Culturally Sustaining Pedagogies in CS: Modern K12 Outreach and its Adaptability in a Global Crisis

Jazmin Collins
Computer Science Department
Arcadia University
Glenside, USA
jcollins_01@arcadia.edu

Kami Otero De Owens
Computer Science Department
New Mexico State University
Las Cruces, USA
kotero4@nmsu.edu

Vensan Cabardo
Computer Science Department
New Mexico State University
Las Cruces, USA
vcabardo@nmsu.edu

Sarah Hug
Social Science Research
Colorado Evaluation & Research Consulting
Westminster, USA
hug@colorado.edu

Raena Cota
Computer Science Department
New Mexico State University
Las Cruces, USA
raenac@nmsu.edu

Enrico Pontelli
Computer Science Department
New Mexico State University
Las Cruces, USA
epontell@nmsu.edu

Abstract—This paper describes the ways in which an established K12 informal learning program, called Young Women in Computing (YWIC), utilizes culturally sustaining pedagogical practices to support learning, development, and leadership of youth outreach participants as well as undergraduate instructional staff. Authors emphasize the leadership roles undergraduates (here, authors 1-3) play in developing and implementing outreach designed and embodied at a Hispanic-Serving Institution. The three themes illustrated in this study include (1) opportunities for agency, or ownership, choice and autonomy for undergraduate leaders, (2) an emphasis on relationality, or developing personal relationships among undergraduate leaders and youth, and (3) the multiplicity of relevant knowledge and "ways of knowing" which contribute to viable pathways into computing. This paper argues the elevation of undergraduates better apprentices the next diverse educators and leaders in computing. Keywords — student agency, culturally sustaining pedagogy, Hispanic Serving NMSU, relationality

I. Introduction

The field of Computer Science (CS) has been troubled by a profound lack of diverse and equitable expansion for many years. The CS field continues to struggle with the exclusion of minoritized groups and women. Such exclusion has proceeded to foster a blindsided viewpoint of the IT and computing industries, where bias leans towards the majority demographic in both development and production, hindering both the progression and progressiveness of the CS field. There is a great need within CS to begin incorporating excluded voices to cease this disparity, bringing in the valuable contributions of groups such as women, ethnic and racial minorities, and LGBTQ+ community members, who are currently unheard in the field.

The creation of co-curricular CS outreach programs that seek to support women and other minorities in the field of CS are in dire need, at multiple levels of education. But how should we go about exposing K12 groups to the CS industry, in a manner that will encourage and attract women and other underrepresented groups? How should we teach CS to groups traditionally excluded from its borders, and build effective learning environments that will make these groups feel welcome and supported?

This paper presents a CS outreach program designed with such questions in mind. The program seeks to create a culturally-sustaining informal education environment for young learners of CS. By analyzing the unique pedagogical practices of this program, we seek to encourage other outreach programs to evaluate their methods through a lens of student-based inclusion in design. Our research questions are the following:

1) *How did the Outreach Program use culturally sustaining pedagogical practices to support learning for undergraduate and K12 students in computer science?*
a) How did YWiC adapt to the pandemic?

II. Theoretical framework

A. Culturally Sustaining Pedagogical Practices

We focus on the concept of *culturally sustaining pedagogies* to understand how the summer outreach team developed and implemented summer programming for youth 11-17 during the global pandemic of 2020. Culturally sustaining pedagogies [1] are a specific form of asset pedagogies that a) center non-dominant practices, values, knowledge systems and beliefs, b) engage in teaching and learning with an eye towards pluralism not conformity nor "gap-bridging," and c) highlight emerging cultural and linguistic practices important to youth. We emphasize *scaffolded agency*, *relationality*, and *multiple ways of knowing* in our paper, and highlight these elements of culturally sustaining pedagogies in this section.

1) Scaffolded Agency

In higher education learning settings, there are inherent (often implicit) expectations of participants and staff regarding how power is distributed, and who has *choice and voice* [2]. In programs emphasizing culturally sustaining pedagogies, power is, by design, less hierarchical than in traditional educational

settings. While working within the constraints of group membership and relative status, participants within a culturally sustaining learning community have opportunities to create organizational practices that enhance opportunities for expansive learning [3].

