Centering the Identities of Girls of Color in Computational Thinking Programs

Patricia Garcia
School of Information
University of Michigan
Ann Arbor, USA
garciapg@umich.edu

Ashley Jackson
School of Education
University of Michigan
Ann Arbor, USA
jacksash@umich.edu

Laura-Ann Jacobs
School of Education
University of Michigan
Ann Arbor, USA
lxjacobs@umich.edu

***Abstract*—Efforts to broaden participation in computing have revealed the need for a deeper theoretical and empirical understanding of how girls of color form computing identities. In this paper, we use the concept of identities-in-practice as an analytical frame to examine how girls of color engage in computational thinking practices. Our research investigates how the identities of girls of color can be leveraged as funds of knowledge in learning spaces and asks the following research question: How does centering the identities of girls of color impact their engagement with computational thinking practices? We provide a program overview of CompuGirls, describe our curricular design approach, and share results from pilot implementations of the program offered at public libraries in Michigan, Arizona, and California. Results from our pilot year demonstrate that integrating identity exploration into a computational thinking curriculum results in a mutually reinforcing relationship where girls of color experience reflective identity development while simultaneously increasing their understanding of computational thinking. We present our approach as a promising avenue for connecting computing knowledge and skills to girls' identities and lived experiences. By focusing on the girls' identities, the program re-imagines computational experiences by fostering interactions with computational thinking from a personal perspective. Ultimately, we argue that centering girls' identities should be viewed as an integral part of the learning process and not tangential.**

***Keywords*—computing education, computational thinking, gender**

I. Introduction

Despite numerous efforts to broaden participation in computing, disparities in participation among underrepresented minorities continue to persist across all educational levels. While we acknowledge that the barriers to diversifying participation in computing are varied and complex, we argue for the urgent need to deeply examine the social and cultural barriers that result in differential learner participation and stratification along racialized, gendered, and classed lines [1]. For girls of color in particular, scholars [2] have explicitly advocated for a greater theoretical and empirical understanding of how the social and cultural aspects of learning environments impact the formation of computing identities [3] and how the intersections of gender and race shape their educational experiences [4].

This project is funded by IMLS award LG-80-16-0116-16

978-1-7281-7172-2/20$31.00 ©2020 IEEE

Motivated by research that has demonstrated the pedagogical utility of centering girls' identities in curriculum materials [5], this study draws from sociocultural theories of identity to examine girls' experiences reflecting on their identities throughout the course of engaging in computational thinking practices. We define the concept of "identity" as a form of self-understanding that is complex and negotiated across contexts and in relationship with others [6] [7]. As such, our study addresses the following research question: How can identity exploration can be leveraged to promote computational thinking (CT) practices among girls of color, ages 13-16?

This paper presents preliminary findings from an informal STEM program designed in collaboration with library partners. The program includes the development of a 20-hour computational thinking curriculum implemented across three geographically-dispersed public libraries in Michigan, Arizona, and California. Results from our pilot year suggest that integrating identity exploration into a computational thinking curriculum results in a mutually reinforcing relationship where girls of color experience reflective identity development while simultaneously increasing their understanding of computational thinking practices. By focusing on the girls' identities, the program re-imagines computational experiences by fostering interactions with computational thinking from a personal perspective. We present our approach as a promising avenue for connecting computing knowledge and skills to girls' identities and lived experiences. Ultimately, we argue that centering girls' identities should be viewed as an integral part of the learning process and not tangential.

II. Background

A. Social and Cultural Barriers in Computer Science Education

Participation in computer science education continues to be unevenly distributed, resulting in educational inequalities that further contribute to diversity gaps, particularly among underrepresented minorities such as women and students of color. For female students of color specifically, some of the most embedded and harmful contributors to diversity gaps in computer science are social and cultural factors that result in unwelcoming learning environments. These social and cultural factors include racialized and gendered stereotypes of their

STEM abilities and interests [8] and positioning of female students of color as lacking motivation, unable to master challenging STEM course content, and missing the social supports necessary to fully participate in an academic culture [9].

Thus, in order to persist in learning environments like computer science courses, female students of color are faced with navigating a learning environment and institutional culture that often does not honor or legitimize their identities, interests, and abilities. The result of learning environments that privilege dominant language and literacies are pedagogical approaches and course content that are mistakenly perceived as "neutral" [10]. Within this paradigm, computational thinking is often taught using presumably "neutral" approaches that emphasize the mastery of task-based skills such as correctly applying the syntactic and semantic rules of programming languages.

