Equitable approaches: Computational thinking through design

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Introduction

One reason for the increasing calls for young people to engage in computational thinking is future job demands and related critical issues of equity about who is on track to take advantage of these opportunities. A number of initiatives are changing the computing education landscape: Scratch and Code.org make online drag-and-drop logic and coding experiences accessible to elementary schoolers; the *Exploring Computer Science* curriculum and *Principles of CS AP* make it possible to offer computational topics to high school students regardless of prior experience. We also need to make sure that we are watching the numbers and understanding the patterns of participation: *Who is engaged? How is it going for them? What are they doing next? Is enthusiasm for computational thinking supporting young learners or do they become frustrated or disillusioned with the work?*

In our poster we begin to address these questions by sharing the Digital Youth Divas program, focused on building and supporting a social ecosystem of computational learning in communities that have been underrepresented in engineering and computing fields. Our design incorporates computational thinking (Wing, 2008; NRC, 2011) and learning trajectories, an ecological approach that envisions learning as happening across time and environments (Barron, 2006) and Hidi and Renninger's four-phase model of interest development (2006). The girls do introductory programming but in this poster we look at approaching computational thinking through design, including breaking down a challenge into a series of more approachable parts, recognizing patterns and sequences across projects, and finding and fixing errors through systematic troubleshooting strategies. We posit that understanding how to design experiences for underrepresented populations who have been traditionally underserved is critical to engaging such populations in computational practices.

Methods and Context

Across the country, minority students have less access to rigorous math and science classes (US Civil Rights Data Collection, 2014). In Chicago public schools, part of the third largest school district in the US, students are 38% black and 47% Hispanic. Inequities in computational opportunities across the city (Pinkard *et al.*, 2016) and for girls more generally (e.g. Margolis & Fisher, 2003) prompted us to design successful computational making experiences for girls that promoted confidence and sense of fit with computational learning activities.

Digital Youth Divas is a blended online and face-to-face out-of-school program to engage middle school girls in Chicago with introductory circuitry and programming projects through fabrication and design. The program has been offered during out-of-school time since 2013. Girls from around the city are invited to participate in the free program, and we especially recruit girls from communities underrepresented in computer science and engineering.

Program	20-weeks, 3 hours a week on Saturdays; January-May 2016
Participants	98 girls, representing 63 schools across the city
	Ages 10-14: 32% 4/5th grade, 32% 6th, and 36% 7/8th
	59% black, 18% Latina, 11% mixed race, 7% white, 5% Asian
	Annual household income ranged from under \$20K (12%) to over \$100K (22%), with a median range of \$50-70K (23%)
	37% of girls' parents did not have a college degree and 31% had advanced graduate degrees

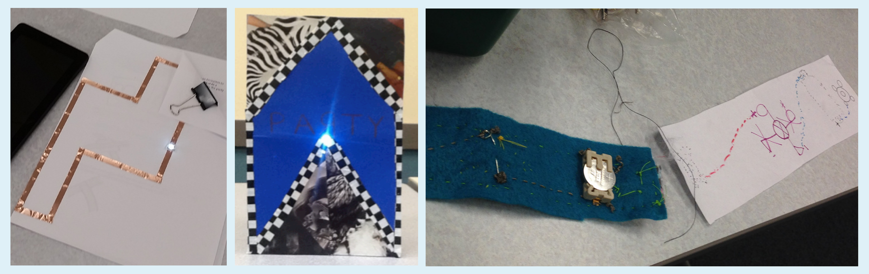
Data collection representing different levels of participants

Cohort	Pre-post surveys of interest, access, experience (Barron *et al.*, 2010; 2014) and knowledge assessment (Peppler & Glosson, 2013) for all classes (N = 98 girls across 5 classrooms)
Individual	Youth interviews (N=6) about their work and practice

Multidimensional program model

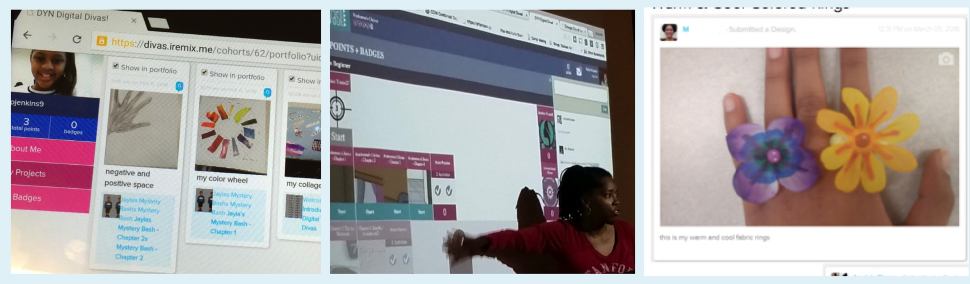
digital youth divas

(1) Self-paced project-based learning activities. Building on the *Grinding New Lenses* e-craft series developed by Kylie Peppler and colleagues (2014), modular instruction units weave computational and digital literacies through the development of creative artifacts. Each unit promotes independent work and problem solving through complex design projects that are broken down into smaller activities.



