experience with fluency-building experiences (Barron, Walter, Martin, & Schatz, 2010). We conducted short interviews with these seven girls (four at

Cedar and three at Elm) at two time periods during the program. Interview protocols were adapted from existing instruments used in prior work: a *learning ecologies interview* the explored youth histories with technology and learning across spaces and time (Barron et al., 2009) and an *artifact-based interview* using student work as a shared reference point to discuss new knowledge, the design process, and plans for learning more (Barron et al., 2014). All interviews occurred during regularly scheduled DYD programming and were audio recorded; the artifact-based interviews were also videotaped. The learning ecologies interviews were approximately 20 min, and the artifact-based interviews were approximately 5 min long. Transcribing all interviews resulted in 67 pages. Throughout this article, pseudonyms are used to identify individual learners to ensure confidentiality.

Analysis

We used an inductive process (Strauss & Corbin, 1998) to analyze the extensive qualitative field notes, digital ethnographies, and youth interviews and connect data to the theoretical ideas of narratives and interest development, which led us to iterate on the narratives themselves. This set of data amounted to 39 text documents totaling 236 pages.

We began by conducting a line-by-line analysis (Emerson, Fretz, & Shaw, 1995) of the observation field notes, interview transcripts, and online ethnographies. Focusing on a random set of roughly 10% of the data collected, three senior members of the research team (two professors and one senior researcher) inductively applied codes to the data, which led to the development of an initial codebook with 64 codes. Examples of codes were group learning, motivation, student–student interaction, student–instructor interaction, STEM interest, race, and stereotype. Three graduate research assistants then applied the initial codebook to the corpus of data. In cases in which several codes defined a phrase, researchers used multiple nested codes to label data, ranging from phrases to multiple sentences that best illustrated the codes. The entire research team, which consisted of the senior members and graduate research assistants, met weekly to mediate inconsistencies and uncertainties in the coding and discuss modifications to the codebook, which included adding new codes and collapsing existing codes that were repetitive. The final codebook consisted of 77 codes grouped into 11 hierarchical categories so that we could better see patterns and themes. After creating the final codebook, the graduate students then iterated, applying the codebook to the entire corpus of data until the team reached a verbal agreement of saturation (i.e., no new phenomena were identified and the codes were correctly applied). In this article we present data from the codes and categories that related most closely to our research questions and

frequencies of application (see Table 1). In the following section, we present quotes that illustrate unique ways in which the co-design process impacted girls' feelings of agency, social and STEM identity, and situational interest.

RESULTS

This section summarizes results from inductive coding of our corpus of data for the duration of the DYD program at the two locations. Data used in this section include field notes from the face-to-face implementation at both schools, weekly ethnographic descriptions of activity in the online iRemix space, and transcripts of interviews with focal case learners. Our findings address the narratives as a unique artifact girls encountered as part of the DYD program, the practices that situated the narratives in the program, and the specific co-design aspect of the implementation. The section is broken into three parts that represent primary themes of youth agency, interest, and identity.

TABLE 1
A Selection of Codes Grouped by Code Type and Described by Definition

Category	Code	Description	N
Social ideologies	STEREOTYPE	Thoughts or beliefs that essentialize or problematically characterize certain types of people or certain ways of doing things (which are often proxy for talking about certain groups of people)	10
DYD program	NARRATIVE	Reference to the DYD narratives	52
	CHARACTER	Reference to a character or characters from the DYD narratives	40
Learning practices	ENGAGEMENT	Any reference to the level of engagement with any aspect of the DYD program	32
	MOTIVATION	Any reference to the reason anyone (mentor or youth) does something related to the DYD program (e.g. complete a project, use the iRemix platform, etc.)	51
Identities	LEARNER ID	Relates to or positions a student's identity as a learner, someone who develops new knowledge, figures things out, uses resources, etc. (including self-positioning)	29
	CREATOR ID	Relates to or positions a student's identity as a creator, someone who has innovative and new ideas, is able to make things they imagine, etc. (including self-positioning).	28

(*Continued*)

TABLE 1
(*Continued*)

Category	Code	Description	N
	STEM ID	Relates to or positions a student's STEM identity, someone who engages in science, technology, math, and engineering work (including self-positioning)	22
	DESIGNER ID	Relates to or positions a student's identity as a designer, someone who is artistic, can visualize and organize designs, etc. (including self-positioning)	16
	AGENCY	Youth being conscious of their ability to do something	14
	ARTIFACT ID	Youth connecting a specific artifact or material object (e.g. DYD project work) to some aspect of their own identity	6
	NARRATIVE ID	Youth connecting a specific story or character from the DYD narrative to some aspect of their own identity	4
Relationships	STUDENT-CHARACTER	Reference to some interplay between youth and characters (e.g. online interactions between girls and characters, girls talking about characters in the narrative)	31
	STUDENT-NARRATIVE	Reference to the relationship between the youth and the narrative (e.g. any discussion or reflection of the narrative by girls in the program)	25
Interests	INTEREST	Reference to youth personal interests, desires, or hobbies (can be related or not to DYD components or topic areas).	120
	STEM INTEREST	Reference to youth interests, desires, or hobbies related to STEM (circuitry, programming, etc.)	25
	FASHIONINTEREST	Reference to youth interests, desires, or hobbies related to fashion-related things (art, modeling, sewing, etc.)	24
Other	AFFIRMATION	Expressed agreement, affirmation, confirmation	8
	PERSPECTIVE SHIFT	Reference to a change over time about their views of themselves, STEM work, or the program.	5

N indicates the number of times a code was applied in the data set.

