Designing Diverse Informal Learning Environments to Support Computational Thinking

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Abstract

This work examines the design of computer science informal learning programs in two public libraries offered through a university-library partnership. Specifically, the work focuses on dilemmas encountered by program facilitators when designing informal environments that focus on engaging culturally diverse youth with CT concepts. We analyzed over 40 reflection journals from program facilitators, illustrating content selection, pedagogical decisions, and the application of culturally relevant frameworks related to the design of the computing environment. Findings of this study provided insights related to the design, implementation and outcomes of informal computing programs for youth from diverse backgrounds.

Purpose & Perspectives

Computational Thinking (CT) involves skills that help youth analyze and solve real-world problems drawing on computer science (CS) principles (Wing, 2006). According to Wing, "CT is a fundamental skill for everyone, not just for computer scientists" (p.33). Many youth, however, experience new technologies in their daily lives as consumers while few have opportunities to create computing innovations and develop CT skills (Repenning et al., 2015). Although efforts have been made to increase access to CS, participants continue to represent a fairly homogeneous group (Astrachan, Cuny, Stephenson, & Wilson, 2011). Certain populations, such as females and non-Asian minorities, remain severely underrepresented in computing (Cuny, 2012). To address this inequity, research suggests promoting local partnerships with both formal and informal

environments and implementing service-learning programs where undergraduates with a CS background assist local providers using research-based practices (Ericson & McKlin, 2012).

Local partnerships between universities and libraries can serve to promote youth CT development and expand access by engaging diverse populations (Maloney et al., 2008; Summers & Buchanan, 2018). Libraries are unique learning environments as they have reinvented themselves in response to 21st century needs by offering a variety of low-tech and high-tech activities intended to improve computational skills among the youth in their communities (Myers, 2009). Nevertheless, research documenting the ways in which university-library partnerships can help promote youth CT knowledge and skills is sparse. Some prior work on introducing programming in libraries aimed at identifying the types of resources that could be used to foster CT learning; however, prior studies did not examine how to design effective learning environments in informal settings, particularly design dilemmas experienced by facilitators (Bilandzic, 2016; Koester, 2014).

To address this gap, we draw on theoretical foundations related to the design of learning environments with an emphasis on sociocultural perspectives (Falk & Storksdieck, 2005) and culturally responsive frameworks (CRF) (Ladson-Billings, 1995; Pollock, 2008). Our work utilizes four distinct strategies aligned with culturally responsive frameworks: 1) research-based computer science practices for teaching and engaging a diverse population of youth; 2) practices that build on the knowledge and assets of communities; 3) undergraduate computer science students as facilitators and near-peer mentors; and 4) culturally responsive interactions between facilitators and youth underrepresented in computer science (Codding, Mouza, Rolón-Dow & Pollock, 2019).

Our goal is to address design dilemmas that arose during our university-library partnerships with two public libraries. We address dilemmas related to the design of such learning environments and present the decisions facilitators made while addressing those dilemmas. Additionally, we examine how these decisions reflect the use of CRF to facilitate culturally responsive interactions and create an affirming learning environment. Our analysis is shaped by the following research questions:

1. What types of dilemmas do facilitators encounter while designing informal learning environments to support the development of youth CT skills in public libraries?
2. How do facilitators' decisions reflect CRF in designing informal learning environments that support youth CT knowledge and skills?

Methods

Background and Context

This work is situated in a larger effort to broaden participation in computing through a three-pronged approach: teacher professional development, college field-experience course, and sustainable partnerships. In this paper, we focus on the latter two strategies. The field-experience course combines college classes with field-experience in formal or informal settings. The class meets weekly to identify and implement CS teaching resources, lesson modeling, discussion of pedagogy, lesson planning, and reflection. In the field, groups of undergraduates meet with educators weekly to plan lessons, lead activities, and facilitate after-school programs. Although participants do not intend to pursue teaching careers, they enroll in the course with a desire to share their CS expertise with others and to strengthen their technical communication skills.