B. Computational Thinking Practices

The concept of "computational thinking" continues to undergo definitional and conceptual debate [11] [12] [13]. Computer science education researchers have proposed and studied a variety of thought processes including abstraction, pattern generalization, systematic processing of information, algorithmic thinking, decomposition, parallel thinking, conditional logic, among others [12]. In our own work, the focus on computational thinking practices aligns with efforts to create an actionable definition of computational thinking that can be studied qualitatively and quantitatively [14]. Rather than focus on abstract thought processes or mental syntheses that are difficult to identify due to their conscious or unconscious nature, this research focuses on computational thinking practices, or what learners "do" as they engage in computational problem solving within the larger context of STEM learning [15] [16].

Within K-12 contexts, research has largely focused on teaching computational thinking via programming [17] [18]. Researchers have focused on developing tools that make programming more accessible to K-12 students; for instance, several studies have examined the effectiveness of using visual programming tools such as Scratch [19] [20] [21] and MIT App Inventor [22] to teach computational thinking and programming skills. While these approaches have yielded successful results, there remains a knowledge gap on how the practices of computational thinking are connected to students' cultural and social experiences and their future career goals and interests.

III. Conceptual Framework

Research in STEM education has broadly demonstrated how grounding learning in students lived experiences and identities promotes academic achievement [23] [24]. We utilize the concept of identities-in-practice [25] to examine how girls engage in computational thinking practices through identity work and in relationship with peers and facilitators. The concept of "identities-in-practice" examines identity development in situ as learners participate and learn the practices of a community [26]. In designing the curriculum, we focused on providing girls opportunities to enact disciplinary literacies related to computing via computational thinking practices. Moje [27] defines disciplinary literacies as "the different knowledge and ways of knowing, doing, believing, and communicating that are privileged" in particular domains. By focusing on computational thinking practices, we provided opportunities for the girls to participate in the "doing" and "communicating" that are privileged within computing contexts.

IV. Research Design

A. Context

The data used for this study was drawn from a pilot implementation of CompuGirls, a computational thinking program offered in public libraries in Michigan, Arizona, and California from June 2017 to June 2018. Research has demonstrated that informal learning environments are a promising forefront for engaging students in STEM [28] [29]. We partnered with libraries because they have a long history of providing youth services, are embedded in communities, often work directly with families and community partners, and represent safe settings that provide public access to resources [30].

We recruited three library partners by considering the following factors: demographic makeup of library patrons and communities, geographic location of branches (e.g. rural and urban), and institutional availability of resources, such as staff and funds devoted to young adult programming. These selection criteria allowed us to recruit a racially, ethnic, socioeconomically, geographically, and institutionally diverse set of partner sites. The three partnering sites are library systems located in an urban city in Southeastern Michigan, a rural town in Southern California, and an urban city in Central Arizona. In total, we collaborated with eight library professionals, which included youth services librarians, paraprofessionals, and branch managers.

B. Curriculum

The pilot program utilized a curriculum that combined computational thinking and identity-based activities. The curriculum includes ten modules that covered computational thinking practices drawn from the AP Computer Science Principles Curriculum Framework [31] (see Table I for examples of practices). The curriculum was co-developed by the research team and the eight participating librarians through a series of in-person and remote meetings. The librarians provided feedback on the content and pacing of the activities, as well as suggestions for ensuring that the curriculum could be feasibly implemented across a range of library systems.

TABLE I. Computational Thinking Practices

Practice	Definition
Analyzing problems and artifacts	Analyzing complex problems by breaking them down into smaller units
Creating computational artifacts	Designing a solution for a problem by developing a process or set of rules
Using abstraction and models	Removing extraneous details to identify general principles or models

Each module consisted of 2-hours of computational thinking activities (20 hours total) that utilized low-cost materials such as batteries, LEDs, paper, and colored markers. The majority of the activities (sixteen hours) were ”unplugged” activities that did not require a computer and two modules (four hours) were Arduino activities that were completed at a local makerspace. ”Unplugged” efforts aim to teach computational thinking skills and practices using methodologies that do not require access to computers [32] [33] [34]. The research team and participating librarians made a joint decision to create a predominately unplugged curriculum in order to accommodate future library partners with limited computer and internet access. In addition to focusing on computational thinking practices, each module offered identity-based activities that were intentionally designed to center student identity and experience within the learning process. While each of the modules follows the breakdown described below in Table II, we will discuss two illustrative lessons in this paper.

