Building Computational Thinking in K12 Outreach to Serve Latinas: Impact of Moving Summer Programming Online

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Introduction

In the summers of 2020 and 2021, two online summer camps were organized and sponsored by the New Mexico State University computer science department co-curricular staff and student development team. The undergraduate and graduate student staff, many of whom were campers as K12 students, were tasked with developing an online program for young women and girls that adhered to what they defined as the "culture" of the program, one that emphasized exploration, choice, building community, and inspiring a growth mindset towards computational thinking, all elements of high quality STEM outreach programs for youth (Noam & Shah, 2014). This paper utilizes survey, assessment, and interview data in a mixed method investigation of the K12 outreach effort that investigates from multiple perspectives whether and how a program maintained fidelity with a move online.

Conceptual Framework

This case study considers the learning ecologies framework for considering how Latinas are supported in their ambitions in computing within the computer science department New Mexico State University. According to Bevan, "A *learning ecology* is the physical, social, and cultural context in which learning takes place" (2010, p.8). For this case, data was collected from programmatic efforts and from interviews and observations of staff. The use of the term "program culture" throughout the interviews brought out the need to consider the learning environment as a whole—beyond the curriculum as developed to take in the curriculum as enacted, the interactions among peers, the social aspects of the online synchronous program as designed, and the cultural contexts of learners and staff as they navigate program implementation. The program draws on the notion of building from Latinas' assets (Espinoza, 2011) to develop a learning ecology supportive of positive youth development (Baron, et al 2012; Bell, et al 2009; Damon, 2004).

Literature Review

Latinas are severely underrepresented in technical careers—they make up 1% of electrical engineering and 2% of computer science degree earners while they represent 8% of the U.S. resident population overall (https://ncses.nsf.gov/pubs/nsf19304/data) . Studies of Latinas in STEM indicate evidence of *intersectional marginalization* Latinas face in technical fields, or the harmful ways stereotypes about Hispanics and women in STEM hamper Latinas' success both in the academic and professional STEM settings (Espinosa, 2011; Johnson, 2007; Ong, et al, 2011; Sax, et al, 2018). In this case study, we describe how one computer science department in a rural, low income community in the US Southwest creates support structures for women, particularly Latinas, through multiple program leveraging, near peer

mentoring, and intentional recruitment strategies. The paper documents evidence of impact from data sources that span K12 and undergraduate student populations. The intent is to describe how the program supported Latinas across multiple levels of education to pursue computing academic and career pathways.

Results of Programmatic Impact for Youth Online

Participants in these camps took part in 3 evaluative activities. First, participants were interviewed by camp staff regarding their current knowledge of computing concepts. At the end of the camp, they were interviewed using the same set of questions as well as one reflective question. They also took a retrospective survey regarding their experiences in camp. The retrospective design allows the participant to measure their growth at one point in time. Researchers were also given access to student journal entries over the time period of the camp. This year, additional items were added to focus on the online format, and how it compared to other online and face to face programming they have had in the past. As part of a related computer science department effort (NSF award # 1833630) undergraduates who work with the outreach effort are interviewed annually—in this way we learn about how running the outreach program influences undergraduate student computing pathways.

Research Question 1: How do camps compare in their ability to influence student attitudes, identity, and knowledge regarding computer science?

The data were compared across programs in two ways—by focusing on the range and mean of the change score, or the "after" minus "before" scores, of participants, and by comparing mean post scores. The data are divided by item type, with attitude and identity items combined and self-report of knowledge gains combined. We note the positive change score ranges across the attitude and identity items for both camps, from +0.46 to +1.48. As in past years, the change score range for skill development is higher and broader, from +1 to +2.68 across both camps. In the third row of the table below, we see only "post" score ranges for attitude and identity, which remain in the "agree" range. Similarly, post scores for the skill development items are solidly in the "agree" to strongly agree range.

Likert response descriptive statistics (1=strongly disagree; 5= strongly agree)	PROGRAM HS	PROGRAM MS	Range across camps
Change score range, attitude and identity	**0.60-1.48**	**0.46-1.14**	**0.46-1.48**

Change score range, skill development	**1.6-2.68**	**1.0-2.5**	**1.0-2.68**
After item score ranges across all items, attitude and identity (1 is negative/strongly disagree, 3 is neutral, 5 is positive/strongly agree)	**3.84-4.80**	**3.73-4.77**	**3.73-4.80**
After item means across all items, skill development	**4.24-4.48 (6.36 for phrases known)**	**4.18-4.64 (5.09 for phrases known)**	**4.18-4.64**

Research Question 2: Does NMSU outreach influence student attitudes, identity, and/or knowledge regarding computer science?

The retrospective model allows for students to indicate "before program" and "after program" ratings at the same point in time. As in past years, in each of 18 items, statistical analyses show that students increased their interest in, understanding of, value of, and sense of belonging in computer science. There w a total of 48 participants, all of them identifying for a program for "girls and young women."[1] Paired t-tests for the whole group of surveys are statistically significant, indicating growth on every item in the survey, and the same statistical tests hold true for each sub population (middle school girls and high school girls). The combined group shows significantly different results in the items related to "before the camp" and "after the camp," with t-test results ranging from -4.07 to -12.08, where negative values relate to the order in which items were compared.