(2) Representational instructional resources. Each project is accompanied by learning resources that model computational thinking as done by a community of racially diverse female computational makers. Troubleshooting videos and how-to guides feature technology and engineering help from experts who look and sound different than traditional stereotypes. Projects are launched from and anchored within a narrative story, in which middle school characters use problem solving strategies to address a real-world challenges they face.

(3) Online social learning platform. The network allows girls to access project instructions and resources, upload work and develop a portfolio of projects, and receive feedback and interact with others through project-based comments.



(4) Community of learners. Adult mentors support girls on and offline and peers work side-by-side and engage in community building activities.

Learning gains across learners

Q: Was there evidence of knowledge gains, even for those girls who had no prior experience?

Measure: An existing measure of procedural knowledge used with *Grinding New Lenses* projects (Peppler & Glosson, 2013) was adapted. The item asked girls to draw the connections required to model a working series circuit from a battery and an LED light both with positive and negative terminals. The pencil and paper assessment was administered to all girls on their first day in the program and again on their final day. Results were scored on a 4-point scale from 1 (no understanding) to 4 (full understanding). [the lead researcher and 2 research assistants achieved >76% inter-rater reliability for 25% of the data corpus]

This assessment was not the focus of the Digital Youth Divas program, nor was it shared with mentors who worked with the girls each week. Rather we were interested to see if there were measurable knowledge gains through the computational design and making activities that built community and individual interest and agency (Pinkard *et al.*, in press).

Additionally, we wanted to see what this looked like for students at different knowledge levels. 50% of the cohort came into the program having previously taken classes in circuits and electricity (34% in school and 16% out of school).

An intention of the program is that girls learn with and through a community of diverse female computational makers. As such, we wanted to ensure that all girls were learning, regardless of prior experience.

Repeated measures ANOVA with prior experience as a between-subjects factor revealed that girls' scores increased significantly over the course of the program, $F(1,37) = 28.78$, $p < .001$), and that this was true for those with and without prior experience.

While girls did not evidence complete understanding at the end of the program, this racial minority female middle school cohort with varying levels of expertise were successfully increasing their understanding together. They learned from and helped each other.

Importance of procedural planning

Q: How did girls talk about problem solving through design?

During interviews with individual girls (representing a cross section of prior experience) about their projects the girls explained procedural project steps and evidence of revision and troubleshooting techniques, some of which happened across settings, as girls brought work home. Some girls also articulated a recognition of how systematic thinking about design work was critical to successful projects.

"It's a bracelet that you make, and you design it yourself. And then you have to set up the LED, and you have to make sure that you have the conductive thread in the right place, and that you sew everything right. If you have the negative on the wrong side, it won't function. And if you have your conductive thread, if it's not sewn right, it's not gonna work. Like mine, it didn't work. I had to take out the conductive thread. And then me and my dad, we sewed it back."

"First I had to sew the materials on, then it got kind of rough because we had to put the LED light on and the things to strap it on, and the battery and the battery holder and the bracelet. It was a little bit uncomfortable at first, but I glued some cotton in it [at home] and it feels better."

"I thought that it was just gonna be like, we just sat in front of computers and learned about coding, but it's not. We had to do team work and you had to...You just had to be unique and different. And you had to think a lot because if you didn't think, you wouldn't know what to do about your designs. It wouldn't work."

Positive outlooks and affect

Q: Was there affective interest in the work and ideas for future activities?

The post survey included practical reflection questions about the program and the project work.

95.5% were happy with their final project, and 68.5% were ready to show it off to other people. When asked about the pace of the program on a 5-point scale from 1 (way to slow) to 5 (way too fast), girls thought the speed of work was just right (M = 2.9, SE = 0.10). They were also asked to report how much they thought they learned from the program on a 3-point scale from 1 (nothing) to 3 (a lot), and on average they believed they learned something M = 2.5, SE = 0.12.

There were no significant differences between girls with more and less prior experience for these analysis.

Implications and future

The program framework can be of use to educators in formal and informal computing environments, and emerging findings may help curriculum developers, professional development coordinators, and program designers design and refine environments to be relevant to a range of young learners. Initial results reveal significant increases in girls' content knowledge and feelings of success and enjoyment in the work. Project development was a key aspect of the environment that engaged girls in cycles of computational planning, process, analysis, and troubleshooting and the project as an artifact invited attention and support from peers, parents, and program mentors.

We are beginning a collaboration with public schools in a predominant minority community, including professional development opportunities and codesign work to re-envision these types of experiences for middle school classrooms keen to engage their learners in computational thinking opportunities in ways that can be embraced by all students.

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