This work examines two such partnerships between undergraduates and library staff members in the Scratch Technology Club (STC) and the Coding Club (CC) in two public libraries

during a period of one semester. The STC partnership centered around two-hour events every Saturday morning for 10 weeks. On average, 5-14 youth ages 7-15 participated in each STC session. The ratio between male and female participants was about 1:1. The CC partnership implemented one-hour events on the first and third Tuesday of each month for a total of five sessions. Two additional sessions were held on alternate Tuesdays specifically targeting a group of high school students from nine charter schools, which utilized the library as a bus stop. Yellow school buses dropped dozens of students off in front of the library each afternoon. On average, 5 youth ages 8-15 participated in regular CC sessions and 7 high schoolers participated in each additional session. Participants in both sessions were primarily African-American and a majority of the high school participants were female.

While these programs served different populations of students, they share a similar mission to provide youth opportunities to develop CT skills. Any youth interested in participating was permitted to attend, though many had no prior experience with CT. As a part of the partnership, the public libraries provided resources and logistical supports.

Participants

Facilitators included four undergraduates responsible for the design and implementation of their respective programs (Table 1). The university course professors provided instructional guidance to facilitators.

Table 1. *Facilitator Backgrounds in Fall 2017*

	Facilitator	Gender	Major/Year
STC			
	Cathy	F	non-CS/Senior
	Carrie	F	CS/Sophomore
CC			
	Carrie (also facilitate in STE)	F	CS/Sophomore
	Nancy	F	CS/Sophomore
	Jose	M	CS/Sophomore

Data Sources

Data were collected from multiple sources including: (a) facilitators' weekly reflection journals (N=40); (b) facilitators' end of the program reflections on content and pedagogical decisions (N=4); and (c) detailed field observations of all sessions to ensure the reliability of the data set (Hatch, 2002).

Facilitators' weekly reflection journals. Facilitators were required to reflect upon their teaching experience at the program every week. In their reflection, they needed to briefly report the implemented lesson components (e.g., learning activities, covered CS concepts) as well as their reflections about their teaching including what went well in their lessons or questions that they had during their teaching. The length of their weekly journals ranged from 200 to 400 words.

Facilitators' end of program reflection. Facilitators were required to provide a holistic end of program reflection as they completed their field teaching experience. The requirements of this reflection included asking the facilitators to provide anecdotes or evidences about how their teaching had changed throughout their 10-week teaching experience such as comparing their

pedagogical approaches. The average length of the end of the program reflection was about 700 words.

Data Analysis

Data were analyzed using a priori codes developed during a previous study of 80 weekly journal reflections to identify dilemmas faced by instructors and decisions to address those dilemmas. Two researchers first went over the coding scheme to redefine the categories using several journal reflections (Table 2) and subsequently coded the data from each program based on the updated coding scheme.

Table 2. *Coding Scheme*

Categories	**Sub-Categories**	**Definitions**
Dilemmas	Diverse Learners	Refer to learners' diverse background with programming, skills, interests, and culture.
	Uncertainty of Participants	Refer to unknown participation rates for weekly sessions
	Limited Resources	Refer to limited physical resources (equipment such as laptops) and human resources (support)
	Learners' Engagement	Refer to issues related to learners' content knowledge - returned learners mixed with new learners.
Decisions	Addressing Personal Factors	Decisions relate to learners' personal characteristics which support a successful learning experience, such as prior knowledge, background, expectations, motivations and so forth
	Addressing Sociocultural Factors	Decisions relate to collaboration, use of tools, and culturally responsive relationship development
	Addressing Physical Factors	Decisions related to the learning environment, including the design of the setting which affect what learners retain.