2) Relationality

According to Dillard, teaching is "care work" [4]. Culturally sustaining pedagogical practices ensure that learning is built upon relationships among students and between educators and learners. Creating a learning environment with an emphasis on relationships can increase student motivation [5] and increase learners' sense of belonging to the content matter and to one's learning community [6].

3) Multiple ways of knowing

Culturally sustaining pedagogy does not limit learning targets to those that are purely academic, and in fact highlights multiple ways of knowing. Curriculum is (in some cases) negotiable, and projects introduced to learners have "low floors, high ceilings, and wide walls" [7] to offer multiple entry and exit points to the content. Culturally sustaining pedagogies highlight not only the traditional beliefs, values, and language practices of learners who are from marginalized groups, but also the cultural practices of youth as they build their own cultural practices, particularly in this time of the pandemic.

III. METHOD

A. Data sources

We utilize the following data types: participant observation across multiple roles in the outreach program, formal reflection notes and transcripts on outreach teaching experience guided by the "outsider" author #4, undergraduate leaders' focus groups, artifacts of programming planning and implementation (e.g., camp schedules, curricula, and handouts and prompts), as well as youth participant artifacts (e.g., portfolios).

B. Data analysis

This participatory case study used iterative analytic practices, and represents both "insider" and "outsider" viewpoints [8]. We employed Merriam and Tisdell's practice of intertwining data collection and analysis [9], utilizing constant comparative methods of meaning-making [10]. First, author 4 reviewed documents, assignments, surveys, interview assessments of youth participants, portfolios from participants, panel transcripts from a conference where undergraduate leaders described their experiences, and participant surveys as part of her role to evaluate the youth program from the K12 participant perspective. Author 4 outlined the themes from culturally sustaining pedagogies with the team. Authors 1-3 began detailing how their experiences resonated (or did not resonate) with the themes introduced. The team met first to document their reflections on their experience developing, implementing, and adapting summer outreach for Summer 2020. Reflections were in small groups, and the groups took notes that were shared across the team. Large group discussions were audio taped and transcribed. This paper privileges the point of view of undergraduate instructional leaders.

C. Context of the Case

The YWIC outreach program is one of many programs facilitated by NMSU to promote interest and growth in the field of CS among youth for middle and high school young women. In 2015, the summer outreach expanded to include CS Adventures, a co-ed CS summer program for high school students. CS Adventures occurs following the YWIC high school program, and many YWIC participants also participate in the co-ed programming, creating a more balanced gender composition in CS Adventures than is typical for CS programming. While the team leads both sets of programs, the undergraduate leaders often identify as "YWICers." The program promotes from within: in 2020, three of the undergraduate leaders once were K12 program participants. This longevity with the program helps to maintain the programmatic culture.

From the viewpoint of YWIC K-12 participants, the program is an outreach initiative which creates an empowering environment for learning and engaging with material. Participants are taught material in a way that mirrors the concept of scaffolding, with each unit introducing the core concepts of its subject to provide a basic understanding of it, followed by opportunities for "open builds" where participants then utilize this understanding to create their own projects [12]. Staff interact with participants through daily icebreaker activities. The camp culminates in a "showcase," where participants share their projects with one another, with undergraduate leaders, and with family and friends they invite to the event. According to undergraduate staff, the programs developed and run by the NMSU CS team has a particular culture—they describe it as doing things "the YWIC way" in interviews and written responses. This paper attempts to document the norms of practices of YWIC.

IV. RESULTS

The results section is divided into multiple parts. Culturally sustaining pedagogical practices are addressed in two ways: through delineation of design elements by theme, as well as with data from undergraduate leaders that illustrate YWIC practices. In the discussion, we highlight how the original design of NMSU's outreach may have supported flexibility and re-development in the summer 2020 virtual implementation.

A. Culturally Sustaining Pedagogy By Design

According to Gutierrez and Jurow, intentional design can "*reorganize practices so as to engender new forms of knowledge and expertise that embody characteristics of the best of both sets of practices, albeit in new forms.*" [13]. In the case of the NMSU's summer outreach, the practices of curriculum development and pedagogical leadership build from the strengths of undergraduate leaders, rather from a "top-down" model of faculty or staff decision making. The table below shows the design features of the NMSU's outreach that privilege undergraduate leadership and learning environment development that allows for access to computing across multiple pathways.