Agency Through Co-Design and Making

… every opinion that I had, they did it. [20150515_Interview_Elm_Maarika]

Our findings suggest that participants both accepted their roles as contributors and exhibited agency as co-designers of the narratives. They did not hesitate to

make comments about potential improvements that could be made to the narratives and took seriously their responsibilities and contributions.

Participants demonstrated agency by identifying themselves as designers of the narrative as opposed to user testers (Druin, 2002). One participant commented on an initial version of a visual narrative that only consisted of black-and-white sketches, saying,

> I really liked it, but I thought it would be more than just sketches. I think a way we can make it better is to add color and so we can see the people, it looked like all the same people. [20150206_Fieldnotes_Elm]

Use of collective language like *we, us*, and *our* exemplifies the extent to which the girls felt a part of the design process and recognized how their comments could effect change. Participants' comments about the narratives also reflected an awareness of audience for the narrative story beyond themselves. For instance, a participant explained her rationale for suggesting a change to the visual narrative sketches, saying, "The story isn't boring, but nobody would stay up just watching drawings. It would be better if it had color and features like eyes and nose" [20150206_Fieldnotes_Elm].

One of the main suggestions made that demonstrated the agency girls felt was to include themselves in the storylines and to reauthor their own stories. One girl said, "I don't know if you make the stories or not, but you should add some of us into the story, like us in this room." Another girl suggested that "one way to make it better" would be to make it a series in which actual students acted out the storyline, allowing them to redefine the narratives as they related to their current lives [20150206_Fieldnotes_Cedar].

These quotes begin to illustrate how students embraced the narratives, made the story their own, and exerted their agency as co-designers to make improvements. These findings led to direct changes in the narrative, including articulating character details as opposed to using the original intentionally vague character sketches (see Figure 3) and adding projects that allowed girls to tell their own story. For example, starter assignments such as the About Me video project and the construction of an online profile page enabled girls to tell their own story through video and writing. These assignments were shared through the online platform, adding to the community contributions from other girls in their cohort as well as the virtual characters.

Although evidence of agency through co-design was evident in field notes from both schools, individual learner perspectives within the two environments were different. In response to interview questions directly about their contribution to the DYD narrative design, the girls from Elm were confident about their influence, whereas the girls from Cedar responded with more caution. These girls told us that they offered their opinions about the story in class but they did not think these opinions would be used to modify the actual narrative artifact: "It wouldn't make a difference because they already
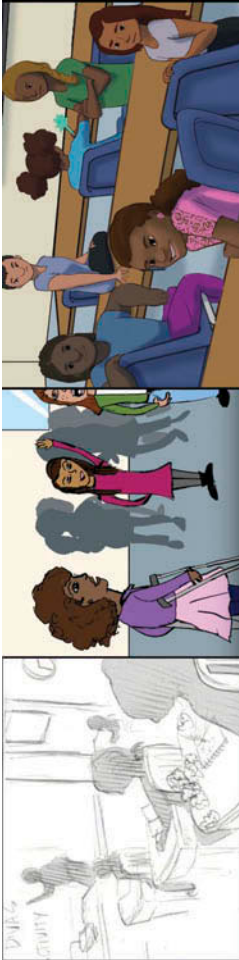
FIGURE 3   Images showing three stages of character development during the co-design process.

made the story, it was already made, and they don't got time to change it" [2015_LEinterview_Cedar_Siena]. This variability between school learners may be a result of the particular subset of girls who were selected to be interviewed, but it also may suggest something about the general culture of each school. Elm's emphasis on African American identity and self-efficacy perhaps positioned its students to more easily take on the role of contributor, whereas at Cedar it took significantly more effort to elicit student opinions. In addition, girls from Cedar were immediately willing to engage in the co-design process, whereas girls from Elm were more reserved in their initial comments. This required mentors to apply power transfer techniques from the co-design process, such as reminding girls that there were no wrong answers, they were the experts, and others would benefit from their opinion (Druin, 2002; Muller, 2003).