TABLE II. INDIVIDUAL MODULE BREAKDOWN

Lesson Section	**Description**
Supporting Identity Exploration	Girls engage in individual or group activities that facilitate an exploration of personal or collective identity
Anchoring Computational Thinking	Facilitator introduces CT skill by making an explicit connection to the identity-based activity
Promoting Knowledge Transfer	Facilitator guides girls in transferring their identity-based understanding of CT to a STEM context such as circuitry
Facilitating Reflection	Facilitator prompts girls to reflect on their understanding of CT from an identity-based and STEM-based perspective

C. Participants

Due to the personal nature of the identity exploration and the availability of resources, the program enrollment was capped at ten girls per implementation. Recruitment efforts targeted girls from diverse racial, ethnic, and socioeconomic backgrounds between the ages of 13-16. Given the focus on serving girls of color, participants from diverse ethnic and racial backgrounds were given priority enrollment. The enrollment percentages broken down by race (Table III) did resemble the overall demographics of the community. The recruitment was conducted by the librarians who hosted “open houses” where girls were invited to learn about the program and engage in hands-on activities similar to those they would experience if enrolled in the program, such as constructing simple circuits using copper tape, LEDs, and coin cell batteries. Additionally, the librarians presented at junior high schools, contacted local organizations such as chapters of Women in Science and Engineering (WISE), and advertised the program on library and city government websites. In total, 64 girls were recruited to participate in the program (Table 2).

TABLE III. PARTICIPANT DEMOGRAPHICS

Site	Start Date	No.	Racial/Ethnic
AZ	06/17	3	67% Latina 33% Asian
	10/17	9	33% White 33% Multiracial 11% Latina 11%African American 11% Native American
	03/18	10	60% White 30% Multiracial 10% Asian
	06/18	9	56% White 44% Multiracial
CA	7/17	4	100% Latina
	4/18	4	100% Latina
MI	06/17	9	77% African American 22% White
	03/18	7	71% African American 29% White
	06/18	9	78% African American 22% White height

D. Data Collection

The pilot program was offered over summer, fall, and spring breaks and held in “teen zones” or other youth-oriented spaces within the three libraries. The data for this study was collected during nine pilot implementations of the CompuGirls program offered from June 2017 to July 2018. Given the complex nature of learning, we implemented a protocol that allowed for the collection of varied data types that captured participants’ behaviors, actions, and artifact creation related to identity expression and demonstration of computational thinking practices.

Two researchers attended each program session and collected participant observation data. One researcher focused on taking field notes and the second researcher on collecting audiovisual recordings and student-created artifacts. Participant observation activities included co-facilitating icebreaker activities that focused on personal and group identity, helping participants troubleshoot during STEM activities, engaging in whole group reflection activities, and debriefing with librarian facilitators after daily sessions. In total, the observational data collection approach yielded systematic field notes, audiovisual recordings of program activities, and photographs of student-created artifacts such as journal entries, group projects, and expressive artwork.

E. Data Analysis

We used an inductive and emergent process to develop codes by directly examining the data in relationship to three broad interest areas [35]. The broad interest areas included girls’ behaviors and actions related to: 1) participation in a community of practice such as engaging in a collaborative learning process; 2) development of “identities-in-practice” through engaging in activities and tasks related to computational thinking; and 3) negotiations of “identities-in-practice” in relationship to peers, facilitators, and self-positioning. Based on these broad interest areas, three members of the research team analyzed a subset of the data and created codes through the process of verbal consensus-building. The codes were applied to the entire data set by two members of the research team. The two members coded blindly (meaning they could not see each other's code applications) in the qualitative data analysis software Dedoose. After all data was coded the research team members ran a code application comparison and created analytic memos for disagreements. Each analytic memo included a rationale for the code(s) application in order to facilitate a larger group discussion with all seven members of the research team. The entire research team engaged in the process of verbal consensus-building to resolve instances of disagreement; however, in order to honor the interpretive process, we did not aim to reach complete agreement and allowed for variance in interpretation.

The analysis process included cross-checking interpretative claims using data and investigator triangulation. Data triangulation occurred by converging information gathered across the textual, audio, and visual forms of data. Investigator triangulation occurred through the use of multiple researchers in the process of data collection and analysis to "balance out the subjective influences of individuals" [36]. Thematic analysis of the coded raw data occurred through a collaborative process where there was a "joint focus and dialogue" among the three researchers "regarding a shared body of data, to produce an agreed interpretation" [37]. The agreed interpretations were used to create themes and interpretive claims that were representative of all three sites. While we did note variance across the three sites, we did not conduct a comparative analysis and instead report on themes that surfaced across sites.

V. FINDINGS

Given the paper's focus on exploring how identity exploration can be leveraged in the learning process, the findings from this paper will focus on how identity exploration was used as an entry point to computational thinking. Thus, rather than focus on quantitative measures of computational thinking gains, we present a detailed analysis of a particular activity that highlights how girls were able to transfer their understanding of decomposition (e.g. analyzing complex problems by breaking down them into smaller units) as grounded in their personal identities to a STEM-related context.

