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# The role of recognition in disciplinary identity for girls

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**Abstract**

Computing fields are foundational to most STEM disciplines and the only STEM discipline to show a consistent decline in women's representation since 1990, making it an important field for STEM educators to study. The explanation for the underrepresentation of women and girls in computing is twofold: a sense that they do not fit within the stereotypes associated with computing and a lack of access to computer games and technologies beginning at an early age (Richard, 2016). Informal coding education programs are uniquely situated to counter these hurdles because they can offer additional resources and time for engagement in specially designed activities developed around best practices to improve girls coding identities (National Research Council [NRC], 2009). We draw upon research by Calabrese Barton et al. (2013) and Carlone and Johnson's (2007) research as a lens by which to examine girls' coding identity work in an informal coding education setting—a concept not currently defined in the science education research literature. In this paper, we describe the coding identity trajectories of three middle school girls who participated in a coding camp: Lilly, Victoria, and Beth. Our results provide a conceptual framework that will guide future research on coding identity that better encompasses the role of recognition by educators and peers on youth's coding identity development. This framework can be used to guide broader science education identity research, particularly as it applies to informal STEM education settings that work to engage students, especially girls, across the STEM spectrum.

**KEYWORDS**
coding identity, informal science education, middle school

## 1 | INTRODUCTION

The United States has demonstrated a historical commitment to improve the public's understanding of science, technology, engineering, and mathematics (STEM) (Committee on STEM Education of the National Science and Technology Council, 2018; President's Council of Advisors on Science and Technology [PCAST], 2012). This emphasis on STEM is situated in the need to develop a society of STEM literate individuals who possess a broad array of innovative tools and disciplinary ways of knowing that position them to make informed choices about critically important events that affect the quality of life of all citizens (National Research Council [NRC], 2010). In addition, the United States needs a cadre of individuals with interests in and aptitudes toward relevant disciplines that feed into the STEM pipeline (PCAST, 2012). Computing fields are a particularly important STEM subject area to consider as these fields are foundational to most STEM disciplines. Computer science, however, is the only discipline to show a consistent decline in women's representation since 1990, at which point women represented 35% of the field, whereas in 2013 they represented 26% (Corbett & Hill, 2015).

This declining representation of girls and women in computing began in the 1980s when technologies such as personal computers and video games were marketed to boys, a campaign that resulted in boys selecting computing as educational majors and careers (Henn, 2014). Girls were not the target of such campaigns leading to a lack of access to computers, a phenomenon that when coupled with other factors such as real and/or perceived stereotypes leads to a discipline portrayed as one dominated by middle class, White males, has resulted in women and girls struggling to identify with coding (Corbett & Hill, 2015; DiSalvo, Guzdial, Brukman, & McKlin, 2014; Master, Cheryan, & Meltzoff, 2016; Richard, 2016; Zarrett & Malanchuk, 2005). For this paper, we examine computing through the lens of coding, the underlying language and set of skills that are foundational to careers in STEM such as computer science, computer programing, gaming, and other technology fields (Corbett & Hill, 2015). Coding competencies—as we define them for this paper—are crucial skills needed to engage in the core practices of computer science outlined in the *K-12 Computer Science Framework*. These skills include understanding why computer technologies work, how to create these technologies, and the impacts that these technologies have on society and the natural world (K12 Computer Science Framework Steering Committee, 2016). Careers that utilize computing are predicted to grow over the next decade and practitioners with computing degrees have higher earning potential with starting salaries at $62,000—much higher than starting salaries in other careers (Corbett & Hill, 2015). Consequently, if girls and women continue to be excluded from these fields, they are at risk of losing salary dollars that rely on coding skills. In addition, the field of computer science and multiple industries beyond computer science risk losing diverse ideas and inputs if women are not provided with opportunities to develop the language skills of coding required to succeed in such fields (Hill, Corbett, & St Rose, 2010; K12 Computer Science Framework Steering Committee, 2016).

### 1.1 | A crucial stage in girls' identity development—The middle school years

Research highlights a correlation between programs that support youths' development of coding and gaming interests at the middle and high school levels and their future interests in computer science (Corbett & Hill, 2015; Kafai, Rishard, & Tynes, 2016). However, students of color and girls do not benefit from these programs if the programs do not address identity issues facing these groups. For girls, the issues stem from lack of access to games, the gendered lack of support in playing computer games, and lack of role models (Corbett & Hill, 2015; Kafai et al., 2016). Girls can fall into two main groups in relation to coding: those who have no interest because they do not see coding as aligned with their salient identities; and those who have an interest in coding but are minimally supported to pursue these interests as they progress in school because of gendered and racial stereotypes in STEM that prevent girls and people of color from feeling a sense of belonging (Archer et al., 2012; Poirier, Tanenbaum, Storey, Kirshstein, & Rodriguez, 2009; Tai, Qi Liu, Maltese, & Fan, 2006). Our study attends to the latter group and focuses on girls in their middle school years. Data indicate that middle school is the developmental stage when girls with an initial interest in STEM disciplines, which broadly encompass coding, begin to lose that interest (DiSalvo, 2016; Goffman, 1955, 1956). This research highlights that this is a crucial stage when competing cultural values begin to shape developing identities of girls and drive how they act and wish to be seen by others.

### 1.2 | A science identity framework to understand coding identity

To understand this loss of coding interest, we use the concept of coding identity, which is based on Carlone and Johnson's (2007) science identity framework. In this framework, the authors define science identity development as opportunities wherein individuals develop and/or strengthen competence in science, perform these competencies, and are recognized by perceived experts for these performances. Carlone and Johnson discuss how "recognition" is the component that needs more study because how and if a girl is recognized for her performance has the potential to move her toward or away from a science identity trajectory. We build upon this concept to describe a framework for coding identity. The study of coding is a relatively new concept (Corbett & Hill, 2015) and understanding how individuals develop a sense of belonging in computer science spaces that require the use, understanding, and application of the language of coding will be crucial in ensuring equitable representation of girls and women in computing fields. One way to ensure this equity is to apply our understanding of how girls develop strong science identities by helping them build competencies in coding (e.g., programming a robot to move in various ways) and by providing supportive spaces where girls can perform competencies and be recognized for these coding competencies by others (e.g., educators or peers acknowledge the programming of a robot by excitedly saying "you did it" or "good job"). When youth have opportunities to perform and be recognized for their competence in coding, they develop confidence in their skills leading to the development of a strong coding identity and a sense of belonging in computer science spaces.

## 1.3 | Stereotype threats to girls′ computing identities

Unfortunately, girls struggle to see themselves as competent in computer science because they have not had opportunities to develop skills. In addition, cultural stereotypes related to who succeeds in coding, limits the level of recognition girls receive making them not equally recognized in K-12 computer science education (Hong, Wang, & Moghadam, 2016). Master et al. (2016) found that girls' have a lower sense of belonging in computer science classrooms than boys because of perceived disciplinary stereotypes. Such stereotypes represent computer sciences as being dominated by White, technology oriented, and socially awkward males (Cheryan, Plaut, Handron, & Hudson, 2013) that work in social isolation (Cheryan, Master, & Meltzoff, 2015) devoid from the communal goal orientation of helping others (Diekman, Brown, Johnston, & Clark, 2010). This portrait does not support girls' particular ways of identity development: girls prefer to work collaboratively with peers (Adams, Gupta, & Cotumaccio, 2014; Riedinger & Taylor, 2016) and girls prefer to engage in activities that positively impact their communities (Carlone, Johnson, & Scott, 2015; Cheryan et al., 2015; Diekman, Weisgram, & Belanger, 2015). It is not surprising then that the K12 Computer Science Framework Steering Committee (2016) cited that only a small percentage of girls take standardized computer science exams (only 22% took the 2015 AP Computer Science A exam). This is in alignment with the low percentages of women who enter college to study computer science, graduate with computer science degrees, and pursue careers in computer science. Given the important role that the coding plays in the disciplinary practices of computer science, understanding how girls perform and are recognized for their coding competencies (i.e., development of their coding identities) becomes increasingly important if we are to ensure equitable access to computer science and intersecting STEM disciplines.

## 1.4 | Development of disciplinary identity, stereotypes, and classroom power differentials

The concept of disciplinary identity has become an important topic of discussion in STEM education. In 2017, the *Journal of the Learning Sciences* published an issue on disciplinary identity, highlighting how learning environments can be structured to influence the development of identities that comprise the various disciplines of STEM. In their introductory article Bell, Van Horne, and Cheng (2017) proposed that learners' disciplinary identities "explain how and why individuals engage within and across the learning environments they frequent" (p. 367). Individuals align themselves with or choose to participate in disciplines based on that discipline's relevance to their other salient identities. Engagement may also be based on perceived disciplinary stereotypes and the misalignment of those stereotypes with an individual's salient identities (e.g., I like to be outside in nature and scientists work in sterile boring labs, therefore, I do not want to be a scientist). According to Bell et al. (2017), disciplinary identity development occurs through "continued and deepened participation in epistemic activities" wherein individuals are recognized for their participation and performance in epistemic activities (e.g., conducting an experiment to answer a scientific question, designing, building, and testing a device that solves a real world problem, or coding a device to complete a particular task) and develop a sense of belonging because of their continuing and deepening involvement with the classroom community (p. 372). School science classes often ignore youths' outside-of-school experiences that influence the development of their identities or they simply do not connect with these salient identities because of the way science is presented in formal classrooms (Bell et al., 2017; Thomas, Minor, & Odemwingie, 2017). Formal schooling often operates under the assumption that everyone can be a successful student while ignoring the historical, political, cultural, and social influences that create power differentials that make success only applicable to certain students (Carter Andrews, Brown, Castro, & Id-Deen, 2019; Collins & Bilge, 2016). This power differential can negatively impact the disciplinary identity development of girls of color because White middle class ways of knowing are positively recognized (Caraballo, 2019; Carter Andrews et al., 2019), positioning girls of color and girls from low-income households to make choices about the ways they perform and the identities they assume when considering ways to be viewed as a good student (Hancock, 2016). As such coding identity development will compete with minoritized youth's other cultural values and the stereotype threats that shape how they act and wish to be seen by others (DiSalvo et al., 2014)—crucial components of identity development.