Though school cultural differences may have impacted students' perception of their impact on the narrative design process, field notes illustrated that girls at both schools exhibited agency as digital creators. Many shared their ideas for domain-related work beyond what was required, including new projects and ideas for revision. During a session, one girl reflected, "I would like to [make a] headband just like this and make it light up and stuff. And other things like shirts we will be making and bracelets, and bows and stuff" [201502_ABInterview_Elm_Maarika], and another was overheard saying, "I wish I could make it so it would only light up when you push a button" [20150217_Fieldnotes_Cedar]. Although these are suggestions, they represent how the girls were independently assessing the small next step in their learning pathway and connecting that step with their personal interests or goals. Even the girls who did not yet assign themselves an identity as a creator described their creative experiences: "I don't create stuff. I just do what they tell me to do and create … I try to create it and then try my best" [20150516_LEinterview_Cedar_Siena]. There is a direct relationship between youth's identity as a creator and their appropriation of the learning process, as they make plans to learn more and seek out resources to do so (Barron et al., 2014). These statements reflect how the girls may have been moving along the stages of interest development, shifting from doing something that was asked of them toward doing something that they initiated. This also suggests that the co-design process itself could also be a catalyst for creating situational interest than can then transform into more well-developed interests (Hidi & Renninger, 2006). Although this was not our intent, future studies could explore the impact of co-design on interest development.

Recent work has called out the importance of articulating, recognizing, and fostering *agentic* strategies for women of color in the computer science field, highlighting professionals who have used their own agency to create

success for themselves (Hodari, Ong, Ko, & Smith, 2016). For these middle school girls, working through complex design projects and having a voice that impacted program design supported them in developing a sense of themselves as agents in the DYD environment. It is important to note that mentors explicitly positioned the girls as contributors to the program, addressing their efforts in the co-design process and acknowledging successes in challenging STEM activity work.

> [Mentor] A. walks through the thought process of how to use apps like that, a lot of the time people design things to solve problems. "Who is asking girls your age from the south side of Chicago about what kind of apps they want to see or make?" A. is up front with them about the goals of the program, about how girls often don't go into these fields. She tells the girls that they are in a new program, and that they want to be able to expand this program to other schools, and they are going to help us do that. [20150116_Fieldnotes_Elm]

Throughout the year, the mentors revisited the girls' contribution to the program, specifically highlighting the changes made to the narrative as a result of their participation.

> [Mentor] S. says "You remember how we watched that video, and you said that you wish they had faces?" S. explains that there are illustrators working on the new version of the story, and that we have some drafts for you to look at. [20150327_FieldNotes_Elm]

The practice of positioning builds on previous DYN work (Barron et al., 2014). Programmatic iteration included DYD professional development articulating specific mentor practices to position girls as creators, community members, and long-term STEM learners, highlighting the importance of encouraging student contributions online and offline and regularly showing girls how they were shaping the program. Although this was tailored to the co-design process in this iteration of DYD, this approach is relevant to all design activities youth learners are engaged in during the DYD program. These design activities also are related to the emergent narrative in specific instances as youth design artifacts and contribute their work to the online community.

Narrative and Situational Interest

> The story added funniness, flavor … [without it] it would be like what am I doin' this for? [20150515_LEInterview_Elm_Melanie]

Overall, results indicate that narratives may trigger situational interest in STEM learning activities for middle school girls. Girls demonstrated engagement with the narrative stories within the DYD environment and indicated that the stories offered some girls motivation to continue engaging with the story. In field notes of program sessions, girls frequently were described as wanting to know more from day to day: "While discussing, Elaine asks if they will get to read the rest of the story" [20150116_Fieldnotes_Elm].

> [Mentor] A. asks if they liked it, they both say yes, one girl says that she would like to hear the 2nd part now. A. asks if they would like to read it on their own, and one girl says that she would like to keep reading on her own because it's interesting. [20150116_Fieldnotes_Elm]

In a voluntary after-school or out-of-school program, these types of motivators that can establish links from one program day to the next are especially valuable, as learners have choices about what they continue to participate in, and they can also anchor a connection to previous sessions, allowing for a more seamless continuation of work if girls are absent. In this way, the narratives in the DYD program were a situational component (Hidi & Renninger, 2006) that was able to connect with or spark interest with some of the program participants.

Building on the idea of motivation through narrative, the co-design process explored modes of dissemination. Although the narrative was an intentionally developed artifact within the DYD environment, the way it was introduced and practices of how it was used were highly impactful and became a focus of co-design discussions. For example, as the following excerpt from field notes highlights, girls shared that community and collaborative reading practices were appreciated:

> [Mentor] A. asked the girls if they would rather read the book on their own, or have her read out loud. [The girls] said that they would rather her read it. A. begins reading the story. They sit close together, huddled around A. and [mentor] S. They seem engaged in the story. Girls are smiling as A. reads, they have leaned in a bit since it began. It seems like they are interested. One girl claps when it's finished! [20150116_Fieldnotes_Elm]

This excerpt begins to highlight how narratives were one part of the DYD environment but that their connection to other situational components of the program, in this case the community of peers and mentors, was important in how the narratives actually played out in situ.