A. Anchoring activities in girls' identities offered a personal entry point to computational thinking practices.

The girls in the program participated in an "I Am" activity that was designed to bridge computational thinking practices with self-knowledge through an exploration of one's complex identity using the practice of breaking down complex concepts into smaller units, also known as decomposition. The librarians facilitated a discussion of social identity groups that prompted the girls to reflect on the complexity of their identity and multi-group membership. In order to encourage reciprocal sharing, the librarians used a list of identity categories provided in girls' journals (Figure 1) to share examples of their own complex identity.

FIG. 1. SAMPLE JOURNAL PAGE LISTING IDENTITY GROUPS.

For example, Kendra, a teen services librarian, shared, "I am an adult woman who identifies as white and middle class." The librarians encouraged girls to use the practice of decomposition to gain a deeper understanding of their complex identities by asking them to "break down who they are" into discrete social identity groups and further reflect on their position as a member of multiple social identity groups.

For instance, Jasmine (all names are psuedonyms) used the social categories listed in the journal activity to reflect on her personal identity. While she had many social identity categories to choose from, she chose those that described her age, race, gender, class, religion, and language. When asked why she chose these personal identifiers, she paused, giggled, and then responded, "I guess these are the one's that most people probably notice about me." Her response revealed her process of breaking down her complex identity into smaller units included reflecting on how others saw her. Her response demonstrated that she was able recognize how her identity is complex and often negotiated in relationship to others.

B. Anchoring activities in girls' identities offered a personal grounding to return to when applying computational thinking in other contexts.

Since we were interested in capturing data on their "identities-in-practice," we followed up identity-based activ-

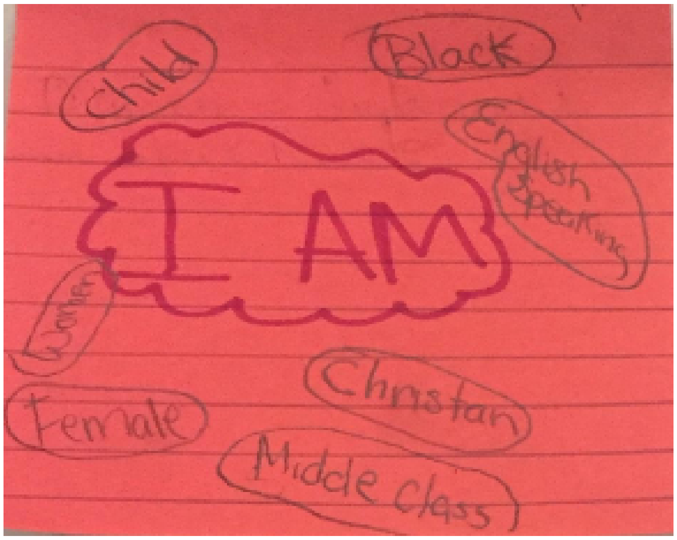

FIG. 2. BREAKING DOWN COMPLEX IDENTITY INTO SOCIAL IDENTITY GROUPS.

ities with STEM activities that incorporated computational thinking and provided girls opportunities to participate in the ways of "doing" and "communicating" that are privileged within computing contexts. For example, after decomposing their identity, the girls were asked to apply the same skill to the creation of circuit. Most of the girls were creating circuits for the first time which resulted in nervousness. However, the librarians facilitating the activity reminded the girls that they could decompose the circuit in the same way they had decomposed their identity in order to understand how it worked. The girls worked together to decompose the circuit they were creating by first listing all the components and then describing the relationship between them (Figure 3).

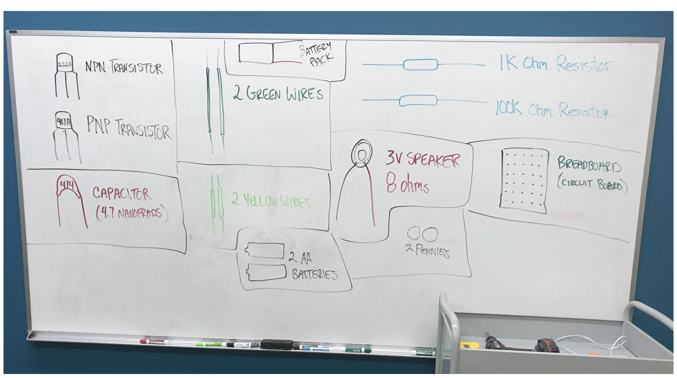

FIG. 3. DECOMPOSING A COMPLEX CIRCUIT ON THE BOARD.