### 1.5 | The role of informal learning environments on disciplinary identity

The 2017 *Journal of the Learning Sciences* issue also focused on the role that various learning environments—including informal STEM education spaces (Pinkard, Erete, Martin, & McKinney de Royston, 2017)—can have on participating youth's disciplinary identity. Bell et al. (2017) argued that these learning environments must be inclusive, relevant, and impactful to be conducive to disciplinary identity. Consequently, this paper focuses on girls' coding identity or an adolescent girls' sense of competence in coding during an informal summer coding camp—Girls Code. The camp created coding relevant projects wherein girls could bring knowledge from their home and school experiences to solve problems in the ways described by Bell et al. (2017).

Informal education programs are an optimal place to address the disciplinary identity of coding among girls because they allow youth to build a community and see their own cultural experiences as legitimate forms of capital, thereby allowing their developing coding identities to better intertwine with their other salient identities (DiSalvo et al., 2014; NRC, 2009). Successful informal STEM education programs provide girls with learning environments that are physically and psychologically safe spaces where positive social norms, supportive peer and role model relationships, and a sense of belonging are developed (Simpkins, Riggs, Ngo, Vest Ettekal, & Okamoto, 2017). These learning environments support the development of disciplinary competencies, such as efficacy and skill building, by providing time and space for youth to cognitively struggle with ideas, make mistakes, and tinker with technology (Corbett & Hill, 2015; Denner, Martinez, & Thiry, 2017; Gardner-McCune & Jimenez, 2017; Kafai et al., 2016; Khalili, Sheridan, Williams, Clark, & Stegman, 2011; Rankin & Thomas, 2017; Scott, Martin, & McAlear, 2017; Scott, Sheridan, & Clark, 2014; Simpkins et al., 2017). Youth have opportunities to engage in STEM practices, such as asking questions, communicating ideas, and drawing conclusions from evidence (Brickhouse & Potter, 2001; Carlone & Johnson, 2007; NRC, 2009; Olitsky, 2006; Painter, Jones, Tretter, & Kubasko, 2006; Polman & Miller, 2010).

Informal STEM education programs focused on computing have been shown to positively impact girls' and other marginalized groups' interest in and attitudes toward coding and gaming (Çakır, Gass, Foster, & Lee, 2017; DiSalvo et al., 2009; DiSalvo et al., 2014; Erete, Pinkard, Martin, & Sandherr, 2016; Kim, Sinatra, & Seyranian, 2018; Pinkard et al., 2017; Thomas et al., 2017). However, not all of these studies have utilized an identity lens nor do they study the same outcomes (e.g., changes in attitudes) or technology concept (e.g., gaming and coding). The majority of these studies have centered on game design programs focusing on the foundational knowledge of coding and introducing girls to multiple ways in which coding can be used with game design, but they do not examine outcomes of coding identity.

Multiple studies have focused on girls' changes in attitudes toward gaming. For example, two studies on an out-of-school program: Digital Youth Divas (DYD) centered on girls' interest in game design through their participation. In one study, Erete et al. (2016), examined changes in the interest of girls who interacted with a DYD fashion design game. In another study, Pinkard et al. (2017) focused on how DYD empowered middle school girls of color when they were given control and provided with opportunities to voice their input over decisions related to the game. Stewart-Gardiner, Carmichael, Latham, Lozano, and Greene (2013) also focused on the role of girls' participation in a grocery shopping game design program on their attitudes toward computer science. Robinson, Pérez-Quiñones, and Scales (2016) studied the impact of a computer science afterschool program on 37 African American middle school girls' attitudes toward computer science through user interface design and evaluation. The study found that introducing girls to computer science produced positive outcomes because the design and evaluation activities built on participants' existing knowledge and interests. In one last study, Thomas et al. (2017) focused on a long-term gaming program (3-years) for African American girls to identify how productive struggle opportunities related to computational thinking and effected girls' perceptions of game design. Specifically, the authors used qualitative methods to determine what strategies girls used to overcome difficulties. These studies highlight the value that informal gaming education programs can have on participants but they do not share a common outcome measure nor do they focus on coding, making it difficult to determine how or even if lessons learned from these programs can be translated to others.

Other computing related studies concentrate on more specialized domains that have incorporated interest as a metric. For example, Jethwani, Memon, Seo, and Richer (2016) focused on changes in youth's perceptions of cybersecurity after participating in a two-week cybersecurity summer program where they worked to solve cyber forensics problems. The findings showed that girls developed an understanding of cybersecurity, which resulted in raising their interests in the domain. Many of these studies inform practitioners' understanding of best practices for engaging girls in computing related endeavors but they do not provide researchers with a way to understand the broader role that coding identity performances and recognition within these settings can have on interest and persistence.

The only study to focus on identity development in coding was conducted by Çakır et al. (2017). This case study examined how a game-design workshop structured through a lens of identity exploration defined as relevance, exploration, safety, and scaffolds, changed girls' attitudes toward computer science. Although this study had a rigorous design, the intervention was only a one-day workshop. The authors used a psychological definition of identity for their paper defined as a set of "traits, roles, characteristics and social group memberships that define who one is" and provide a lens through which individuals interpret their own experiences and potential future actions (p. 118). The workshop called TechGirlz introduced 21 girls in Grades 5–8 to different programming languages and game design activities. The authors used a pre and post survey that measured attitudes toward programming and gaming. After participating in the workshop, girls had improved confidence in design and programing. Although this study served as a step toward understanding identity like the others described here it cannot help the research audience until a common framework is designed.

This review of literature highlights the need for a foundational framework of coding identity that can be used to study youth's identity development in programs that rely on coding as the language for computer science. This study focuses on the experiences of three middle school girls in an informal coding camp to outline a coding identity conceptual framework. We explore coding identity episodes wherein there are opportunities for the girls to perform their coding competence and to be recognized as coders. The research questions that drove this study were:

1. How do girls perform their developing coding identity work?
2. How do educators and peers' recognition influence girls' coding identity development?

## 2 | CONCEPTUAL FRAMEWORK

Current research points to STEM identity formation and the coalescence of STEM identity with youths' other salient identities as playing a major role in their continued STEM interest and persistence (Brickhouse & Potter, 2001; Calabrese Barton et al., 2013; Carlone, 2003; Carlone & Johnson, 2007). We draw upon foundational research by Calabrese Barton et al. (2013) and Carlone and Johnson (2007) on science identity. These authors define science identity as a girl's sense of *who they are* and *what they are capable of* in science contexts, which influences *who they want to be in the future*. (Note, we use the term science identity when referring to the foundational literature because that is the term the authors used, when we reference our study, we use coding identity). Research highlights that the development of science identity is impacted by interest in science (Eccles, 2007; Gilmartin, Denson, Li, Bryant, & Aschbacher, 2007; Hazari, Sonnert, Sadler, & Shanahan, 2010), perceptions of science and scientists (AAUW, 2010; Aschbacher, Li, & Roth, 2009; Corbett & Hill, 2015), self-efficacy in science (Eccles, 2007; Hazari et al., 2010; Rittmayer & Beier, 2009), and how individuals position themselves and are positioned by science experiences in their homes, schools, and out-of-school settings (Calabrese Barton et al., 2013). These factors ultimately affect young women's identity trajectories either toward or away from science (Calabrese Barton et al., 2013). Positive science identity occurs when one feels competent with their knowledge, when they can successfully perform the skills of the discipline, and when they are recognized by perceived experts in science (Carlone & Johnson, 2007). At the middle school stage, a positive trajectory toward science could occur as girls engage in identity work in which they are "recognized, supported, and leveraged toward expanded opportunities for engagement in science" (Calabrese Barton et al., 2013, p. 37) and they become a more central and competent science participant in the classroom or informal science education program because of that work (e.g., their scientific community of practice [Lave & Wenger, 1991]).

Calabrese Barton et al. (2013) argue that identity can be observed through "what students say and do, how a student and their work is recognized and by whom, by the resources they access and activate to do so, and by how they position themselves in relation to others and to the object of the activity while taking particular roles" (p. 43). As students conduct their identity work, they leverage resources in varying ways, try on roles within different communities, and position themselves and are positioned by others within the community. The authors suggest that to study identity work, you need to do so over time and space—focusing on key events that can only be defined as "key" in retrospect. There is always tension between an individual's identity work and how it is accepted and rejected by others. This is particularly true for girls of color in STEM due to the stereotype threats and power differentials they face (as described above).

Calabrese Barton's work drove our conceptual framework in which we concentrate on three girls over time focusing on key events of recognition. In the events, we examine how each girl positions herself and is positioned by the community of Girls Code, which includes educators, peers, and guest speakers who work in the field (e.g., mentor/role models).

We used the science identity framework as a foundation to examine girls' coding identity development to create a coding identity framework to guide future research. In order to gain competence and improve one's identification with coding, we hypothesize that girls need to have opportunities to demonstrate their competence and be recognized as coders (Carlone & Johnson, 2007). Coding in our study focuses on the use of coding as a foundational language for other endeavors related to computer science (e.g., programming robots, game design) that were part of the Girls Code curriculum. Performances of coding competence include moments where girls were working on coding related activities during the camp (coding identity work) such as coding a robot to follow a particular path or programming a robot to move an item to a drop point under challenging constraints. When performing these competencies, girls could choose to advocate for their performances by calling peers, educators or other adults over to them or girls could be recognized as these individuals noticed and commented on their work. As girls are recognized by peers, educators, and mentors, they begin to develop more confidence as a coding person. Eventually they are called upon to answer questions and they drive conversations thereby performing coding identity, not just competence.

We acknowledge that the disciplinary work of coding is different from the disciplinary practices required to productively engage in science. However, we draw from the framework of identity developed in science because it is built on the features of disciplinary identity that Bell et al. (2017) highlight as requirements for individuals to continuously and deeply participate and develop a sense of belonging in a particular disciplinary space. We situate the language acquisition and application of coding within the disciplinary practices described in the *K-12 Computer Science Framework*. The framework describes a set of seven core practices that students should engage in if they are to develop competencies in computer science and with computer technologies, which require a strong grasp and use of the coding languages (K12 Computer Science Framework Steering Committee, 2016). When students engage in these coding rich practices, they are positioned to understand why computer technologies work and how to create technologies that attend to and critically examine the impacts of coding on society and the natural world. We define the practices in the methods section and apply them to the coding activities that girls engaged in during this study.