One girl went a step further in envisioning the interconnectedness of the narratives and the actual DYD community, describing a desire to act out the

story instead of simply reading it, saying "It's easy to follow the story, but I just want to [act it out] for fun" [20150206_Fieldnotes_Elm]. Although role playing was not a part of the DYD objectives, the students' desire to "be" the characters prompted questions about the function of role-playing narratives in interest and identity development. Although one intention of the narratives was to provide an alternative reality in which recognizable characters girls could relate to were engaged in STEM activities, building on visibility and identity work by Lee (1995, 1997) and Nasir (Nasir & Cooks, 2009), the girls wanted to write themselves directly into the story. This finding prompted us to iterate on various portions of the program model to allow girls to role play.

One change was to use the online platform to incorporate opportunities for participants to interact with the narrative characters. iRemix profiles were created for a few key characters from the narratives (two teachers and five girls), and DYD mentors managed these avatars. Teacher characters were used to launch assignments and assess submitted work. The story was modified to prompt girls to engage in online interaction with characters. For example, in one narrative installment the main character, Roshonna, receives a mysterious color-coded note in her locker. The girls were asked to respond to Roshonna in the online environment to help her decode the message using color theory. This approach yielded engaged responses in which girls both solved the problem and included a personal message, such as "hi Roshonnah im [participant name] i read the story and what i think the preson [sic] is trying to tell you is that you should be more nice, friendly, calming, cheerful, and dont let Mackenzie and Caitlin or anger get to you" and "Be calm and don't care what people say" [20160113_OnlineEthnography]. Girls also were observed interacting with one another in the face-to-face environment around these online messages to virtual characters: "Most of the group is finished writing the message, Saria and Amaya are still working, Saria asks what the subject of the message should be. They are discussing their messages, Saria looks at Amaya's screen to see what she wrote" [20150127_Fieldnotes_Cedar].

The concept of a learning system that enables educators to engage with youth through character avatars was part of the Fifth Dimension after-school clubs, in which a mythical wizard character helped to resolve conflicts in individual and community learning activities through e-mail exchanges. As with DYD, research into the Fifth Dimension found this strategy to impact both community and individual motivation to continue work and persist through problems (Kaptelinin & Cole, 1997). In one narrative DYD installment, a competition was seeded in the online environment that effectively brought girls into the narrative, generating collaboration and community across schools:

> Students initially posted their flower designs as submissions to the competition, then, in this same blog, began commenting on each other's work and congratulating

the winners. They are using "@" to identify who they are communicating with. Girls from each face to face site are communicating with each other, so the interactions aren't limited by site. [20150309_OnlineEthnography]

These examples highlight how the design process allowed for iterations to the program model, both to the specific narrative artifact but also in the development of social practices around the use of the story to increase nondominant girls' participation.

In addition to becoming immersed in and engaged by the story and sharing practices related to narratives, girls specifically expressed connections to project work and how narratives incentivized their participation in domain-specific STEM assignments. One girl stated, "They were really interesting and really … They're not just stories that aren't at all relevant to what we're doing—they're really relevant … [to] the projects that we did" [20150519_LEinterview_Cedar_-Flora]. Another identified a specific project that showed up in the story (see Figure 2): "[The story] goes along with what we do … It was interesting, 'cause the girl made her own e-cuff. That's why we made e-cuffs, from the story" [20150519_LEinterview_Cedar_Siena]. During an interview near the end of the year, one participant explained, "It made me wanna get really, really into Digital Divas because as I was reading the stories, I figured out that the things that they're doing in the stories are what we're gonna be doing in the club" [20150515_LEInterview_Maarika]. This girl went on to differentiate narrative-driven learning from school learning:

Because it's fun. We're learning. It's like how we learn in school when we read. In Digital Divas, we read and then we do hands-on. So if we were just doing hands-on, we wouldn't know what to do. And then it'd be boring because [the lead DYD mentors] will always be talking. "Do this, do that, you wanna do this." [20150515_LEInterview_Elm_Maarika]

Again, this reveals how the narratives were perceived in connection to another primary component of the DYD program, in this case project-based learning. Field notes revealed how the mentors purposefully framed the narrative in relation to activities and project work and how students took up that framing:

Mentor A. asks, "does this make sense why you're doing this?" *[researcher note: They are making mood flowers—not glowing ones, that correspond with the color wheel]* Group responds with "yes." A. asks, "But, why do you think you're doing this?" Filomena says "Relate to Roshonna and to be a part of the story." [20150210_Fieldnotes_Cedar]

Toward the end of the school year and program cycle, girls were asked to post an online reflection of their experience. Despite not being prompted to discuss any specific aspect, girls differentiated unique components of the program model, including narratives, projects, and mentors, calling each out as uniquely important to their experience:

> I think Digital Divas was extremely fun. The stories were engaging and it was awesome to be able to make what the characters were making. This year was a lot different from last year but I like it. My teachers are some of the nicest ones I've ever had and they were just like friends to me. I could not have been happier in this club and I hope the girls that join next year will have as much of a good time as I had. DIVAS ROCK!!!! [20150524_OnlineEthnography]

These quotes from the co-design implementation, found across different data sets (online traces and in-class observations from the cohort, and interviews with individual girls) offer encouraging evidence that narratives may incentivize not only participation but also situational interest by providing context and purpose for girls to complete activities associated with STEM learning. Although we did not survey every girl individually about her perspective, we consider this positive perception of the stories widespread, as more than one third (37%) of excerpts coded as narrative mentions were combined with a code of motivation or engagement.