As a knowledge checkpoint, girls were asked to reflect on how they used decomposition throughout the identity and circuitry activities. As demonstrated in Figures 3, reflecting on identity and decomposition led girls to make connections between their self-knowledge and the practice of disentangling complex concepts such as personal identity. Sarah shared how decomposition helped her both identify three personally salient identity categories, as well connect the act of breaking down her identity to the creation of a circuit.

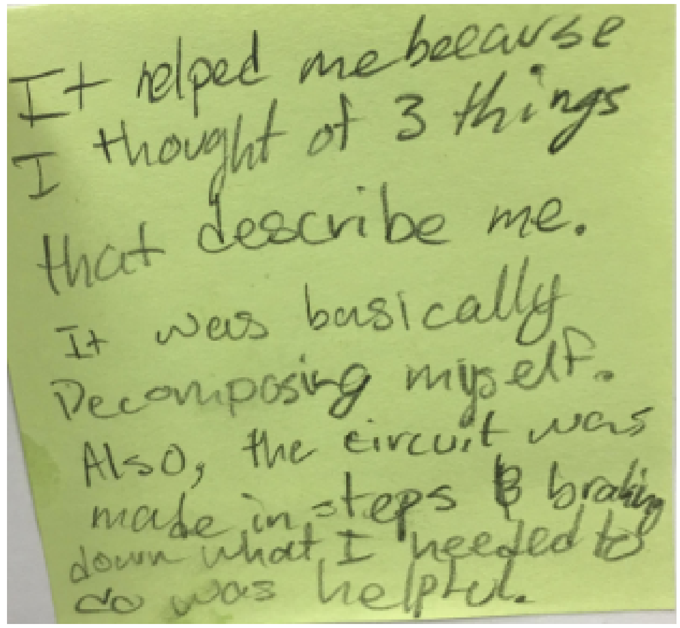

FIG. 4. CONNECTING BREAKING DOWN COMPLEX IDENTITY TO BREAKING DOWN PARTS OF A COMPLETE CIRCUIT.

The remainder of the activity continued to increase in complexity and introduced controlling physical outputs by combining their circuitry knowledge with Arduino code, such as creating the circuits and sketches to make buzzers, speakers, and lights turn on. With the introduction of programming via Arduino sketches, the librarians were able to once again build on the girls' previous knowledge of decomposition that was grounded in the identity-based activity to explain how to break down complex code into small chunks that could be tested.

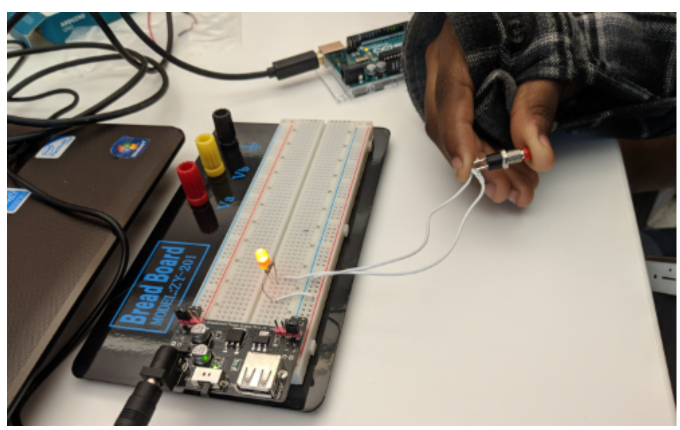

FIG. 5. COMBINING CIRCUITRY KNOWLEDGE AND CODE.

Ultimately, our analysis found that the girls were able to begin practicing decomposition within a context that they know intimately – the self. By grounding initial decomposition practices in their personal identity, the curriculum afforded librarians an anchor point to return to when the introduction of new and more complex skills began to feel overwhelming.

For our next steps, we plan to iterate on the design of the curriculum and conduct further implementations across all three sites. While this iteration predominately focused on racialized and gendered experiences, we are specifically interested in further incorporating experiences from a broader spectrum of identity categories, such ability, sexual orientation, and the intersection of these categories.

VI. Discussion

The act of learning science and engineering practices has been described as a cultural process that requires students to "cross borders" [38]. As girls of color are learning computational thinking practices, they are often interacting with discourses that may align or differ from their own. Research in science education has pushed for science educators to imagine a space where students' learning and identities can come together to form a learning experience that does not force them to leave behind their cultural knowledges and lived experiences for the sake of learning science [39] [40]. Results from pilot implementations of CompuGirls demonstrate that centering girls' identities in process of learning computational thinking practices is a promising avenue for connecting computing knowledge and practices to girls' lived experiences.