Figure 1, highlights our conceptual framework. In this figure, demonstrations of competence with coding and the recognition of these performances of competence result in a trajectory closer to (or away from) a coding identity. To move toward a positive coding identity, youth must have opportunities to practice skills and develop competencies in coding. Then girls must be positively recognized for these performances of competence. Once girls have experienced repeated moments of recognition, they begin to develop confidence in their coding identity and begin to perform coding identity (e.g., drive conversations, lead discussions, help other youth) beyond just performing coding competence. In programs like Girls Code, youth have opportunities to practice skills and develop competence (e.g., practice with specific coding languages, connecting and building on coding skills to work through more difficult tasks, successfully programming robots to do ever more difficult actions). Some of these opportunities occur in a social setting (e.g., in front of others) leading to public performances of coding skills. In some cases, youth have agency in how they want to perform the competency or how they want to amplify their accomplishments for recognition, but in other cases youth have no control over

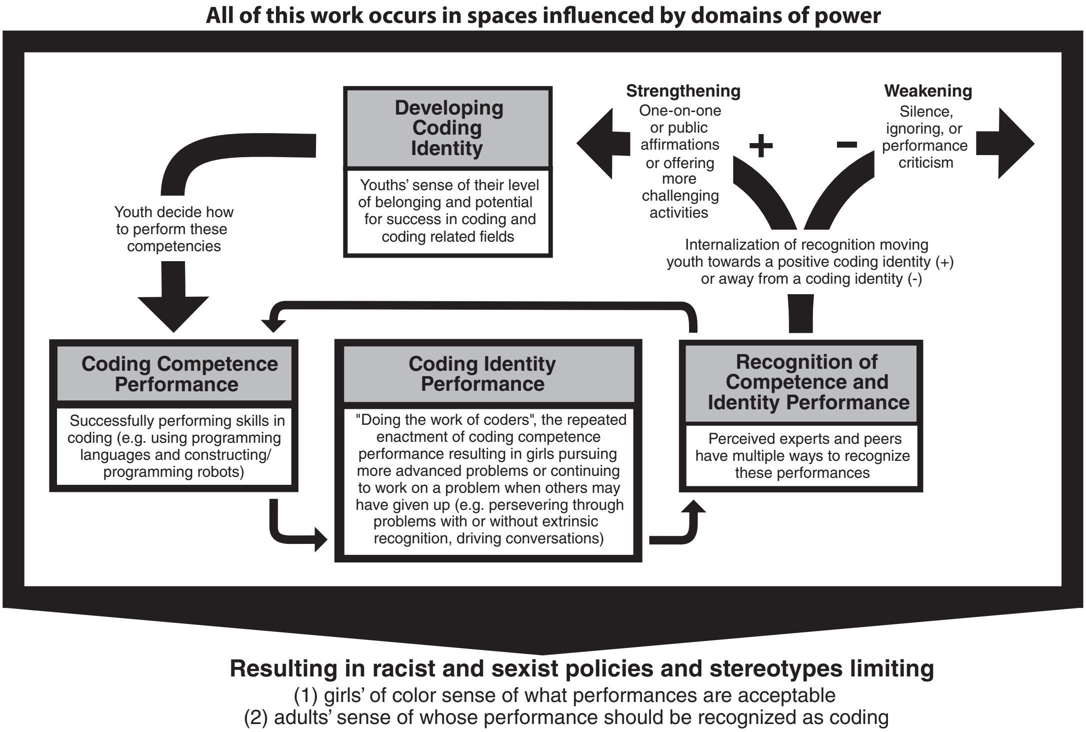


**FIGURE 1** Coding Identity Work Conceptual Framework. Coding identity work begins as performances of competency. Individuals begin to perform coding identity when they continue to demonstrate their competence through repeated moments of problem solving despite setbacks or even a lack of recognition. Coding competence performance and coding identity performance build on each other and can be recognized by perceived experts to strengthen or weaken coding identity

how stereotypes or the cultural rules of the environment affect the recognition they receive (Carter Andrews et al., 2019; Collins & Bilge, 2016). The positive recognition from perceived experts (e.g., affirmations, offering more challenging options) is valuable in thickening a person's coding identity. Similarly, the negative recognition by perceived experts (e.g., silence or ignoring the performance) can reduce one's sense of belonging and coding identity. Youth interpret and internalize all forms of recognition and then decide if their competence is valued and whether they belong in coding based on others' reactions to them and their own interests and sense of success. This coding identity development is cyclical with youth engaging in various and repeated performance opportunities and interpreting the recognition, aligning coding with their other salient identities (i.e., a positive coding identity trajectory), or seeing coding as not compatible with their other salient identities (i.e., a negative coding identity trajectory). All of this identity work occurs in spaces that are influenced by the domains of power resulting in racist and sexist policies and stereotypes that limit (a) girls' sense of what performances are acceptable and (b) adults' sense of whose performances should be recognized as coding (Allen & Eisenhart, 2017; Calabrese Barton et al., 2013; Collins & Bilge, 2016).

In our study, we focused on coding identity work episodes within three specific activities: *Jewelbots©*, *Ozobots®*, and *Lego Mindstorm®*. These activities were chosen because they were referenced by the participants as times when they saw themselves doing the work of coders. “Doing the work of coders” is the performance of a coding identity, this is more than simply performing skills in coding (e.g., solving one problem). To define episodes of coding identity work, we focused on moments where girls were publicly and repeatedly performing coding identity work (i.e., actively and repeatedly engaging despite setbacks in the coding activity and connecting with others through verbal communication) and how this work was recognized by educators and peers within Girls Code (Carlone & Johnson, 2007). It is important to note, although an individual has agency in their choice of performance, there are stereotypes that may constrain the type of performance they choose to perform as well as how, and if, these performances are recognized by experts (Allen & Eisenhart, 2017; Calabrese Barton et al., 2013; Dawson et al., 2019). Educators and peers react to certain girls' performances in various ways including: positive recognition (e.g., announcing the success to the group or one-on-one interactions with individual); noncommittal recognition (e.g., silence or no acknowledgement of the performance), or negative recognition (e.g., reprimanding or punishing). The individual's interpretation of the types of recognition influences how—or if—she moves along a trajectory toward or away from a coding identity (Allen & Eisenhart, 2017; Dawson et al., 2019).

## 3 | METHODOLOGY

The goal of our study was to explore coding identity work episodes wherein recognition was evident to understand how girls perform their coding identity work and the ways in which educators' and peers' forms of recognition influence coding identity development during Girls Code. There were multiple data sources for this study, including both quantitative and qualitative data collected from: participant applications, pre- and post-survey instruments, video observations, and focus groups.

### 3.1 | Quantitative data

The quantitative data in this study came from participants' applications to the program and their pre- and post-survey responses. These sources measured multiple aspects of coding identity including science capital, attitudes toward science, self-efficacy, and perceptions of scientists using instruments tested among K-12 students (Archer et al., 2012; Aschbacher et al., 2009; Assessing Women in Engineering [AWE], 2008; Fraser, 1981; Moore & Foy, 1997). Science capital scores could range from −24 to +27 with the following designations: low (−24 to −7); medium (−6.5 to +10), and high (+10.50 to +27). There are currently no validated instruments to measure coding-specific identity, so metrics for STEM identity were chosen (Aschbacher et al., 2009; AWE, 2008; Fraser, 1981; Moore & Foy, 1997). Previous factor analysis on the survey items used in this study resulted in five factors, which could then be conceptually grouped into two broad categories: STEM Self-Efficacy and STEM Identity (Roberts & Hughes, 2019). Scores were based on Likert-type items. We categorized respondents as having a high Self-Efficacy and/or Identity if their score was above the average and low if the score was below the average. Pre-surveys were administered electronically on the first day of the camp before participants engaged in any activity and post-survey was administered electronically on the final day of camp in the afternoon. The results from these surveys and participant applications were used to develop vignettes of the girls' coding identities over time (Calabrese Barton et al., 2013). The questions asked on the camp applications and the pre- and post-survey can be found in the supplementary material accompanying the online article.

## 3.2 | Qualitative data

The pre- and post-surveys included open-ended questions asking youth their perceptions of coding and coders and what activities made the girls feel most like a coder to provide further context to the quantitative responses. In addition, we video recorded all activities during the camp. Videos were transcribed verbatim and video and transcripts were examined to understand how girls engaged in coding identity work and how the resulting performances of this work were recognized by others (Calabrese Barton et al., 2013). The second author was a participant observer throughout the camp and conducted focus group interviews with the girls at the end of each day and on the last day of the camp. In the interviews the girls were asked to discuss times when they felt like they were doing the work of a coder or computer science professional, if there were particular times when they experienced frustration and how they handled that frustration, and if their ideas of coding professionals changed because of the activities they were engaging in. Follow-up questions were asked of participants to press them to elaborate on their answers. We used these focus group responses as well as open-ended responses on the post-survey to determine each girls' coding identity status at the conclusion of camp. These responses identified activities during the camp that influenced the girls' coding identity in their own words.

## 3.3 | Context

The setting for our study was the Girls Code camp, a one-week all-girls coding camp held in the summer of 2017 at a large interdisciplinary lab (∼300 scientists, engineers, and staff) in the Southeastern United States. Girls Code introduced and reinforced the idea that coding is a crucial part of STEM and that coders are scientists who are part of the larger STEM community. Two educators, Becky and Mary (pseudonyms), led the camp. Both women are White, middle school science teachers from local schools in the community. Becky also taught a coding afterschool club at her middle school. Fifteen middle school girls participated in the camp. Demographic information for participants can be found in Table 1.