CSP element	Through Intentional Design

Supported agency- undergraduate staff	Undergraduate staff develop and implement curriculum with use of past curriculum units as models; Weekly meetings of undergraduate staff before program and daily meetings following camp allow for collaboration and support of each curricular unit while maintaining ownership by "lead;" Intentional recruitment of former participants as staffers;
Relationality	Structure of undergraduate staff time creates multiple opportunities to collaborate- "lead and co-lead" structure for implementation creates teams of undergraduate staff; Flow of each day in youth programming includes social time for youth AND undergraduate staff, youth reflection as a group, and undergraduate staff "debrief time;"
Multiple ways of knowing/ multiple paths towards computing excellence	Multiple interests/sets of expertise modeled by undergraduate staff- double majors, many bring in interests to curriculum; Portfolio prompts were designed to elicit information about how technology was relevant to each youth participant- gave space for connecting to diverse interests; Flexibility and adaptability allowed undergraduate staff to be responsive to student interests to support engagement (e.g., Minecraft open build time added based on interest) Showcase and individual websites create a space for "sustaining culture" of all kinds- including youth culture, not just "static traditional cultural practices and norms

1) Supported Agency

The first theme is the explicit offering of agency to undergraduate staff and to youth participants through the choice and self-direction expected from staff and youth throughout the programs. Undergraduate staff begin the process of curriculum development in late spring, with multiple models of past efforts available to new staff. As many staff were learners in one of the NMSU's outreach programs in the past, staff build on their experience as students to develop curricular units that would "fit" the tone and spirit of YWIC, with short periods of direct instruction, guided practice, and open build time.

The empowering nature of YWIC continues with its final project showcase. Several researchers in informal science education have agreed that such youth showcases are valuable as a best practice for youth, emphasizing the organic interest it can develop within youth for learning [11, 14]. The showcase itself is also formulated as a "designed space", allowing participants and their guests to navigate the room according to their own interests, examining whatever project exhibits they wish to. Finally, this showcase gives participants a chance to reveal what they've been working on and highlights them and their creativity as the culmination of the program.

a) Evidence of agency

A new undergraduate staff member described her efforts developing a new curriculum unit for the online outreach program in summer 2020, and the care taken in making sure the resources were accessible to all students who joined the program virtually, no matter their technical knowledge or the quality of the technical equipment in their home.

"So my curriculum was based on the internet of things. Making students realize how objects can be connected through the internet, and that was particularly challenging online because we don't have these objects to work with, that are

common. So I had to really think about, how can I get these students to connect things without assuming that they have certain objects that are capable of connecting to the internet within their house?"

This quote reflects both the responsibility the undergraduate leaders accept in designing curriculum online and the need to balance assumptions about youth access to technological resources. This consideration of youth resource access is particularly vital in areas of our rural county. The county has a median income three quarters the national average, has 29% of children living in poverty, and is 86% Hispanic/Latino/a, a group that is drastically underrepresented in computing.

With undergraduate leader acceptance of agency, or ownership in the program comes the need to troubleshoot problems that arise. In a panel with peers, author 3 described an issue that arose with curriculum in the online outreach that led to a shift in curriculum during the summer outreach program.

"I had plans to do lessons on this application that would allow you to create music in Python. And I didn't realize until we had actually got into having them install it, that it was only available for Windows or Mac. So I had to completely refactor my curriculum. There is a browser-based tool for making music that we ended up having to shift to at the last minute instead."

Rather than forgo the lesson, the tool was switched out for one that was available to all students enrolled. Undergraduate staff managed the change as they continued to run the program for youth participants.

2) Relationality

The second theme is the emphasis on relationality, building relationships with intention across staff, staff and youth, and youth and their peers. The directionality of this communication is also important; it is vital that staff communicate information to students in an effective manner, but it is equally important that students are receptive to this information and feel comfortable reaching out to any of the staff members for assistance or feedback. The third, Youth-Youth, describes the efforts taken to build a community in which students were comfortable with and enthusiastic about collaborating with each other, in both social and technical capacities.