Narrative and Identity

> [The main character is] a teenage me, I see her as myself. [20150210_Fieldnotes_Cedar]

One of our main objectives in this work was to understand the role of narrative in developing positive STEM-related interests and identities. When we examined aspects of the multidimensional nature of identity in relation to the DYD through coding of the corpus of qualitative data, three themes emerged: (a) how the narratives connected with the girls themselves and their immediate world; (b) how the narratives, especially as part of the co-design process, brought up issues of race and ethnicity and opportunities for direct discussion around STEM stereotypes; and (c) how the narratives connected with engineering and computer science content and practices.

The written narratives initially revealed few details about the outward appearance of the characters as a way to connect with girls through character actions and interests as opposed to physical attributes. When discussing this version, participants immediately made statements about how they envisioned the characters. Their descriptions included comparisons to themselves, people they knew,

and familiar media characters. One participant described the main character as "relatable" [20150210_Fieldnotes_Cedar] and another shared, "Roshonna is my favorite character because, isn't she the one who built the icicle crowns for the dance? I would do something like that. I like to create things" [20150515_LEInterview_Elm_Maarika]. One girl identified Roshonna as her favorite because of her fearless and capable personality: "'Cause she's like, this girl, she's not afraid of anything. She can take on anything she wants to take on" [20150515_LEInterview_Elm_Melanie]. Our goal in creating the narratives was not only to introduce STEM activities but also to present characters that were physically similar to the target audience and that challenged gender stereotypes in hopes of connecting participants with personas that positively influenced their self-efficacy. As exhibited in these example quotes, the girls' initial opinions about the characters were generally positive and connected to perceptions of themselves as creative and capable.

There were numerous comments relating characters to people girls knew or recognized. The recognition included characters and actions that were less than ideal, including what one girl described as "the drama," but for many girls such challenging characters and situations made it an authentic portrait of middle school. Showing how the girls connected with the characters and projected onto them personality and physical characteristics not included in the narrative, one student said,

> I think Ms. G is a big old mean lady, because she has to deal with theater and kids … She has glasses and wrinkles, average height. Sometimes she is nice, but mostly she mean, and she don't smile a lot. Short hair, gold necklace. [20150206_Fieldnotes_Elm]

Another girl referenced a former teacher in her description: "I think she looks like a teacher that used to work here, Mama April. She was my complexion" [20150206_Fieldnotes_Elm].

They also saw connections between characters in the narrative and characters in contemporary media:

> Like, when Jayla stole Roshanna design, I was watching *Pretty Little Liars* that day. This girl stole her design for her prom dress … It compares because they all work as a team, and I was thinking about *Empire*, because even though they fight a lot, at the end of the day, they still work as a team to get the job done. [20150515_LEInterview_Elm_Melanie]

Another girl at a different school also referenced the American teen drama *Pretty Little Liars* (and perhaps even the same episode), referring to a plot narrative of someone stealing someone else's idea, and mentioned also that the characters on

the show had a similar focus on fashion: "they make stuff, and they wear like style" [20150519_LEinterview_Cedar_Siena].

Related to the girls' character analysis and identification, throughout the co-design process there were frequent mentions of race and ethnicity when participants described how they imagined the characters. Initially we intentionally did not define characters in this way, yet participants seemed to link certain personality traits to physical attributes. One student said that she thought that the main character was "Caucasian." When asked why, she responded, "I don't know how to describe it … she wasn't snooty; she was like regular and girly" [20150206_Fieldnotes_Elm]. Another student chimed in and said, "She might have been mixed, because sometimes she acts black and sometimes white" [20150206_Fieldnotes_Elm]. Another said that the main character had to be a "blue-eyed blonde" [20150210_Fieldnotes_Cedar]. When reflecting on a character that was initially antagonistic to the protagonist, one girl described the character as "real, real, real light skinned and she thinks she is everything, but really she not, and she needs to talk to somebody and she wants all the attention" [20150206_Fieldnotes_Elm]. At the beginning of the program, these conversations were sometimes tentative, perhaps indicating that this type of frank discussion was not often encouraged in formal learning settings: "'I knew she was …' she trails off and [mentor A.] says 'Why are you whispering?' Monica says 'I knew she was white.' Julie says 'She is bougie and rich and white'" [20150327_Fieldnotes_Elm]. Comments such as these that link personality traits to particular phenotypes indicate that participants had previously encountered racialized and gendered stereotypes, whether or not they consciously endorsed them. These comments signal the importance of designers deeply understanding the stereotypes that nondominant girls experience in order to create counternarratives and images that lead to positive self-images and STEM identities.