## 3.4 | Selection of cases

For our cases, we wanted to purposely select illustrative cases of coding recognition that included racial dynamics because our goal was to understand how girls perform coding identity work and how this work is recognized, which is constrained by cultural power dynamics (Calabrese Barton et al., 2013; Carter Andrews et al., 2019; Collins & Bilge, 2016; Hancock, 2016). According to Merriam (2009), case studies are best for understanding meaning—in our study, the goal was to understand the role of performance and recognition on coding identity development. Consequently, the unit of analysis for our study was the coding identity work episodes wherein we could witness how coding competencies were performed by participants over time and how these performances were recognized by the Girls Code community. We selected three girls as illustrative cases (Creswell & Poth, 2017) because they experienced moments of coding identity work with moments of social interaction that could be captured by our video cameras. All three girls moved beyond coding competence performance toward repeated performances of coding identity (e.g., continuing to work on coding problems

**TABLE 1** Girls code demographics ($N = 15$)

| | Number of participants | Percentage (%) |
|---|---|---|
| Grade completed | | |
| Fifth | 4 | 26.7 |
| Sixth | 6 | 40.0 |
| Seventh | 5 | 33.3 |
| Race/ethnicity | | |
| Hispanic or Latino/a | 3 | 20.0 |
| Asian/Asian American | 2 | 13.3 |
| Black/African American | 4 | 26.7 |
| White/Caucasian | 6 | 40.0 |
| School type | | |
| Public | 5 | 33.3 |
| Magnet/charter | 7 | 46.7 |
| Private | 3 | 20.0 |

despite frustration or setbacks). Additionally, we chose these cases because we wanted to include girls who had varying levels of recognition during the camp, and because these cases represent a diversity of girls who could have their attempts at performance constrained by cultural power domains. Coding competence was defined as moments where girls were working on coding activities and where the video footage included recorded conversations related to attempts at solving coding problems (e.g., programming a robot to move in various patterns). For the purposes of this study, we also needed to capture recognition in these videos, which meant there needed to be a social or group aspect wherein individuals could react to the coding competence performance. We denoted coding identity performances as the repeated enactment of coding competence performance resulting in girls pursuing more advanced problems or continuing to work on a problem when others may have given up.

Of the 15 girls who participated in the camp, six did not have complete survey information needed to determine levels of Self-Efficacy and Identity. These six girls were not considered as cases because of this lack of data. Of the remaining nine girls, we reviewed their Pre- and Post-Self-efficacy and Identity scores to categorize girls according to high and low pre-scores and post-scores focusing on changes from pre to post (Roberts & Hughes, 2019). The following were the averages (on a five-point scale) for the nine campers: Pre-Self-Efficacy (4.29), Post-Self-Efficacy (4.26), Pre-STEM Identity (3.76) and Post-STEM Identity (3.91). From these nine girls, we chose to focus on three (Lilly, Beth, and Victoria, all names are pseudonyms) because of the three different ways they performed their identity work and were recognized by educators and because we wanted to include girls of color in our sample.

Lilly, a Latina girl, was the only girl of color to fall in the high Self-Efficacy and Identity category. Her performance of coding competencies represents how recognition from educators can amplify coding identity performance and work. Beth, an African American girl, represents a girl of color in the low Self-Efficacy and Identity categories. Additionally, we chose Beth because we wanted to examine interactions between girls that interacted with our other cases and Beth, Lilly, and Victoria's interaction overlapped on many occasions. Beth represented how identity work can be recognized inconsistently and without amplification. Our third case, Victoria, was a White girl, who like Beth fell into the low range of Self-Efficacy and Identity. However, she—unlike the other two—made multiple attempts to amplify her coding identity work, which in some cases resulted in recognition, but not in others. Before finalizing these cases, we watched all video footage to ensure that these three girls had multiple coding identity episodes.

Our three cases represent three different types of coding identity work and recognition and varying levels of confidence in their competence as measured through self-efficacy. (a) Lilly completed seventh grade before the camp and identified as Latina by checking this box on her application. She was consistently and vocally recognized by educators as a coding expert for continued effort in solving problems and collaborating well. She stood out as an exemplary quantitative example of a person who came into the camp with the highest STEM Self-Efficacy (pre 4.95/post 5.00) and STEM Identity (pre 5.00/post 5.00) and these remained the same throughout camp. (b) Victoria completed seventh grade before the camp and identified as Caucasian by checking this box on the application. She was recognized by teachers for continued effort in solving problems but not in a vocal or public way. (c) Beth completed fifth grade before the camp and identified as African American by checking this box on her application. She was recognized for her repeated persistence in solving problems but not for specific coding skills. Victoria and Beth had the two lowest Pre-Self Efficacy (4.06 and 4.02, respectively) and pre-Identity scores (3.33) of all participants.

## 3.5 | Selection of activities

Across the week, the girls engaged in various activities including team building, role model interactions, and watching videos of STEM professionals and coding specific content. In addition, the girls' engaged in coding activities in which they were positioned as coders in ways that align with the practices of computing. Table 2 includes a description of each activity and how it aligned with the K-12 Computer Science Core Practices that have been designed to position students to understand how computer technologies work and the broader impact of these technologies on society. These include (a) fostering an inclusive computing culture, (b) collaborating around computing, (c) recognizing and defining computational problems, (d) developing and using abstractions, (e) creating computational artifacts, (f) testing and refining computational artifacts, and (g) communicating about computing (K12 Computer Science Framework Steering Committee, 2016).

There were three activities (e.g., *Jewelbots©*, *Ozobots®*, and *Lego Mindstorm®*) from this larger list that all participants—including our three cases—identified as influential to their sense of doing the work of a coder and were thereby influential to their coding identity development. We describe these activities and the participant interactions briefly here to assist the reader in understanding the experiences that our three cases engaged in as coders during the camp.

1. *Jewelbots© (Arduino®)*. Jewelbots are bracelets that can be coded on the computer to complete certain actions such as lighting up in different colors. This activity occurred on Day 1 and was completely individual with each girl seated in front of a computer. Becky introduced the activity and then walked around the computer lab to provide help. We saw Becky help both Victoria and Lilly during this activity. Beth had no interaction with her peers or the educators during this activity but she was observed staying on task based on her work

**TABLE 2** Description of each coding activity and its alignment to K-12 computer science core practices

| Activity | K-12 computer science core practice | Description and example |
|---|---|---|
| Binary necklaces | *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs. | The girls watched a video on binary coding and then created necklaces of their names using white and red beads. |
| First code (upside down cups) | *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs.<br>*Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | The girls were tasked with creating a pyramid of red cups, writing directions (confined by up, down, and over codes) to describe what the pyramid looked like. The pyramid was then deconstructed, and another girl had to build the pyramid based on the codes. |
| Spero | *Practice 2: Collaborating around computing*, specifically creating team norms, expectations, and equitable workloads to increase efficiency and effectiveness that incorporates feedback.<br>*Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs.<br>*Practice 5: Creating computational artifacts*, specifically modifying an existing artifact to improve or customize it.<br>*Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | Throughout the camp, the teams of girls were challenged to program Speros (robots) to complete different tasks such as traveling along a path or creating a particular shape. In this coding, they were required to use the existing technology including the application that drove the robot and to code the actions of the robot within the constraints of that application and the particular movements it afforded. Teams constantly tested their plans and the codes that they created to meet the call of each challenge. |
| Jewelbots | *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs.<br>*Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | The girls coded Ardino-based digital jewelry to light up in particular patterned ways after installing and debugging the Ardino application on their individual computers. The application allowed them to code particular tasks. They spent much of their time identifying and fixing errors within the application. |
| Ozzobots | *Practice 2: Collaborating around computing*, specifically creating team norms, expectations, and equitable workloads to increase efficiency and effectiveness that incorporates feedback.<br>*Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs.<br>*Practice 5: Creating computational artifacts*, specifically modifying an existing artifact to improve or customize it.<br>*Practice 6*: Testing and refining computational artifacts, specifically testing artifacts and identifying and fixing errors using a systematic process. | The girls coded the Ozobots (mini robots) to complete tasks using colored markers or block coding on the computer. In this activity, girls work individually or in groups to complete particular tasks or challenges. When work in teams they had to work collectively to code, problem solve, test, and refine their robots to complete different tasks depending on the challenge. |

(Continues)

**TABLE 2** (Continued)

| Activity | K-12 computer science core practice | Description and example |
|---|---|---|
| Lego Mindstorm | *Practice 2: Collaborating around computing*, specifically creating team norms, expectations, and equitable workloads to increase efficiency and effectiveness that incorporates feedback. *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs. *Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | Girls collaboratively built Lego Mindstorm robots and coded them on the computer to complete certain tasks and move in particular ways. This group required the development of norms and equitable workloads to complete the iterative testing, refining, and planning required to build and code the robots. The process of coding the robot required the use of existing block coding or the development of more advanced coding. |
| Scratch | *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs. *Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | The girls coded with scratch using block or more advanced coding to develop, test, refine, and troubleshoot animations, games, and illustrations. |
| Makey Makey | *Practice 4: Developing and using abstractions*, specifically extracting common features from a set of interrelated processes, evaluate existing technological functionalities and incorporate them into new designs. *Practice 5: Creating computational artifacts*, specifically modifying an existing artifact to improve or customize it. *Practice 6: Testing and refining computational artifacts*, specifically testing artifacts and identifying and fixing errors using a systematic process. | The girls brought item home to make their own playable Makey Makey device which was coded using scratch or their own code to complete a series of actions. Girls' engaged in multiple iterations to refine their devices as they tested them. |

progress on her computer. Lilly could be seen helping her neighbor, Victoria. As the Jewelbots activity continued, the teachers acknowledged Lilly as one of the individuals who had successfully "figured out" parts of the code and directed individuals who needed help to ask her.

2. *Ozobots*®. On the morning of Day 3, the girls were given Ozobots (little robots that can be coded using markers or a computer to complete particular movements such as spinning and speeding up). In the morning, the girls were in the classroom seated at tables in groups of four. All three of our cases were seated at the same table. At first, the girls were given their materials (e.g., an Ozobot, papers, markers, and an Ozobots reference guide). The girls were told to practice different codes using markers outlined in the Ozobots reference guide. Thirty minutes into the activity, the guest speaker gave the girls a challenge—they had to program the Ozobot to push and/or move blocks along a path to a drop zone. In the afternoon, the girls moved into the computer lab to use block coding on the computer to code their Ozobot, which the guest speaker explained could involve higher levels of coding difficulty including

using algebraic codes. Later in the day, the girls were assigned to one of two groups to complete an Ozobot challenge. Lilly and Victoria were in the same group and Beth was in another. For this challenge, the groups were tasked with constructing a track with markers along a large strip of paper that incorporated eight different types of code, which the Ozobots could travel along to reach the end point without bumping into each other. In this activity, the groups struggled to come to consensus. Beth's group had a leader who directed them. Beth drew on one small section of the larger paper for the entire activity. She did not speak to nor was she spoken to by her teammates. On the other team, Victoria tried to take a leadership role in her group. She periodically asserted herself by telling the group that certain codes would not work and one or two girls disagreed with her. Lilly helped to troubleshoot problems within this group.