According to undergraduate leaders and program managers, every stage of the program creation and delivery experience was collaborative. The existence of a team of support staff served to ensure that program leaders could direct their attention to activities that involved teaching and interacting with students. All undergraduate leaders had specific roles to play in each element of the project, creating a sense of positive interdependence [16] useful in teamwork and necessary in developing relationality among staff.

a) Near peer relationships by design

Staff are all undergraduate students with nearly all attending NMSU, closer in age to students than traditional camp instructors or professors, and connect with students through daily activities. This "near-peer" mentoring is a valuable practice for youth in informal CS education [17] as a method that encourages individual learning with teacher figures who are not necessarily seen as distant superiors.

b) Intenional community building by design

Each day, the agenda included two activity blocks set aside for community building in the virtual setting. Rather than taking the approach that community building in the learning environment occurs only in the beginning, the NMSU's summer outreach incorporated interactive ice breakers and games 20 times throughout the 2-week camp. Both leaders who ran the activities in the co-ed camp in 2020 were women who attended the outreach events as high school students and served as role models for current youth participants.

In a field like computer science, in which most CS professionals and CS learners are men, it is important for co-ed populations to see women in leadership roles to combat gender bias in the field [18]. All of the undergraduate leaders participate in these activities—the goal of making sure undergraduate staff participate is to build rapport for youth through their engagement in informal dialog and play in the icebreakers and games.

Reflections on the summer outreach experience in informal focus groups brought out the following quote from author 2, indicating undergraduate leaders made attempts to build rapport and normalize the struggles of troubleshooting in computer science:

"Honestly, the best moments I've had is like when I'm working one on one with students, and we're like sitting there debugging together, and I get to show like, 'okay, I don't know how to solve this problem. So let's solve it together.' And so those are my favorite moments."

In a conference panel about outreach during a global pandemic, undergraduate staff explained their experiences as outreach leaders.

Author 3: We all have experience in one technology or another. So it's like if one of us knows Java more, maybe we'll get a Java curriculum. If one of us knows Python more, we'll write up a Python curriculum. And that's sort of how we've been operating all of our skills, mesh together so that we can give a robust curriculum.

Author 2: And we also teach each other too. That's another fun element of YWIC.

Undergraduate Leader 1: I really enjoyed over the summer that you always have help because everyone's always willing to help each other out. If you're having problems with the students, having technical issues, one of the other camp leaders is there to help them out so you can keep going with your curriculum. So even though we all bring something individual to the table, I think that over the summer, it worked really well with all of us.

NMSU's outreach programs are designed to ensure that participants and undergraduate leaders have opportunities to get to know one another and build relationships within and across groups. The near-peer mentoring that the program elicits because of its design lends itself to creating cohorts of young women and young men who can develop a sense of belonging to computing and potentially to NMSU's Computer Science department itself.

3) Multiple ways of knowing/multiple pathways into CS

The third culturally sustaining pedagogical practice visible in the implementation of NMSU's outreach programs is the focus on intentionally nurturing multiple types of expertise in computing and allowing for youth to forge multiple pathways into the computing community. All of the team members of YWIC come from different backgrounds and bring along their own unique experiences. Some undergraduate leaders are pursuing and succeeding in Computer Science degrees and yet had no previous experience in the field before college, some are very new to the degree, some who have had a lot of exposure to CS, some who enjoy CS but have pursued other fields, as well as members who came into CS from completely different fields of interest. The collective experiences that undergraduate leaders provide contribute to diverse and progressive outreach programs and curricula.

As the program manager (author 5) put it, curriculum development is left to the undergraduate leaders to promote diversity in curricular topics as well as to promote ownership of the program by the undergraduate leaders. The leaders in turn learn to bring in pop-culture that youth participants share with undergraduate leaders—this has led to integration of programing with Elsa, Star Wars games, an Avatar themed escape room, and K-Pop, to name a few. Undergraduate leaders add in these cultural references and cues to maintain enthusiasm in computing projects and camp activities.

V. DISCUSSION AND IMPLICATIONS FOR PRACTICE

Culturally sustaining pedagogies created within NMSU's outreach programs are great examples of progressive, inclusive, and diverse pedagogies that effectively encourage and motivate students of underrepresented communities to pursue Computer Science. They do this by: incorporating and being keen to non-dominant practices, values, knowledge systems and beliefs that students may have, also by developing more of a pluralistic approach to teaching, and by connecting to the students at a near-peer level by highlighting cultural and linguistic practices important to youth.