Although our initial narrative representations intentionally did not address race or gender, we subsequently redesigned them to create a set of characters whose racial, gender, and personality compositions were more varied and more directly visually addressed (see Figure 3). Using the narrative representations in this way, we sought to offer students a range of ideational resources and diverse constellations of racial and gender identities and personalities that were explicit counternarratives to the types of stereotypes students had articulated. It is interesting that these perceived character race and ethnicity descriptions were explicitly connected not to STEM knowledge and learning stereotypes but rather to certain behavior characteristics and personality traits. The girls identified with the idea of the characters as makers and designers but also paid greater attention to some of the social aspects without including the STEM aspect as part of these initial discussions about the narratives.

How did the girls' identification with the characters shape their project-related activity and learning? To more explicitly draw in STEM and address any

FIGURE 4   Screenshots from two Digital Youth Divas (DYD) video learning resources featuring the DYD program manager.

intersectional stereotypes, we iterated on the need to have open discussions about issues such as stereotyping and inherent biases with young girls in STEM programming. As before, the aim was to offer a variety of ideational resources that attended to the intersectional identities, including those related to STEM, that might emerge for the students. The girls saw much about the narrative characters that they related to themselves or related to others in their everyday life, while at the same time these characters were regularly engaged in complex STEM activities. During an interview, one girl discussed how watching the girls enact a project within the narrative allowed her to see that as a model for something she was able to do:

> After you read a challenge, like if you read a story and they say that Roshanna and Lisa design something new for the [competition] … and then [the platform] they give you a competition, so it's like, okay I'm doing this, I thought I wouldn't be able to do it, but I'm doing it for real. [20150514_LEInterview_Elm_Melanie]

This recognition of the characters as models for their own activities is encouraging, and the program iterations explore questions about who can and should pursue STEM learning and what the different opportunities and challenges look like for different groups of people. Specific program modifications include more explicit support of mentor-led discussions with girls about one another's experiences through built-in discussion prompts that are offered both online and offline. In addition, the stories of the mentors are highlighted to share strategies for overcoming challenges faced by nondominant women and girls, especially in STEM. To further connect issues of identity and stereotype specifically to STEM activities, new activity resources were developed, including troubleshooting videos and how-to guides featuring technology and engineering help from people who looked and sounded different than traditional stereotypes of STEM experts (see Figure 4).

DISCUSSION

Evidence of Narratives and Supporting Practices as a Way to Encourage Engagement and Interest

In this article, we share the framework of the DYD program as a model that is intentionally designed to disrupt the racialized and gendered disparities in participation and interest and identity development in STEM fields. We highlight the four components of our design framework, namely, the project-based curriculum, interactive narratives, an online social learning network, and adult mentors. We also share findings from the pilot year of the DYD program focused on the development of interactive narratives that allow connections for nondominant girls. These findings offer evidence that nondominant girls' STEM engagement and interest was sparked through the DYD program and that iterative refinements resulting from the co-design process further deepened participation and interests.

In particular, the interactive narratives motivated girls to continue with the challenging STEM activities and contributed a sense of authentic purpose to the work. The narratives also provided a relatable fictional community of girls highly engaged with STEM-focused activities that showed promise for supporting racially and economically nondominant girls' practice-linked STEM identities. Our analysis suggests that the narratives served as material and ideational resources for identity development that were even more powerful when coupled with the relational resources of the social and instructional practices present in the blended DYD program design. Specifically, our qualitative data reveal that the nuanced nature of how the characters were presented and visualized created natural opportunities for students to make public their own stereotypes or their awareness of limiting racial, gender, and intersectional storylines, which energized discussion and conversation within the program. At the same time, participants continuously wrote themselves into the narrative, wanting to be represented as characters and making connections to their own lives. This can be seen as a form of self-positioning, as girls try on STEM participation in ways that may feel safe, potentially leading them to incrementally more dedicated participatory practices (i.e., within their DYD small group, within their DYD program, and outside of DYD altogether).