Findings

Dilemmas while Designing Informal Learning Environments

Facilitators discussed four types of dilemmas while considering learning environment design. The first dilemma focused on designing a learning environment that helped *all* youth,

independent of their background, develop CT knowledge and skills. Carrie documented these challenges after her first week at STC: *"After teaching one class, I have learned that the greatest challenge with teaching in a library setting will be catering to the needs of all students."*

The second dilemma focused on varying participation rates among youth, ranging anywhere from zero to ten participants. For instance, the facilitators of both clubs were never sure which youth students would be in attendance. Moreover, new youth joined every week with varying degrees of CS background knowledge. Such transitional participation made it difficult to plan activities and prepare equipment to meet the participants' needs.

The third dilemma, limited resources, often worked in combination with the second dilemma. This resulted in facilitators raising concerns about how to balance and maximize effectiveness: *"This week we had the highest number of students with a total of 12, so students had to share laptops and tools which is why we had them work in pairs"* (Cathy, STC). Facilitators also faced a lack of support from library staff. Although anticipating a supporting role, expectations changed after meeting with library staff: *"Ms. B is not equipped to run the program due to IT not being her area of expertise and other responsibilities she has at the library. This meant that [we] have to set into the leadership position and run the program" (Jose, CC).*

The fourth dilemma was a culmination of the first three. With continually new and diverse learners, ongoing uncertainty of participation, and limited resources, facilitators found it challenging to engage learners in the learning activities: *"When explaining the basics of Scratch, many of the returning students were bored and didn't want to pay attention, while some of the new students struggled"* (Carrie, STC).

Addressing Dilemmas with Decisions

Throughout the programs, the roles of undergraduates shifted from instructors to facilitators. Their decisions, which included both content and pedagogical considerations, were based on personal, sociocultural and physical factors.

Personal Factors: As facilitators' knowledge of participants developed, so did their ability to make reflective and engaging decisions addressing personal factors. Facilitators frequently collected participant feedback through observations and conversations, modifying their plans based on youth engagement and feedback from the previous week. CC facilitators learned that their participants enjoyed friendly competition: *"We did a Finch maze with the high schoolers, making it complicated with thin lanes and twists and turns. The kids had a lot of fun coding their robots and we timed them individually against their friends. They got really competitive with it and continued to edit their code to make their robots beat previous times"* (Nancy, CC).

Considering most youth lacked prior CT knowledge, facilitators sought to make CT concepts engaging and relevant. They provided youth with knowledge and skills to construct personal, meaningful artifacts and helped them establish a linkage between CT concepts and their applications. Carrie (STC) noted, *"This is a good lesson plan because it relates algorithms to things they can easily understand, like the steps they take to get ready in the morning. This lesson also uses a fun activity, making paper airplanes, to engage students."*

Table 3 illustrates the computing tools and CT concepts selected and taught by the program facilitators at both libraries. Facilitators carefully weaved the tools and CT concepts with participants' interests and real-life applications into a lesson design, such as incorporating the idea of using robotics in serving at cafeterias.

Table 3. *Computing Tools and CT Concepts at STC and CC (Fall 2017)*

STC	CC	Description/Example

Technologies	Makey-Makey Finch Robots Ozobots Scratch 3D Printing	Makey-Makey Finch Robots Ozobots Scratch PencilCode	
Concepts	CS Unplugged	CS Unplugged	"a collection of free teaching material that teaches Computer Science through engaging games and puzzles that use cards, string, crayons and lots of running around" (https://csunplugged.org/en/)
	Loops:	Loops	Scratch programming blocks such as "repeat # times," "forever," and "repeat until"
	Variables	Variables	Operators and inputs
	Sensing	Sensing	to detect different factors of project such as color
	Conditionals	Conditionals	If-Then Statement
	Operators		to script math equation using operators Boolean blocks such as ( ) < ( ).
	Broadcasting		messages that are sued to communication with multiple sprites