Interestingly, while the focus on identity was originally proposed as an entry point to computational thinking practices, our study found that an emerging theme of identity exploration serving as more just an entry point; instead, integrating identity exploration into a computational thinking curriculum resulted in a mutually reinforcing relationship where girls experience reflective identity development while simultaneously increasing their understanding of computational thinking. As shown in the "I Am" activity, identity exploration helped girls understand computational thinking practices, and through the practice of computational thinking they began to understand their own identities at a deeper level and in more complex ways.

We analyzed identity development as a negotiated process that includes community membership and participation in shared practices. Thus, we found that fostering a sense of community was integral to creating an environment where girls could feel safe to explore their identities. In order to foster a sense of community, the research team and librarian facilitators encouraged the girls to develop a set of shared practices. In the first group activity, girls are invited to participate in norm-setting by creating guidelines for their learning environment through a "Safe Space" activity. For this activity, girls are asked, "What do you need to feel safe here?" First, girls reflected on these questions individually and identified their own individual needs on sticky notes. We urge researchers and practitioners to ensure that they have created a safe and affirming learning environment before asking girls of color to share personal information that may make them feel vulnerable.

VII. Limitations

In line with other forms of interpretivist work, the goal of this study is to highlight the experiences of this particular set of girls to illustrate the potential of merging identity exploration and computational thinking practices. Additionally, since identity exploration and reflection is an intimate and personal experience, the sharing of girls' experiences may raise ethical concerns regarding privacy and disclosure in research processes and reporting. Thus, as a research team, we mindfully reflected on how to safely represent aspects of the girls' personal experiences. We mitigated privacy and disclosure risks by anonymizing the data presented and carefully selecting data that did not disclose potentially identifiable experiences.

VIII. Conclusion

Research [41] has emphasized the need for curriculum materials and classroom pedagogy to take into consideration girls' interest, experiences, and ideas. In our study, we aimed to address the need to discuss racialized, gendered, and classed experiences more explicitly in learning environments [9]. By honoring girls' complex identities in the process of learning computational thinking practices we sought to make space for their multiple subjectivities in the process of science learning and allowed for diverse entry points to computing knowledge and practices. From our work, we found that identity exploration provides multiple entry points to learning computational thinking practices through personal self-reflection. We do not view learning computational thinking practices through identity exploration as a replacement for other effective strategies such as visual programming; rather, we present our approach as a complementary and alternative avenue for connecting computing knowledge and skills to girls' lived experiences. By focusing on the girls' identities, the curriculum re-imagines computational experiences by fostering interactions with computational thinking from a personal perspective. Ultimately, we argue that centering girls' identities should be viewed as an integral part of the learning process and not tangential.

Acknowledgment

We would like to thank our collaborator Dr. Kimberly A. Scott and the rest of the research team at the Center for Gender Equity in Science and Technology at Arizona State University. As well as the public librarians who serve as invaluable research partners on this project.

References

[1] D. Fields and N. Enyedy, "Picking Up the Mantle of 'Expert': Assigned Roles, Assertion of Identity, and Peer Recognition Within a Programming Class," Mind, Culture, and Activity, vol. 20, no. 2, pp. 113–131, Apr. 2013, doi: 10.1080/10749039.2012.691199.

[2] N. Akkuş Çakır, A. Gass, A. Foster, and F. J. Lee, "Development of a game-design workshop to promote young girls' interest towards computing through identity exploration," Computers Education, vol. 108, pp. 115–130, May 2017, doi: 10.1016/j.compedu.2017.02.002.

[3] A.-K. Peters and D. Rick, “Identity Development in Computing Education: Theoretical Perspectives and an Implementation in the Classroom,” in Proceedings of the 9th Workshop in Primary and Secondary Computing Education, New York, NY, USA, 2014, pp. 70–79, doi: 10.1145/2670757.2670787.

[4] S. L. Rodriguez and K. Lehman, “Developing the next generation of diverse computer scientists: the need for enhanced, intersectional computing identity theory,” Computer Science Education, vol. 27, no. 3–4, pp. 229–247, Oct. 2017, doi: 10.1080/08993408.2018.1457899.

[5] N. Pinkard, S. Erete, C. K. Martin, and M. M. de Royston, “Digital Youth Divas: Exploring Narrative-Driven Curriculum to Spark Middle School Girls' Interest in Computational Activities,” Journal of the Learning Sciences, vol. 26, no. 3, pp. 477–516, Jul. 2017, doi: 10.1080/10508406.2017.1307199.