3. *Lego Mindstorm*®. On the morning of the fourth day, the girls were divided into two groups at tables in the classroom. Lilly and Beth were in one group and Victoria was in the other. At the start of the Lego Mindstorm activity, the educators gave each group a box with the pieces for their Lego robot explaining that each group needed to select a robot from the directions and then they needed to work together to construct it. The educators told the group that they would code the robot's movements after building it. In this activity, the girls struggled with building the robots because there was only one set of instructions to share across each group. We considered the construction of the robot to be part of the coding activity because it was a prerequisite that needed to be completed before the robot could be coded and because the girls themselves identified building the robots as part of coding, such that building could not be disentangled from the practical coding of the robot. Each group relied on a leader who directed and helped them. Victoria did not actively participate in this activity. Lilly became the leader of her table and Beth, who was in Lilly's group, could be seen diligently tinkering with the robot and testing it.

## 3.6 | Selection of episodes

To identify moments of potential coding identity work, the first two authors watched the videos of all activities that were mentioned by all youth—not just the cases—as moments where they felt like a coder. We were interested in moments within these broader activities where girls demonstrated their skills as coders by solving problems using programming or coding and were recognized for these performances by others, either verbally or in some other form of recognition by educators or peers. For our study, silence counted as a form of recognition. For the purposes of our study, performances of competence and performances of coding identity had to be done in social settings (e.g., when girls were working with each other and/or talking to each other). The girls switched between two rooms during the camp: a classroom and a computer lab. It was difficult to observe performances in the computer lab because the girls would be working at a computer and if they did not talk to anyone or no one initiated a conversation with them, it was often hard to determine whether they were performing a coding competence. Another interesting part of the camp was when the educators chose to give little plastic propeller toys (flarbles) to acknowledge various actions or behaviors including acts of kindness, leadership, and competence. These rewards became an additional way for the girls to be recognized.

## 3.7 | Analysis

A pre-camp coding identity description for each case was constructed from the application and pre-survey responses. Post-camp coding identity descriptions for each case were constructed based on focus group interview data and post-survey responses. The first and second author examined videos from the three activities described above and typed memos describing moments in which each case was observed engaging in coding identity work and/or was observed being recognized by an educator or peer for their competence. The first and second authors came together to discuss their memos and to operationalize the coding identity work. We operationalized coding identity work as moments when our cases could be seen programming or coding and when they engaged in a social aspect of performance and recognition (e.g., attempting to call attention to their work, being verbally recognized by others, or being ignored). These moments of coding identity work began as performances of competency, but once each of the cases continued to demonstrate their competence through repeated moments of problem solving despite setbacks or even a lack of recognition, we identified these as coding identity performances. Both coding competence performance and coding identity performance were part of coding identity work. Our choice of episodes was guided by Calabrese Barton et al. (2013) definition of identity work, "what students say and do, how a student and their work is recognized and by whom, by the resources they access and activate to do so, and by how they position themselves in relation to others and to the object of the activity while taking particular roles" (p. 43). Consequently, these moments had to include two or more people because of the social nature of recognition and performance, which was the focus of our study.

Next, the two authors went back and again viewed all video clips of the three activities individually to code for coding identity work episodes. After reviewing the videos separately, the authors met to watch the recognition moments they had highlighted. Initially, we had an intercoder reliability of 85% for the coding of these coding identity work episodes. We clarified inconsistencies in our definitions of moments of recognition so that we agreed on the episodes that best highlighted the multiple ways in which coding identity work was recognized for our three cases. We created an identity trajectory story for each of the cases based on these videos and survey and interview data. These stories include the descriptions of how recognition from peers and/or educators influenced the youth's coding identity during the camp and at its conclusion.

### 3.8 | Trustworthiness and reliability

We, as the authors, are White women with varying levels of experience with coding. Throughout the project, we considered our own positionality as women and the varying levels of interaction we had with the camp to ensure validity in our research (Creswell & Poth, 2017). The third author has experience programming. She served as a source of validation for defining and clarifying coding and programming terms. The second author was a participant observer during the camp who could provide context to the video footage and ask informal interview questions during activities. She also conducted focus groups with girls at the end of camp. Her role as a participant observer allowed her to develop a rapport with the youth so that they would feel comfortable with the recording equipment and answering focus group. Her prolonged engagement within the camp allowed her to develop trust, understand the culture of the program, and ensured that the authentic voices of the girls were heard. During the analysis of the data, the first author served as a source of critical feedback. When the first two authors compared memos and notes they could see where inconsistencies existed and determine how each person's position - as a participant observer or not - influenced the interpretation of the events. The first author also ensured that the second author was critical of her own interpretations as an insider.

The first two authors coded and reviewed the recognition episodes separately, then met to discuss them. Then the authors reviewed videos together to come to an agreement on how the moment counted as recognition. In addition, we collected multiple sources of data (e.g., application, pre-survey, post-survey, daily focus groups, and post camp interview) from each case so that we could ensure their authentic voices would be heard.

## 4 | RESULTS

### 4.1 | The three cases: Pre camp identities

We begin by unpacking both the STEM and the coding identities that our three case studies came into the camp with before describing their coding identity trajectories. (Note the surveys asked participants both STEM identity specific questions and coding specific questions). All three of our cases entered the camp with differing levels of STEM identity and all indicated a sense of confidence in and experience with coding in their pre camp data. All three provided specific examples of their work with coding.

Lilly had the strongest STEM Identity as measured by the Likert scale questions. She also expressed a high curiosity in "learning more about coding" before the camp. Her quantitative scores on the pre-survey indicated that she had high levels of STEM Self-Efficacy (4.95), science capital (25.00), and STEM Identity (5.00). Lilly was confident in her science and mathematics abilities and saw herself as a top student in mathematics and science. She held positive perceptions of scientists and saw herself as a science person now and in the future. She described herself as not just a science person but a coding person saying:

> My curiosity leads me to researching topics on my own, and I am dedicated to looking for solutions to problems in the world around me. I also happen to be a big video gaming nerd and would love to create virtual reality programs. I am very interested in computer engineering as a career.

Here Lilly highlights her interests in games and coding but also her curiosity and problem-solving skills. Lilly sought out science experiences in the form of shows or books and weekly or online science content at least every day. These experiences included coding which she describes as:

> I had already coded some mini-games on Khan Academy, as well as taken some of the mini-lessons they have available. I also did Hour of Code at least every year, so I had some experience with block coding.

In terms of Likert responses, Beth entered the camp with a medium science capital score (6.00). Her scores on the STEM Identity (3.33) and STEM Self-Efficacy (4.02) sections of the pre-survey indicated that she held a slightly lower perception of her STEM identities than the average. However, on the qualitative questions she indicated that she was confident in her science and mathematics abilities and saw herself as a top student in each of those courses. Because of her grades in math and science, Beth saw herself as having a high level of competence in these courses. Beth reported that she thought about science often but that she did not see being a scientist as an important part of her identity or who she is. She indicated that she read books or magazines about science once a week and searched out science information online every month, however, she rarely (only a few times a year) talked to others about science and/or watched TV shows about science. She agreed that it is important to study science even if you do not want a job in science in the future and that a science qualification can help you get many different types of jobs. She did not believe that other people saw her as a science person nor did she believe that she could use scientific evidence to make an argument, that she knew a lot about science, or that she felt confidence giving science lessons.

Despite Beth's low STEM Identity score, she did articulate a rather strong confidence in her coding experiences and abilities as measured through open-ended questions. In her pre-camp data she indicated that she “enjoys working with computers,” explaining that she had experience coding since she “started studying coding and, enjoyed learning how to type the codes and get the coding program to respond to the action.” She explained her interest in coding as:

> I'm interested in computer sciences like coding and robotics. I'm interested in this field of science because I really like working with computers and making things that could help life be easier in the future.

In addition, she linked science with coding on her pre-survey saying:

> I am interested in computer science because I started to work on coding with my step-dad, and even though we didn't get into things too complicated it was fun to do. Also, my mom sent me into a Microsoft camp, which wasn't code like me and my step dad did on Python or Ruby but it got me even more interested.

This comment shows that she had multiple experiences with coding before the camp. Even though she was unsure about her future career she indicated that she “would love to code a video game.”

Victoria, like Beth, entered the camp with medium science capital score (9.00) and low STEM Self-Efficacy (4.06) and STEM Identity (3.33) scores on the Likert scale portion of the pre-survey. Victoria believed she was a top student in science, however, she reported being only an average student in mathematics. While she reported being a top student in science and searching out science resources—she talked to people about science at least once a week and watched TV shows, searched online, or read about science at least once a month—she held mixed responses related to the value of science and her own competency in science. She indicated a neutral response when asked about her ability to effectively design or build a working project or to lead a team in such an endeavor. Additionally, she was neutral in response to the importance of studying science even if she did not want a science job and to the question asking if other people saw her as a science person. She indicated that she was unsure as to whether she would choose a science career and was neutral in her response to whether she does science related activities. She did respond that she thinks about science often and would feel at a loss if she gave it up, but she did not believe others saw her as a science person. Victoria gave neutral responses to the questions that asked her whether she wanted to be a scientist/engineer and whether she could be a good one.

Despite Victoria's lower STEM Identity score, she did express evidence of confidence and experience in coding through her qualitative responses. She explained that she had “done some coding in summer camps before and in school” and that she had experience “coding projects using Scratch,” a program that she used “every day to make animations and games.”

She indicated that she wanted to participate in Girls Code because she wanted to "learn new things about technology, and how science and technology are linked."

In summary, all three girls had some experience with coding leading them to have confidence in their skills and an interest in learning more. The next section focuses on the portion of Figure 1 where the girls engage in opportunities of performance and recognition within the camp.

## 4.2 | The three cases: Trajectories of coding identity and the influence of recognition

During the camp, we witnessed real time coding identity development for each of the case studies. Each girl received different levels of recognition, which affected their coding identity development. We will show that the recognition of coding competence by the educators, Becky and Mary, had the greatest impact, potentially influencing peer recognition of competencies. The recognition from educators improved each of the cases' confidence in their coding competency, leading them to build on these performances with coding identity performances—repeated moments of problem solving that included persevering through setbacks, ultimately thickening each cases' coding identity.