Through the lens of Nasir and Cook's (2009) framework, our analysis demonstrates that the narrative in its various forms, including written, video, and imagery, provided youth with material resources that supported the girls' engagement and interest development. Likewise, the utilization of tangible representations of characters and situations that were recognizable and relatable to them offered up ideational resources that similarly supported the girls' participation and identification with STEM activities and practices. When the narratives were aligned with creative and challenging multiweek STEM project work with a

community of learners and mentors, they offered up counternarratives about identity, interest, and ability that were catalysts for discussions about identity and STEM. At the same time, these occasions drew on the relational resources of the mentors in the program who encouraged and supported the girls' engagement, interest, and identification with the domain. It is not surprising that these interactions also further deepened relationships across students and mentors. As we show, the ideational resources from the narratives, the various material resources that facilitated the presentation of the narratives and the challenging STEM activities, alongside the relational resources in DYD supported face-to-face and online discussions about social-, project-, and domain-specific identity stereotypes. The narrative artifacts provided girls across program locations and mentors online and offline with a shared resource that energized conversation and relationship development. Mechanisms such as youth–character online interactions further strengthened the relational value between the fictional DYD cohort and the girls in the DYD program.

Significant programmatic changes resulted from the pilot implementation and co-design work, including iterative revision of character art and storylines to make the characters and their physical and personality characteristics more explicit and to purposefully offer a more expansive array of racial and gender identity options. An outcome of this work that impacted the online platform design and practice is recognition of the importance of attending to how and why girls connect their own stories to narratives. The online platform enhanced how girls interacted with the narratives, emphasizing personal connections through fictional profiles and messaging.

Program redesigns emphasized girls' own narratives, including promoting communications with characters in the online environment and seeding reflection of self and STEM experiences at various points during the program. We also trained mentors to engage in practices that more explicitly defined and supported the process of positioning girls as creative and agentic contributors and in promoting frank discussion of their lives and communities and families as they related (or not) to STEM, including time for discussion of racialized and socialized issues in the fictional and real worlds. These findings are encouraging evidence of the first stage of interest development (Hidi & Renninger, 2006) that is linked to the situational components of the environment and of how narratives added specific elements of motivation and sense of connection. It is important to note that the narratives are contextualized within interrelated components such as adult mentorship, project-based assignments, and the online platform.

The Need for Visible Pathways and Overlapping Opportunities

Appreciating the centrality of situational factors for sparking interest (Hidi & Renninger, 2006) and the case for developing interest and identities over time

and across locations (Barron & Bell, 2015), the environmental ecosystem for DYD was inspired by the model of young men's engagement with basketball. In basketball youth develop their core mechanics across formal and informal spaces and build on the resources of peers and mentors by frequently practicing and playing with and against the same cohort. Young men whose interest in basketball is sustained over time often transform their personal identity to pattern themselves after a famous basketball player whose life narrative drives their process for developing as a basketball player (e.g., students follow the practice regimen that they believe LeBron James used as a kid). Hence, this visible community of basketball players serves as face-to-face and virtual role models and mentors who cultivate youth's basketball vision and support young players as they learn the rules, challenge their abilities, and provide emotional and technical support as needed. These coach–player relationships improve the player's ability and can afford a young player valued social and cultural capital that can be leveraged within and outside of basketball communities. Although multiple communities of practice exist around basketball within one city, and each is designed for a unique context, the roles, exemplars, milestones, drills, practice, and play structures are often shared across communities to allow for movement, collaboration, and competition across these basketball communities of practice.

We believe that it is both possible and critical to develop an infrastructure of similar intersecting communities of practice intentionally designed to engage girls across different socioeconomic and racial backgrounds in developing base literacies in core STEM disciplines such as circuitry, programming, design, and multiple forms of fabrication.

In the work of the DYD, we explore questions about application and design to support movement along the stages of interest development, including *how* to create environments that not only ignite but can sustain interests and *what types of* situational factors create inhospitable learning environments. To answer questions of *how* we looked over a 10-year model of creating learning ecosystems that support urban youth to develop digital literacies through mentorship and intersecting opportunities. To answer questions of *what* we looked to Nasir's work on racialized stereotypes and identity resources.

A key goal of this work is uncovering design strategies that can make DYD as sticky as basketball and to create the context for DYD participants to practice their skills outside of program time, similar to the way in which youth interested in basketball practice by themselves between practices. In this article, we explicitly discuss our use of narratives as one strategy. An additional strategy we will use in our next program implementation is to use mentor knowledge of students' strengths and weaknesses to have the narrative characters send e-mails prompting girls to complete a specific mini-task

before the next session. These mini-tasks, similar to basketball drills, will be aligned to instructional areas (e.g., parallel circuits, specific sewing stitches) and assigned when specific girls need more practice in those areas or as enrichment to supplement in-class work. The effectiveness of these mini-tasks, similar to basketball drills, will be in ensuring that the mini-tasks are designed to improve the girls' ability to create quality DYD projects and that the narrative and communication strategies motivate the girls to complete them.