Sociocultural Factors: With participants from diverse backgrounds, facilitators promoted a socially interactive and collaborative environment, allowing peers to communicate, share personal meanings, and construct learning together. To accomplish these goals, facilitators utilized collaborative learning. Cathy (STC) explained, *"We had each student work with a peer to create their final scratch project. They had to include certain features that we have taught them over the semester . . . All the students were familiar with performing these tasks but the difference in this project was they had to create a sprite for themselves and their partner. They also had to interact with their partner, ask them what they like to do, and include it into the project."*

Participants often brought new friends or family to the club. Youth were frequently observed talking, sharing, and helping each other. Facilitators leveraged these sociocultural factors to increase attendance and engagement. Nancy (CC) explained, *"I was worried that the high*

schoolers wouldn't want to come to the program, as I'd been told [by the librarians] that they always said no when asked to come to the coding club, but after [we] convinced one girl to come, about five others followed."

Additionally, facilitators designed an affirming learning environment that encouraged culturally responsive interactions between facilitators and diverse participants. This can be observed in Jose's (CC) reflections about his communication skills. He stated, *"I believe that becoming a better instructor goes beyond having the knowledge in my head and involves a lot of communication skills that make or break my effectiveness as an instructor."* In a later reflection, he expands on this desire for effective and affirming communication by writing: *"I am now more aware of the language and tone I use when talking to the kids because of the impact my words have on their takeaway and experience with computer coding club."*

Physical Factors: Program facilitators frequently rearrange the physical settings to create a more effective learning environment and maximize participation. Lacking space and resources, Cathy and Carrie decided to rearrange the room to better facilitate participants testing their Finch Robot programs. They divided participating youth into two groups and assigned them a carpet and tape to create mazes. Groups then worked to code their Finch Robots to complete the mazes (Figure 1). CC facilitators also addressed physical factors while seeking to expand participation by building Finch Robot mazes in the hallways to attract new participants and increase engagement.

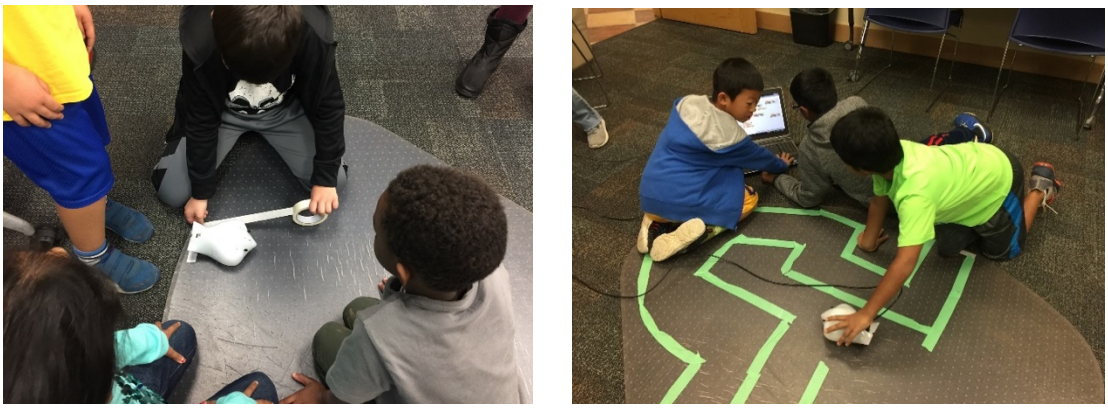

Figure 1. *Participating Students Divided into Two Groups on Collaborating on Finch Robots in the Room*

Significance

In this paper, we provide evidence on how program facilitators, with support from university faculty and librarians, regulated and adapted the design of the library clubs. Findings of this study provided insights related to the design, implementation, and outcomes of informal computing programs for youth from diverse backgrounds. Looking forward, we hope to determine how the cultural context of each library impacts the culturally responsive decisions necessary to increase student engagement and to design an affirming learning environment. Our next steps include developing a culturally responsive training to encourage facilitators to reorient themselves toward their participants by adopting affirming attitudes, intentionally learning about their students, and developing a critical consciousness toward educational equity.

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