[6] A. Calabrese Barton, H. Kang, E. Tan, T. B. O'Neill, J. Bautista-Guerra, and C. Brecklin, “Crafting a Future in Science: Tracing Middle School Girls' Identity Work Over Time and Space,” American Educational Research Journal, vol. 50, no. 1, pp. 37–75, Feb. 2013, doi: 10.3102/0002831212458142.

[7] D. C. Holland, D. Skinner, C. Cain, and C. Cain, Identity and Agency in Cultural Worlds. Harvard University Press, 2001.

[8] M. Ong, C. Wright, L. L. Espinosa, and G. Orfield, “Inside the Double Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering,and Mathematics,” Harvard Educational Review, vol. 81, no. 2, pp. 172–209, 2011.

[9] C. D. Allen and M. Eisenhart, “Fighting for Desired Versions of a Future Self: How Young Women Negotiated STEM-Related Identities in the Discursive Landscape of Educational Opportunity,” Journal of the Learning Sciences, vol. 26, no. 3, pp. 407–436, Jul. 2017, doi: 10.1080/10508406.2017.1294985.

[10] M. Bang, B. Warren, A. S. Rosebery, and D. Medin, “Desettling Expectations in Science Education,” HDE, vol. 55, no. 5–6, pp. 302–318, 2012, doi: 10.1159/000345322.

[11] M. D. DeSchryver and A. Yadav, “Creative and Computational Thinking in the Context of New Literacies: Working with Teachers to Scaffold Complex Technology-Mediated Approaches to Teaching and Learning,” Journal of Technology and Teacher Education, vol. 23, no. 3, pp. 411–431, Jul. 2015.

[12] S. Grover and R. Pea, “Computational Thinking in K–12 A Review of the State of the Field,” Educational Researcher, vol. 42, no. 1, pp. 38–43, Jan. 2013, doi: 10.3102/0013189X12463051.

[13] J. Wing, “Computational thinking,” Communications of the ACM 49, 3: 33–35, 2006.

[14] D. Weintrop et al., “Defining Computational Thinking for Mathematics and Science Classrooms,” J Sci Educ Technol, vol. 25, no. 1, pp. 127–147, Feb. 2016, doi: 10.1007/s10956-015-9581-5.

[15] K. Brennan and M. Resnick, “New frameworks for studying and assessing the development of computational thinking,” in Proceedings of the 2012 annual meeting of the American Educational Research Association, Vancouver, Canada, 2012, pp. 1–25.

[16] S. Grover and R. Pea, “Computational Thinking: A Competency Whose Time Has Come,” Computer Science Education, p. 21, 2017.

[17] F. Buitrago Flórez, R. Casallas, M. Hernández, A. Reyes, S. Restrepo, and G. Danies, “Changing a Generation's Way of Thinking: Teaching Computational Thinking Through Programming,” Review of Educational Research, vol. 87, no. 4, pp. 834–860, Aug. 2017, doi: 10.3102/0034654317710096.

[18] S. Y. Lye and J. H. L. Koh, “Review on teaching and learning of computational thinking through programming: What is next for K-12?,” Computers in Human Behavior, vol. 41, pp. 51–61, Dec. 2014, doi: 10.1016/j.chb.2014.09.012.

[19] K. Lawanto, K. Close, C. Ames, and S. Brasiel, “Exploring Strengths and Weaknesses in Middle School Students' Computational Thinking in Scratch,” in Emerging Research, Practice, and Policy on Computational Thinking, P. J. Rich and C. B. Hodges, Eds. Cham: Springer International Publishing, 2017, pp. 307–326.

[20] M. Resnick et al., “Scratch: Programming for All,” Commun. ACM, vol. 52, no. 11, pp. 60–67, Nov. 2009, doi: 10.1145/1592761.1592779.

[21] A. Ruthmann, J. M. Heines, G. R. Greher, P. Laidler, and C. Saulters II, “Teaching Computational Thinking Through Musical Live Coding in Scratch,” in Proceedings of the 41st ACM Technical Symposium on Computer Science Education, New York, NY, USA, 2010, pp. 351–355, doi: 10.1145/1734263.1734384.

[22] B. Xie and H. Abelson, “Skill progression in MIT app inventor,” in 2016 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC), 2016, pp. 213–217, doi: 10.1109/VLHCC.2016.7739687.

[23] J. Thompson, “Engaging Girls' Sociohistorical Identities in Science,” Journal of the Learning Sciences, vol. 23, no. 3, pp. 392–446, Jul. 2014, doi: 10.1080/10508406.2014.888351.