**Lilly: Positive coding identity through recognition.** Lilly maintained a high STEM Identity and Self-Efficacy score from pre- to post- survey (5.00 to 5.00 and 4.95 to 4.95 respectively), with positive attitudes toward science, positive reactions to struggle and school, high ratings of her own competence in science and the value of science in her life, and others' views of her as a science person according to her post-survey responses. Even in her focus group interview, her confidence in her abilities was apparent. She said that the "debugging [of various programs] was quite easy" during the camp activities. She even replied affirmatively to the question of whether she would have liked the camp to be more challenging. In her focus group interview, she indicated that the Lego Mindstorm robots were the activity where she felt like she was doing the work of a STEM professional because, "you had to build it. You had to code it. It was crazy." She indicated a potential interest in coding as a career that included evidence of her positive belief in her competence: "because the numbers and technology just catches my interest. I am good with this kind of thinking, so maybe it is something I might pursue." Her comment also shows that she believes she is a coder—a demonstration of coding identity—as indicated by her statement that she is "good" with that "kind of thinking". Throughout the camp, Lilly was recognized through verbal comments by the educators and guest speakers and she was formally recognized with flarbles. In many of these recognition moments the educators announced the recognition to the entire class.

The first moment of recognition was during the Jewelbots activity. Because the girls were working individually on their computers, there was little dialogue for us to assess. However, Lilly moved quickly through the tutorials assigned to the group as a way of familiarizing them with the technology and how to code it. The educators would walk by, acknowledge her success, and encourage her to try the next one. Within an hour of the activities, the educators recognized Lilly in front of the group by awarding her with a flarble and told the others to ask her for help, thereby, positioning her as an expert. Here, each successful completion of the tutorial would be an example of her coding competence performance. Her continued effort to keep trying tutorials would be an example of her coding identity performance.

During the Lego Mindstorm activity, Lilly took on a leadership role, which included assigning jobs to people and helping them with the technical aspects. From the beginning of the activity, she took the book that described the technology and provided directions on how to assemble different robots that could be made from the kit and explained to the table what they would be doing. After looking over the directions, she suggested they work on the robot that was the easiest to build. Once the table agreed, she began taking pieces out of the box assigning each person a job. The group was receptive to this. Beth was in this group and immediately began organizing pieces and responding to requests for pieces. Lilly worked with each girl to build and not just direct her. After 15 minutes of work, Lilly asked the group, "How are we all doing? Does everyone feel like they are contributing?" The girls all responded affirmatively while busily working. A teacher walked by, noticed this comment, and awarded Lilly a flarble, publicly declaring it was for her leadership and collaboration skills. Throughout the activity, Lilly interacted with each of the members of the table (walking around the table and troubleshooting with people) and talked to the educators as they came by. She represented the group by responding to the educators when they asked how the table was doing or what they were working on—becoming the de facto leader. She also attempted to support other girls' efforts at problem solving and trouble shooting. For instance, she recognized Beth's coding identity performance and provided words of encouragement. The educators and peers repeatedly recognized Lilly as the leader of the group.

Lilly's peers recognized her as a coder, not just because of her repeated competence performances and her coding identity performances but because she was willing to help others solve problems. In her focus group interview, she specifically referenced the Jewelbots as the most frustrating activity, however, her frustration was not related to any misunderstanding or struggle on her part, but rather, "the people around me couldn't [figure it out]. Everyone was coming to me for help." In an interview the day after the Jewelbots she described her ability to help others as an example of feeling like a coder. She maintained a positive attitude toward the collaboration in her post-survey:

> The collaboration was fun. I didn't think that such big groups could work well (even with multiple people yelling commands to everyone). Collaboration is very important to technology and technology careers because now, technology is everywhere and we need to be able to work together to work with it or build more. I learned that collaboration, deep thinking, and a slow process can help a lot with pretty much anything.

She also had a positive response to group work in general. During her focus group interview, Victoria was complaining about group work claiming that it stressed her out and Lilly said, "[I just] calm down, chill out. Everything is cool. When you're in a group not all the stress is on you. It's cool. No yelling. No over analytical anything. It's just, do your job."

It was clear throughout the camp that Lilly was being recognized by experts (guest speakers and educators) because they verbally encouraged her and publicly amplified her accomplishments to the group. This amplification influenced her peers' recognition of her as a coder. The educators responded to her competence performances with questions to drive her thinking and provide encouragement and acknowledgement of her successes which led her to further develop her coding identity performances, which were recognized and amplified. The educators repeatedly identified her as a key person for her peers to turn to for help. Her peers acknowledged her as an expert by coming to her for help. We have highlighted Lilly's trajectory through

Table 3, which includes the pieces of the conceptual framework relevant to Lilly's positive coding identity trajectory during each of the three activities. The recognition from both experts and peers strengthened her coding identity, which was evidence in her final interview when she expresses a stronger interest in coding as a career.

**Victoria: Attempts at recognition.** Victoria maintained a low STEM Identity score from pre- to post-survey (3.33 each time) and decreased her already low STEM Self-Efficacy score from 4.06 to 3.96. In terms of individual questions, she maintained neutral responses from pre- to post-survey for her sense of competence in her abilities, her commitment to science as a career, and her perception that others saw her a science person. Her pre-qualitative responses compared to post showed some growth. She believed that the camp had improved her coding skills (competence in coding): "The camp showed [me] many things about coding, and let us interact and practice it. This helped me set in stone what I already knew, and I learned new codes as well." Victoria persevered through some problems and when encouraged to try harder problems, readily did so, demonstrating her coding identity performances.

Victoria appeared to be confident in her abilities and was the only one of our cases who actively sought recognition from the educators. These attempts for recognition were met with varying forms of acknowledgement. Beginning on the first day, Victoria sought out recognition from the educators in the form of flarbles, beginning with the Ozobots activities. Within the first minute of the activity, Lilly successfully coded her robot at which time the guest speaker and Mary congratulated Lilly and announced her success to the class—a recognition of Lilly's competence. For instance, Mary announced, "We have another one that is working really well. A nice nitro boost. If you want to look up and compare yours to see her, the way her code looks." Mary then gave Lilly a flarble. Upon receiving the flarble, Victoria, seated across from Lilly says, "Again? I think they have a favorite."—indicating that Victoria thought Lilly was receiving the prizes because she was well liked by the educator and perhaps not because she deserved them. This comment also provides evidence that Victoria was jealous of Lilly's recognition. Later Mary gave Lilly another flarble for working through a more difficult coding problem (coding identity performance)—moving her robot along a curve. Victoria responded by saying to Lilly, "I think you have 10 now [rolling her eyes]. You got it for *just* making a circle."—here she was showing some jealousy over the flarble recognition through her eye roll and her belittling of the achievement ("just"). Victoria was providing negative recognition for Lilly here. But Lilly was not impacted by this because she had the educators recognizing her as a coder which resulted in other peers also recognizing her.

The flarbles became a public source of recognition that Victoria strove to acquire. During the Ozobots activity, Victoria initially spent the time drawing a picture for the Ozobot to move along rather than designing a more difficult code-driven path that required the Ozobot to complete a series of tricks as it moved along a path. Once she realized her drawing was not being recognized by the educators as valuable, she changed her behavior to be more on task and called educators over to recognize. It is important to note that during the Ozobots activity, Beth and Lilly both received flarbles but did not seek out recognition, rather they were working on successive activities, demonstrating competence through each success and demonstrating their coding identity by repeatedly pursuing the activities. Victoria appeared to be more concerned with the recognition of her successful outcomes and less with the process and learning benefits.

Victoria continued to seek recognition for her efforts during the computerized coding portion of the Ozobots activity. This episode highlights the mixed forms of recognition she received. She was one of the first campers to successfully code her Ozobot using the computer. She announced out loud three times that she "got it" before Becky acknowledged it. Perhaps

**TABLE 3** Lilly's coding identity trajectory by activity

| Potential moments for coding identity development | Student competence performance | Teacher recognition | Peer response | Outcomes dimension |
|---|---|---|---|---|
| Jewelbots | Moved quickly through tutorials. | This was recognized by the teacher and announced to the group with flarble. | Peers began to see her as an expert as evidenced by going to her for help. | Improved coding identity which was linked to successful outcomes. Because these were recognized in a group way by the teachers, her peers began to see her not only as a competence coder who they could turn to for help but also a coder who could answer their questions. She was labeled as a leader by the teacher. |
| Ozobots | Moved through various tasks related to coding the ozobot. | This was recognized by the teacher and announced to the group with flarble. | Acknowledged her competence by going to her for help | |
| Lego Mindstorm | Took on a leadership role and organized the group. | Acknowledged her as group leader | Worked on assigned tasks and responded to Lilly's questions and comments. | |

Becky heard her and chose to ignore her, withholding recognition. Once Becky did recognize her efforts she told her to “try something more difficult now that you're the master”. Here Becky provides positive recognition by praising her competence calling her “the master” and challenging her to try something more difficult, something that only a limited number of camp participants attempted. Victoria took Becky's challenge and began to try using algebraic equations as codes. In this episode, we saw Victoria accepting a challenge and attempting to work through it—a demonstration of her coding identity. A minute later she announced, “I think I am right; I think it is actually working.” The guest speaker came over to check. At the same time, Becky asked another girl who had worked with Ozobots in school if she had experience using algebra to code—a possible attempt at creating collaboration among the girls. At this point Victoria turns her chair to face them. When the girl responded that she had used algebra to code and Becky asked her for details, Victoria interrupted to say, “I think I am right.” and moved back to her computer. Neither Becky nor the girl responded to this comment. After some time working on her own, Victoria exclaimed, “Let's see if it works…” She tested it and announced excitedly "It does! It does! It works with the math!." Mary and the guest speaker came to her computer and positively recognized her skills, saying, "It does! What did you do?" Victoria explained: "I made them positive because there are no negative numbers. It wasn't getting the numbers when they were negative." In this exchange, she demonstrated her skills (coding competence) in using math to code and her perseverance (coding identity) through a task that she had some difficulty with as indicated by her asking for help. The educators and guest speakers recognized Victoria, however, this successful coding identity performance was not announced to the class like Lilly's successes were and it sometimes took repeated calls for attention from Victoria to be recognized.

Of all three cases, Victoria appeared to have the most difficulty working in groups and referenced this as a struggle for herself during the focus group interview with Lilly:

> Victoria: I am terrible in groups. As you've probably noticed.
> Lilly: There's a lot of yelling that happens.
> Victoria: I get really mad.
> Interviewer: Did you become better with working with groups?
> Victoria: I've never been able to work that well in groups.
> Lilly: Well, you gotta work on that.