Narratives as a Way to Supplement and Support Mentorship

At the core of the model is the use of mentors to create engaging and inviting learning spaces that rival the stickiness of basketball courts. As stated previously, often the connective tissue with basketball is the role models/mentors/peers whom youth look up to, pattern their games around and seek guidance from, and ultimately compare themselves to. The model relies heavily on the ability to find mentors with backgrounds in the focal content areas, passion for working with young people, and some cultural or geographical connection to the target youth population; who are open to deepening their knowledge; and who are available to work in a variety of youth-facing organizations, often part time and outside of regular workday hours. Our model has proven successful in these terms (Barron et al., 2014), but the reality of the shortage of women in STEM creates a conundrum for implementation of the DYD as an extension of the model. This issue is not unique to our program. The importance of domain-specific role models and mentoring for women in STEM fields is often reported along with the relative scarcity of such relationships compared to men (e.g., Hill et al., 2010; Rosser, 2004).

When designing the DYD, we started from the reality that in Chicago and many urban communities with large numbers of Black and brown youth, there simply is not the availability of women with STEM backgrounds who possess the necessary pedagogical knowledge, technical skills, social capital, and available time to lead programs such as DYD. We refer to the difference between the ideal mentor's and a potential mentor's command of this knowledge as the *mentor preparedness gap*. Hence, our design challenge was to explore ways to ensure that youth are regularly mentored and supported by trusted adults while creatively exploring ways to use technological systems to provide youth with access to domain-specific STEM advice, assessment, and modeling of people and pathways. As described in "The DYD Program Model," the narrative and the online platform, in combination with practices of use, were components intentionally designed to supplement the original model. Specifically, the online space provided participants with easy access to content mentors who assessed their work, resources such as how-to videos, and exemplars of work created by other

girls. The narrative-driven STEM design challenges were intended both to draw girls into wanting to solve (in the real world) the STEM challenges faced by the fictional digital divas and to spark conversation and reflection on their own storylines through intentionally designed interactions with characters, planned discussions with program mentors and peers, and learning tasks designed to engage girls in seeing how their developing STEM knowledge could be applied to their own lives.

Our findings show mentors as key in introducing, positioning, and sharing the narrative stories within the DYD environment, whereas the narratives can be seen as a particular resource for the mentors that supplements their ability to share information, community, and ideas that are part of a collective. In particular, we highlight the use of narratives as one approach to chipping away at the racialized and gendered socialization that encapsulates the daily experience of girls through the creation of an alternative narrative that includes the girls, their friends, the larger community of DYD, and the animated characters who, through careful writing, bring to the forefront issues of socialization that need to be addressed to empower girls to move beyond situational interest when they encounter STEM informal environments that are not specifically created to appeal to them.

Future Work

The work of Nasir et al. (2012) suggests that the journey to becoming conscious of one's storyline and then actively changing it is a long one that requires support. In combination with Nasir and Cooks's (2009) identity resources framework, the racial storylines frame helps us understand how to design interventions that provide the ideational, material, relational, and project-based resources that (re)position nondominant girls relative to STEM practices and identities and also to reframe what counts as STEM (e.g., Gieryn, 1983). It also challenges the participating girls and the adults in their lives to question, critique, and change the storylines that consciously and subconsciously mediate the ways in which they communicate and participate in informal STEM settings (even girl-friendly spaces) and integrate their newly developed STEM literacies into other spaces in which they spend their time.

Reflecting on our design and implementation, we envision three primary directions for future research and design that focuses on deepening our understanding of how to build technologies and create social practices around the narratives and how to share design and research outcomes with broader communities. First, we will further develop communication and interaction features in iRemix (i.e., messaging, tagging, commenting, ways to feature work and make recommendations) to support mentors in providing contextualized just-in-time guidance, motivation, and support to help girls overcome technical and motivational roadblocks that face-to-face mentors may not be equipped to address. A

second direction is attending to girls' social networks to better support adult mentors, parents, and other caring adults in the lives of young women to actively reframe their own narratives of women and minority populations in STEM and simultaneously bolster the growing computational knowledge of girls in the program during and beyond their participation. As part of our next DYD iteration, we are designing workshops for caring adults based on our mentor professional development materials to engage parents in this work and discussion, helping them to broker next steps for their children. Third, we intend to pay close attention to intersecting opportunities for girls to move through their pathway of interest development. The future DYD program will specifically connect and help to guide and maintain connections for girls and their families to local programming and online opportunities to link newly gained experiences to next steps. Combined, we see our future work as part of a larger effort by the learning sciences community, especially research and practice partnership initiatives, to articulate and share promising models to engage underrepresented youth in STEM activities that will contribute to the establishment of transferable design principles.

Returning to our metaphor, girls need their equivalent to basketball courts. Although some distributed efforts exist for girls and STEM, many of these communities of practice are discrete opportunities or contexts rather than intersecting ones. Would basketball be as enticing to young men if all of the well-known players were of a different racial background than theirs, if they were the only boy on the court, if the majority of coaches were women, or if the media coverage only featured WNBA players? Likely not, yet this scenario is akin to that which racially nondominant girls encounter in considering STEM. Girl-centric STEM communities of practice are needed in elementary, middle school, high school, college, and professional spaces both to create spaces for work and development and to grow and make accessible narratives of women engaged in STEM at all levels, over time, and in sustained ways.

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