[24] M. Varelas, D. B. Martin, and J. M. Kane, “Content Learning and Identity Construction: A Framework to Strengthen African American Students' Mathematics and Science Learning in Urban Elementary Schools,” HDE, vol. 55, no. 5–6, pp. 319–339, 2012, doi: 10.1159/000345324.

[25] J. Lave, “Teaching, as Learning, in Practice,” Mind, Culture, and Activity, vol. 3, no. 3, pp. 149–164, Jul. 1996, doi: 10.1207/s15327884mca03032.

[26] Y. Kanno and C. Stuart, “Learning to Become a Second Language Teacher: Identities-in-Practice,” The Modern Language Journal, vol. 95, no. 2, pp. 236–252, 2011, doi: 10.1111/j.1540-4781.2011.01178.x.

[27] E. B. Moje, “Foregrounding the Disciplines in Secondary Literacy Teaching and Learning: A Call for Change,” Journal of Adolescent Adult Literacy, vol. 52, no. 2, pp. 96–107, 2008.

[28] L. A. Bricker and P. Bell, “‘What comes to mind when you think of science? The perfumery!': Documenting science-related cultural learning pathways across contexts and timescales,” J Res Sci Teach, vol. 51, no. 3, pp. 260–285, Mar. 2014, doi: 10.1002/tea.21134.

[29] J. Rahm and J. C. Moore, “A case study of long-term engagement and identity-in-practice: Insights into the STEM pathways of four underrepresented youths,” Journal of Research in Science Teaching, vol. 53, no. 5, pp. 768–801, doi: 10.1002/tea.21268.

[30] “IMLS Focus Summary Report: Learning in Libraries,” Institute of Museum and Library Services, 25-Aug-2015. [Online]. Available: https://www.imls.gov/publications/imls-focus-summary-report-learning-libraries. ations/imls-focus-summary-report-learning-libraries

[31] “AP Computer Science Principles Including the Curriculum Framework,” College Board, 2017.

[32] T. Bell, P. Curzon, Q. Cutts, V. Dagiene, and B. Haberman, “Introducing Students to Computer Science with Programmes That Don'T Emphasise Programming,” in Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education, New York, NY, USA, 2011, pp. 391–391, doi: 10.1145/1999747.1999904.

[33] P. Curzon, “Cs4Fn and Computational Thinking Unplugged,” in Proceedings of the 8th Workshop in Primary and Secondary Computing Education, New York, NY, USA, 2013, pp. 47–50, doi: 10.1145/2532748.2611263.

[34] S. Hug, J. Sandry, R. Vordermann, E. Pontelli, and B. Wright, “DISSECT: Integrating Computational Thinking in the Traditional K-12 Curricula Through Collaborative Teaching (Abstract Only),” in Proceeding of the 44th ACM Technical Symposium on Computer Science Education, New York, NY, USA, 2013, pp. 742–742, doi: 10.1145/2445196.2445452.

[35] J. Lofland and L. Lofland, “Analyzing social settings,” Belmont, CA: Wadsworth, 1995.

[36] U. Flick, E. von Kardoff, and I. Steinke, A Companion to Qualitative Research. SAGE, 2004.

[37] F. Cornish, A. Gillespie, and T. Zittoun, “Collaborative Analysis of Qualitative Data,” in The SAGE Handbook of Qualitative Data Analysis, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom: SAGE Publications Ltd, 2014, pp. 79–93.

[38] G. S. Aikenhead and O. J. Jegede, “Cross-cultural science education: A cognitive explanation of a cultural phenomenon,” Journal of Research in Science Teaching, vol. 36, no. 3, pp. 269–287, 1999, doi: 10.1002/(SICI)1098-2736(199903)36:3¡269::AID-TEA3¿3.0.CO;2-T.

[39] A. C. Barton, E. Tan, and A. Rivet, “Creating Hybrid Spaces for Engaging School Science Among Urban Middle School Girls,” American Educational Research Journal, vol. 45, no. 1, pp. 68–103, Mar. 2008, doi: 10.3102/0002831207308641.

[40] J. S. Brotman and F. M. Moore, “Girls and science: A review of four themes in the science education literature,” Journal of Research in Science Teaching, vol. 45, no. 9, pp. 971–1002, 2008, doi: 10.1002/tea.20241.

[41] C. D. Allen and M. Eisenhart, “Fighting for Desired Versions of a Future Self: How Young Women Negotiated STEM-Related Identities in the Discursive Landscape of Educational Opportunity,” Journal of the Learning Sciences, vol. 26, no. 3, pp. 407–436, Jul. 2017, doi: 10.1080/10508406.2017.1294985.