Victoria recognized that she did not work well in groups. We witnessed this too as she attempted to take on leadership roles but her interactions vacillated from giving direct orders to ignoring questions, none of which were helpful to collaboration in the context of the camp. Her peers did not accept her performances at leadership or coding, often ignoring her, a type of recognition that became increasingly apparent as the camp progressed.

Table 4 highlights Victoria's trajectory during each activity. Here we see the difference between how the educator's recognition influenced peers' perception and recognition of Victoria. The educators' acknowledged her coding successes but did not announce it to the group. Her peers did not recognize her as someone they sought for help and often ignored her attempts for this recognition. This could have been because the educators' did not position her by publicly recognizing her accomplishments to the group or because she did not work well with others and they did not want to encourage collaboration because it would result in negative interactions (e.g., "There's a lot of yelling that happens."). Despite the lack of public recognition, Victoria still developed a more positive coding identity as indicated by her post-camp survey and interview responses. She was able to see herself as a coder because she was able to work through problems despite setbacks and because she did not associate group work and collaboration with coding success.

*Beth: Missed recognition opportunities*. Beth did not show improvement in her pre- to post-STEM Self-Efficacy (4.02–4.01). She showed a slight improvement in her pre- to post-STEM Identity scores (3.33–3.67) but this end score was still below average. Beth did not actively seek recognition like Victoria. She received it periodically but the recognition was typically for her persistence in problem solving (coding identity performances) and not for specific successful outcomes although these did occur (coding competence performance). Beth showed some positive changes on individual questions from pre- to post-survey. She indicated at the end of the camp that she now liked receiving science experiments and kits as presents. She maintained neutral responses to science being an important part of who she was and lack of confidence in being able to explain science to friends. She still maintained a neutral response to whether she thought she could be a good scientist/engineer 1 day but maintained an interest in this type of career. It is important to note that Beth was younger than the two other cases and an African America girl, so her confidence could be related to age or equity issues (Collins & Bilge, 2016).

Beth's qualitative responses provided some evidence of positive change in her coding identity. She believed that the camp had improved her understanding of coding: "I feel like I understand coding more than I did before, because we learned to code robots and scratch games." She also planned to use the information from the camp to "get an internship and for fun." Her positive coding identity was evident in her response to whether she could see herself as a computer scientist 1 day: "Yes, I can see myself becoming a computer scientist one day, because this seemed fun to do and I would love to do it as a job." In her focus group interview, she explained that the Ozobots activity made her feel like she was doing the work of a STEM professional "because we had to make sure it worked all the way through." This statement amplifies her coding identity performances since she could be seen repeatedly persevering through problems.

During the Ozobots activity, Beth worked continuously programming her robot along various routes. During the portion when the participants coded using the markers, she was troubleshooting and talking to Lilly. When Beth completed a successful code (coding competence), the guest speaker noticed it and said, "I like that, very cool!" but she did not announce it to the class like she had done with Lilly. Beth was excited by her success as evidenced through her smiles and animated arm movements. A couple of minutes later, she coded her robot to complete a U-turn and announced it to the group. No one at the table responded. This lack of recognition or neutral response from peers did not dissuade Beth who continued to work on her own (coding identity performance). Another 5 min passed and Mary noticed Beth's work and praised it by calling it "cool!" All three girls were at the same table for this event. Lilly received flarbles from the educators, whereas Beth received verbal acknowledgement. This difference in recognition did not change Beth's consistent effort at the tasks but it shows how educators play a crucial role in amplifying recognition and influencing the level to which identity thickens. Soon after receiving the verbal affirmation from the educator, Beth announced at the table that she was struggling to get her Ozobot to stay in a straight line. After troubleshooting on her own for a minute, she raised her arms in excitement and said, "I did it! Tornado. I did it!" No one at the table acknowledged this coding identity (working through the problem) or competence (successfully solving the problem) performance. This was also the first day of the program so they may have been shy or unsure of how to interact with each other.

During the Jewelbots activity, Beth worked independently. We could see in the video footage that she was progressing through the tasks (coding competence) on her computer screen but no one stopped to talk to her or check on her. This lack of acknowledgement becomes even more important given that most other participants were struggling to make progress in the task and were continually asking for help. Beth was making progress, a progress that would indicate a success in coding that others were not having and a desire to keep coding more difficult problems (coding identity). However, instead of positioning Beth as an expert to help others overcome their struggles, as the teachers had done with Lilly, Beth was not acknowledged for her expertise.

During the Lego Mindstorm activity, Beth demonstrated that she enjoyed struggling with the tinkering aspect of technology. During the activity, Beth paid avid attention when her neighbor was working with the device and showed signs of excitement (high fives and claps) when there were any successes (movement of the robot) from her efforts or her neighbor's. Forty minutes into the activity, Beth was still excited about building and made comments to her neighbor across from her who had lost interest. Beth continued to work on the robot despite her neighbor's lack of interest. Beth demonstrated her persistence and competence in problem

**TABLE 4** Victoria's coding identity trajectory by activity

| Potential moments for coding identity development | Student competence performance | Teacher recognition | Peer response | Outcomes dimension |
|---|---|---|---|---|
| Jewelbots | Moved quickly through tutorials. | This was recognized by the teacher and announced to the group. | None | Improved coding identity based on her perception of her own competence but peers did not recognize her. She maintained a coding identity through her problem solving perseverance (coding identity performance) on projects that she enjoyed. Because she did not connect collaboration with coding identity she could see herself as a coder despite not being recognized as a coder who could help her peers. |
| Ozobots | Once she saw Lilly receiving flarbles, she belittled her accomplishments and sought recognition from the teachers for her own successes.<br>During the computer portion, she demonstrated strong competence in coding and sought attention from the teachers. | Acknowledge success and encouraged her to try something harder. Teachers recognized her accomplishments and then encouraged her to try something harder. | Victoria mainly sought out adult recognition, she rarely interacted with peers. In this activity, her only peer interaction was with Lilly who she belittled and with Beth who she ignored. | |
| Lego Mindstorm | Refused to participate actively. When encouraged to help by the teachers, she said she was not good at building things. | Encouraged her to help with building the Lego robot. | She ignored her peers and they ignored her. | |

solving by continuing to work despite those around her losing interest and the educators recognized this when Becky gave her a flarble and announced in front of the class that it was for "not giving up on the robot." It is important to note that the educator did not recognize Beth's specific coding skills; rather, she recognized Beth's persistence. This is an important skill in coding but it was not explicitly connected to Beth's coding competence.

Beth maintained a positive reaction to collaboration despite frustration at times: "The collaboration here was fun even if we didn't always agree, and collaboration is important because you can bounce ideas off of each other to make something that everyone would like." She also maintained a positive attitude toward struggle: "The most important thing I think I learned is that sometimes things don't work but if they don't just keep trying and you'll succeed." This comment provides further evidence of her coding identity development.

Table 5 highlights Beth's coding identity trajectories by activity. Throughout the camp, there were long periods where Beth was not recognized by educators or peers. The forms of recognition utilized by the educators with Beth were focused on her coding identity performances—congratulating her for "sticking with" a task but not her coding competence performances. This did not gain her recognition from her peers as a coder in the same way that Lilly received. Beth saw persistence as an important skill in coding and therefore, indicated on her post-survey that she saw herself as a potential coder.

## 5 | DISCUSSION: RECOGNITION, COLLABORATION, AND LEADERSHIP

Our study was driven by our goal to understand how girls perform their coding identity work (competence performance and identity performance) and how this work is recognized by educators and peers with the ultimate purpose of creating a coding identity framework for future researchers. We examine this type of disciplinary identity to address the void that exists in the literature around coding identity development and to understand how to better support girls in their development of positive coding identities so that they feel confident to move into computing and STEM fields. Recognition and the interpretation of various forms of recognition influence youth's sense of belonging and future success in coding (Calabrese Barton et al., 2013). Our study provides more details as to how recognition can be enacted in a coding setting.

By focusing on how our cases performed their coding skills and challenged themselves to persevere through successive problems during three influential activities, the reader can better understand how competence and identity performances differed across cases and how forms of educator recognition may have influenced divergent coding identity trajectories. For instance, Lilly and Beth initially exhibited very similar demonstrations of competence by successfully completing tasks and identity by continuing to work on more difficult tasks in a relatively quiet fashion. They did not call educators or peers over to show their successes. Becky and Mary noticed their work, yet they chose two different ways of recognizing these performances. For Lilly, the educators chose to encourage her by announcing her successes to the group and publicly rewarding her with flarbles (e.g., Ozobots and Jewelbots activities). Peers were not only made aware of Lilly's competence, but Lilly was recognized as a central and competent expert within the camp who others sought out or were encouraged to consult for help. Beth was recognized for her perseverance with the reward of flarbles and praise. However, Becky and Mary did not publicly recognize her competence to the class potentially reducing the benefits for Beth's identity development. Indeed, much of the time, no one recognized Beth at all, as she

**TABLE 5** Beth's coding identity trajectory by activity

| Potential moments for coding identity development | Student competence performance | Teacher recognition | Peer response | Outcomes dimension |
|---|---|---|---|---|
| Jewelbots | Worked at her computer. | None | None | Post survey indicates an improved coding identity but her peers did not recognize her. She had multiple coding identity performances and was recognized for these as she continued to work on building projects even after others had given up. However, her coding identity was constrained as mainly related to persistence rather than successful outcomes. |
| Ozobots | Demonstrated competence by moving through tasks. She would exclaim out loud to the table but did not actively seek recognition from teachers. | The teachers were at the table recognizing Lilly. They also saw Beth's successes and recognized them with a flarble but not to the entire class. | Lilly encouraged and acknowledged her successes. Other peers were not aware of it. | |
| Lego Mindstorm | Was the only group member to continue to tinker with the robot even when others had given up. | The teachers recognized her persistence with a flarble and to her group. | Lilly encouraged and acknowledged her successes. Other peers did not. | |

mainly worked individually during each activity. For example, Beth was observed working on her computer for close to an hour without any interaction or recognition from peers or educators in the camp. Beth was clearly making successful progress in her work and chose to persevere, while others were visibly and verbally struggling. However, instead of recognizing Beth as an expert for her competencies, like Lilly was acknowledged in the same activity, Beth's work went largely unacknowledged.