The year of 2020 brought about tests of adaptability, new ideas, and flexibility within education. Many undergraduate leaders felt the importance of outreach and maintaining a program for students who needed a CS outlet was too great to cancel summer programming. Since many of the undergraduate leaders were tech savvy and full of ideas, the leaders decided to switch to online programs. The real struggles came to simulating classroom environments and common human interactions to help with multiple types of learning, and undergraduate leaders were excited to take on the challenge.

In short, the culturally sustaining pedagogies that have developed through 2020 are leading examples of curriculum overhauled and modernized to better suit the needs of youth and underrepresented communities. Creating opportunities for near peer undergraduates to develop, run, and collaborate with others on curriculum that builds on best practices in informal STEM learning can create a tiered learning community in the field that sustains cultural practices and welcomes a diverse body of students into computer science.

References

[1] D. Paris and H. S. Alim, "What are we seeking to sustain through culturally sustaining pedagogy? A loving critique forward," *Harvard Educational Review*, vol. 84, no. 1, pp. 85-100, 2014.

[2] W. Damon, "What is positive youth development?," *The Annals of the American Academy of Political and Social Science*, vol. 591, no. 1, pp. 13-24, 2004.

[3] Y. Engstrom and A. Sannino, "Studies of expansive learning: Foundations, findings and future challenges," *Educational Research Review*, vol. 5, no. 1, pp. 1-24, 2010.

[4] C. B. Dillard, *On Spiritual Strivings: Transforming an African American Woman's Academic Life*. SUNY Press, 2012.

[5] A. P. Rovai and H. Jordan, "Blended learning and sense of community: A comparative analysis with traditional and fully online graduate courses," *The International Review of Research in Open and Distributed Learning*, vol. 5, no. 2, 2004.

[6] L. B. Spanierman et al., "Living learning communities and students' sense of community and belonging," *Journal of Student Affairs Research and Practice*, vol. 50, no. 3, pp. 308-325, 2013.

[7] M. Resnick, *Lifelong kindergarten: Cultivating creativity through projects, passion, peers, and play*. MIT press, 2017.

[8] M. Råheim, L. H. Magnussen, R. J. T. Sekse, Å. Lunde, T. Jacobsen, and A. Blystad, "Researcher–researched relationship in qualitative research: Shifts in positions and researcher vulnerability," *International journal of qualitative studies on health and well-being*, vol. 11, no. 1, p. 30996, 2016.

[9] S. B. Merriam and E. J. Tisdell, *Qualitative Research: A Guide to Design and Implementation,* Fourth Edition, Jossey-Bass, 2015.

[10] K. Charmaz, *Constructing grounded theory*. Sage Publishing, 2014.

[11] P. Bell, B. Lewenstein, A. Shouse, and M. Feder, "Learning Science in Informal Environments: People, Places, and Pursuits," National Academies Press, 2009.

[12] R. Alber, "Teacher Leadership: Six scaffolding strategies to use with your students," http://www.edutopia.org/blog/scaffolding-lessons-six-strategies-rebecca-alber, 2011.

[13] K. D. Gutiérrez and A. S. Jurow, "Social design experiments: Toward equity by design," *Journal of the Learning Sciences*, vol. 25, no. 4, pp. 565-598, 2016.

[14] S. Hug and S. Eyerman, "Instructional Strategies in K-12 Informal Engineering Education - Deep Case Study Approaches to Educational Research," in *ASEE Annual Conference & Exposition*, 2018.

[15] F. Hamidi and A. Moulton, "Using Retrospective Surveys to Assess the Impact of Participating in an Afterschool Maker Learning Program on Youth," in *ASEE Annual Conference proceedings*, 2020.

[16] D. W. Johnson and R. T. Johnson, "Making cooperative learning work," *Theory into practice*, vol. 38, no. 2, pp. 67-73, 1999.

[17] L. S. Tenenbaum, M. K. Anderson, M. Jett, and D. L. Yourick, "An Innovative Near-Peer Mentoring Model for Undergraduate and Secondary Students: STEM Focus," *Innovative Higher Education*, vol. 39, pp. 375-385, 2014.

[18] D. M. Young, L. A. Rudman, H. M. Buettner, and M. C. McLean, "The Influence of Female Role Models on Women's Implicit Science Cognitions," *Psychology of Women Quarterly*, vol. 37, no. 3, pp. 283-292, 2013.