The resulting differences in recognition between Lilly and Beth led to two divergent pathways toward coding identity related to collaboration and leadership. Beth developed a coding identity based on persistence not publicly recognized coding expertise, whereas Lilly developed a coding identity based on successful competence, which allowed her to be recognized as an expert and declared a leader by the educators. As the week went on, Lilly's peers turned to her as the expert during moments of collaboration. As a result, she became not only recognized as an expert but also a leader among her peers. These performances of competence were supported and recognized by Becky and Mary, and then publicly announced to other girls, thereby thickening Lilly's coding identity based on competence. Beth's coding identity was based on her perseverance but not publicly recognized so Beth lost the thickening that peer recognition could have provided. Perhaps, the educators saw coding skills as something that Lilly could teach to others whereas they may not have seen perseverance as something Beth could explain to others.

Previous research on science identity has shown that women (and girls) of color are often limited in their agency to perform science competencies (Calabrese Barton et al., 2013; Johnson, Brown, Carlone, & Cuevas, 2011). Johnson and her colleagues studied women of color majoring in STEM and found that women utilize power through behaviors, speech, and artifacts that are accepted within particular settings. The young women in their study "had to figure out how to balance competing identities; how to orchestrate a credible bid to author a science identity without compromising components of their precious racial and gender identities…to fend off the danger of having unwanted identities ascribed to them, based on their position within the matrix of oppression" (p. 360). Similarly, Calabrese Barton et al. (2013) identified how girls of color were not fully recognized as strong science students because of the stereotypes associated with who is a good science student (e.g., White girls or boys) and what performances are not recognized as being good science students (e.g., being loud often ascribed to Black girls). This could explain the ways recognition differed for Lilly and Beth. Although both of these girls identified as girls of color, neither referenced their race as salient to their identity. Lilly was also White passing. It could be that educators responded to Beth and Lilly differently because of the cultural stereotypes related to who belongs and succeeds in coding (White students), resulting in Lilly being publicly recognized and not Beth.

While Lilly and Beth both received some form of recognition from Becky, Mary, and their peers, they did not actively seek out this recognition. Victoria, on the other hand, actively sought out recognition from those she considered to be her more knowledgeable others (e.g., Becky and Mary). For instance, she actively called Becky and Mary over to her when she believed she had done something "flarble" worthy, a behavior that was not often rewarded by the educators. In some cases, Becky or Mary would encourage Victoria to try more advanced coding based on her success—a form of positive recognition and a call for her to demonstrate her coding identity. However, they rarely recognized her successes or perseverance publicly to the entire group as they did with Lilly.

When Victoria demonstrated successful competences or Beth demonstrated persistence, the educators individually recognized their performance as successful coders but did not announce it to the group. This led to Victoria and Beth not being recognized as experts by their peers. The public recognition of coding success by Becky and Mary appeared to be dependent on collaboration. For instance, both educators publicly recognized Lilly's successful collaborations with her group by situating her as an expert who could help her peers when they were struggling in an activity—a move that resulted in her peers seeing Lilly as a coder. Victoria, on the other hand, did not work well in collaborative situations and while she vied for a leadership role, her peers did not recognize this role. It is not clear whether public recognition of Victoria's skills by Becky or Mary would have resulted in a different power dynamic between her and her peers. However, we surmise the divergent paths taken by the cases highlight: (a) how different modes of recognition, such as public or private acknowledgements, can be used as a tool to support the coding identities of some youth, while constraining others (Dawson et al., 2019); and (b) how recognition by more knowledgeable others (in this case the educators in this setting) can affect how peers recognize one another and themselves as coders (Allen & Eisenhart, 2017).

Victoria's coding identity trajectory relates to previous science identity research (Calabrese Barton et al., 2013; Johnson et al., 2011) that has highlighted the ways in which girls and women have to negotiate stereotypes related to their gender. Stereotypes associated with sexism portray girls as helpers and good “girl” students as conscientious collaborators (Carter Andrews et al., 2019). Carter Andrews et al. describe the ways in which Black girls' are punished for not being “perfect and White” in their study of high school girls' attempts to negotiate sexism and racism in their classrooms. Even though Lilly is Latina, as a girl who could pass as White, she maintained the stereotypical “perfect and White” good student image in that she worked diligently, on her own, did not cause “problems” with her behavior, and when asked to help, she took time away from her work to help others. Victoria did not work well with others. Despite being White, she did not fit the perfect good girl student behavior because she sought out recognition, championed her own efforts, and refused to listen to others. These ego-driven traits are stereotypically ascribed and accepted by men and still central to the culture of many STEM disciplines—including coding (Corbett & Hill, 2015; DiSalvo et al., 2014; Kafai et al., 2016; Master et al., 2016; Richard, 2016; Zarrett & Malanchuk, 2005). This culture is one of the reasons women are not persisting in these fields. Ironically, Victoria might be successful in coding as a career with her current traits despite not being recognized consistently as a coder in this all-girl camp.

Interestingly, all three girls indicated that they improved their coding identity and their sense that they could 1 day be a coder. Each girl was able to negotiate their concept of a successful coder so that it matched their strengths in the camp (successful displays of competence and repeated perseverance through problems). Lilly saw coding as reliant on both collaboration, perseverance, and successful outcomes. She improved her coding identity because she saw herself and was repeatedly recognized by educators and peers as being skilled in all areas. Victoria saw coding as reliant on individual success at problem solving and educators recognized her individual successes and drove her successive attempts at more difficult problems so she improved her coding identity development. Peers did not recognize her for her competence, however, she did not view peers as necessary to strengthening her coding identity. Her attempts to be publicly acknowledged and to vie for a leadership role were focused on the educators and role models who she perceived to be the more knowledgeable others. Beth saw perseverance through a challenge as a central core to coding identity and was repeatedly recognized for her persistence by educators. In many activities, she outlasted her peers in terms of persistence on tasks, which led her to see herself as a coder. Consequently, educator recognition is important to coding identity development but more research needs to be conducted to determine the links between educator recognition, peer recognition, and coding identity.

Our framework for coding identity development was supported through this study. If you imagine coding identity development as a cylinder wherein youth move upwards as they develop a stronger coding identity and downwards or out completely as they lose or do not take up a coding identity, then our three cases came into the cylinder with upward momentum due to their experience with coding and their confidence in their coding skills. They each had successes on individual coding tasks, which helped them develop confidence to try progressively harder tasks and to believe that they could eventually succeed which drove their perseverance. These combined successes in coding competence and perseverance led to stronger coding identities which motivated them to try harder coding activities and to see themselves doing the work of coders. Educators acknowledged these performances through supportive individual or public feedback, encouragement, excitement, or ignoring them outright. The constraints of stereotypes related to who is and can be successful in coding affected how the educators recognized both coding competence and coding perseverance. All three of our cases were able to claim a thickening (or upward movement in the coding identity cylinder) of coding identity because they each ascribed coding skills and perseverance to mean something different.

## 6 | LIMITATIONS

There are limitations to our study. First, in terms of the influence of race and gender, our interviews with educators and youth did not ask them questions about other salient identities so it was difficult for us to determine how important race was to each of them. In addition, because of their young age, these racial identities might not have been salient identities to our participants unlike the women in Johnson et al. (2011) study. Unlike Calabrese Barton et al., 2013, we were not able to assess the full influence of other salient identities on coding identity across time and space because we focused only on the activities within the camp. We were not able to see how each of these girls performed coding identities in school, home, or other out-of-school experiences. And we did not follow these girls over time to determine if the improvements in their coding identity development increased, were maintained, or decreased over time. Future studies could apply our framework to determine how coding identity develops over time and across spaces based on recognition from others.

## 7 | CONCLUSIONS

Our research provides evidence that girls' coding identities, one of many disciplinary identities, can be developed, even over very short periods of time based on recognition by educators and other adults viewed as experts. Despite the varying forms of recognition that occurred throughout the camp, all three girls left with improved coding identities. Lilly saw herself as a coder because she demonstrated her competence and was recognized as an expert by educators and peers. Victoria saw herself as a coder because she was recognized as an expert despite not getting along well with her peers. And Beth saw herself as a coder because she was recognized for persevering in her work.

This study highlights that there are diverse identities within coding that can allow various personalities to see themselves as coders. It also highlights the important role that educators have in fostering these diverse identities, a role that will require closer examination as we strive to create a more equitably gendered coding playing field in the future. Informal coding education programs can offer a safe and supportive space for girls to try on and perform coding identities. Within these coding spaces, educators can try out and perform new instructional practices as they work to help girls develop coding identities in ways that meld with their existing salient identities and champion those identities among the peers that they collaborate with. In addition, educators will need to be aware of their own implicit biases that can lead to differences in how they recognize coding identity performances by girls, particularly girls of color (Calabrese Barton et al., 2013; Johnson et al., 2011).

The importance of educator recognition and peer acknowledgement needs to be a focus for programs and identity studies. Our study highlights the important role of recognition in coding identity development and the ways in which recognition is not only given by experts but also taken up by peers. There are many Beths and Victorias in classrooms and informal educational spaces. To support *all* girls in developing stronger coding identities, we must support the specific needs of each girl. In Beth's case, this might mean more purposeful recognition of her competence. In Victoria's case, this might mean being responsive to her specific interests and supporting her to work more collegially with her peers. Additionally, while rewards, such as flarbles, may be enticing as a way to shape youth behavior, they may have unintended consequences (e.g., jealousy and competition).

In particular, we wonder what role gender and racial stereotypes have on views of leadership and competence. Research highlights how women are viewed as either likeable or competent (Bohnet, 2016) and that Black girls and women are punished for behaviors seen as conflicting with the good girl student stereotype (Carter Andrews et al., 2019). Do middle school girls and educators also hold these stereotypes and could this have affected peers' and educators' responses to Victoria? Or would a boy who acted like Victoria have been respected as a leader? Was Beth performing a constrained coder performance because she felt that her race played a role in how she was or would be recognized? How much did the educators' own racial or gender biases affect their recognition of each girl? The role of gender and race and the impact of stereotypes on how girls shape their coding identities will be important to articulate in future studies.

In conclusion, our conceptual framework will help future researchers to unpack the complexity of disciplinary identity development episodes. Although this research focused on coding as a discipline, the framework can be expanded to other STEM disciplines to better understand how competence and identity performances are recognized and what role educators—and other adults—have on peer recognition. To improve the representation of women and girls in STEM disciplines, like coding and computer science, we need to better understand the role that cultural power dynamics play in recognition.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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