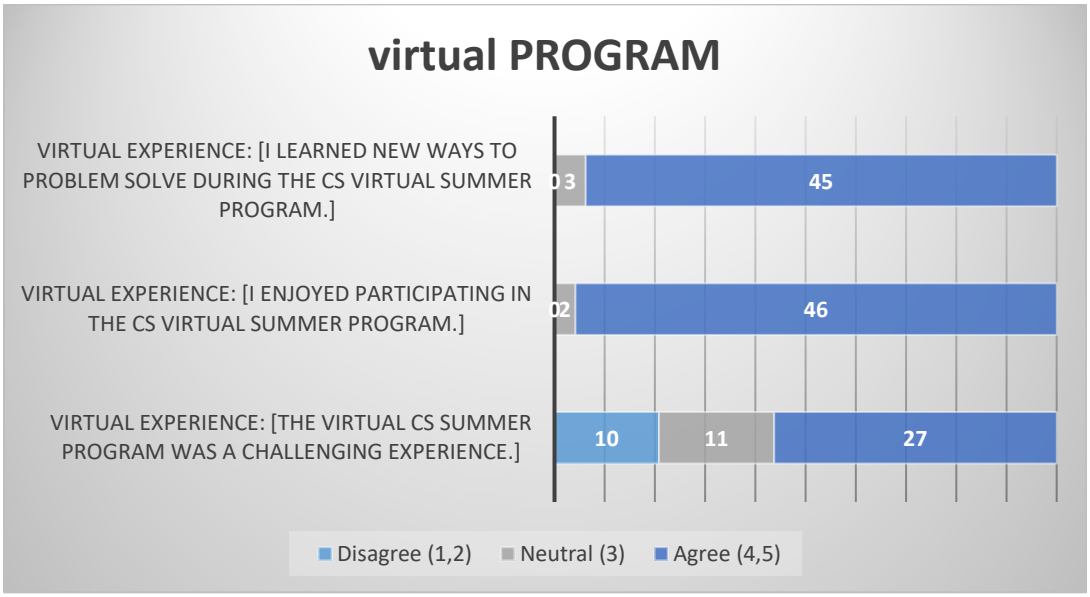
Middle and high school girl populations differ statistically on a few items—for example, the "post" response is higher for high school girls when describing the ways computing might influence them throughout their lives, and when considering whether or not they will take computing courses in the future. High school girls also listed more familiar computing phrases at the end of the program than middle school girls. High school girls also grew more than middle school girls in their pride of their computing skills and in their self-rating of their ability to program arrays.

[1]While camps were listed for girls and young women and no coed camps occurred in the summer of 2021, gender items indicated that some participants preferred not to identify a gender, or identified with a gender that was non-binary.

Research Question 3: How did the experience compare to other online learning experiences, according to campers?

The global pandemic meant in-person summer camps were moved online for summer 2021, just as it was in summer 2020. As in the previous year, this afforded opportunity to reach youth from more rural areas, who would not be able to get to SMALL CITY daily for a full week camp. Many of the formats and curricular adjustments that were made in 2020 were relevant again in 2021. Summer camp participants were asked to compare the experiences with any other online experiences they had, including academic experiences of K12 school which had moved online for students in the spring of 2020 and for some throughout the 2020-2021 academic year. Overall, students found the summer camp compared favorably. Students were asked in scaled items about their experience of the virtual camp. Mean scores neared the maximum 5.0 with means ranging from 3.48 to 4.73. The distribution of responses appears in the chart below.

> *"This virtual experience was just as engaging as the last and challenged me in all the right ways as well. I feel as if I have learned much, much more about CS and I am grateful for that."*



Students were asked to compare the virtual PROGRAM experience to other virtual learning experiences. Seventeen said this item was not applicable, while 18 rated PROGRAM more favorably than other learning experiences online, and three rated PROGRAM similarly to their other online learning. Participants described outreach at Rural Southwest State as more interactive, more engaging, more organized, and more "hands-on." In addition, it was described as cultivating a better sense of community. The quotes below illustrate these points.

> *This virtual experience was way better than the ones I had before. I felt it as a community that supports each other.*

I joined a STEM club this past school year virtually and it was difficult to follow along and I didn't learn much. During the PROGRAM camp I learned a bit about coding and other computer-based things and it was easy to follow along and learn.

This virtual experience was successfully interactive which I heavily appreciated because I have been working online with robotics but it was never this interactive.

Research Question 4: How do students respond to assessment interview questions, and how does this change over time?

Students are assessed with interviews in the first day of camp and at the end of the camp. A random selection of interviews ae selected for assessment in the evaluation of the program, 7 from high school and 7 from middle school, matched by participant. Just as in past years, high school averages were higher than middle school at both pre and post assessments. All students improved their scores from pre to post, with difference scores ranging from less than 1 point out of 12 to 8.44 more points on the post test.

Group: MS or HS	**Total Score - PRE (max=12)**	**Total Score - POST(max=12)**	**Difference**
MS 1	1.33	9.78	8.44
MS 2	3.17	6.78	3.61
MS 3	2.06	5.89	3.83
MS 4	3.83	7.28	3.44
MS 5	0.50	3.00	2.50
MS 6	6.67	8.22	1.56
MS 7	7.89	10.00	2.11
HS 1	6.39	8.28	1.89
HS 2	7.67	8.44	0.78
HS 3	5.94	10.44	4.50
HS 4	4.39	8.33	3.94
HS 5	5.89	7.94	2.06
HS 6	3.67	8.11	4.44
HS 7	3.11	4.67	1.56

Mean score (out of a possible 12 pts)	Pre	Post	Gain score	N
MS	3.63	7.28	3.64	7
HS	5.29	8.03	2.74	7
Total	**4.46**	**7.65**	**3.19**	14

The dataset was tested using a paired sample t-test to see if the post scores were significantly different across all sampled interview participants, however, only 5 of the 7 items were statistically significant. As in past years, Middle school students grow at a similar or higher rate but from lower starting points. There was wide variation across participants, it is possible that with more sampling across data sources there may be a statistically significant difference detected. Most students grew from pre to post with a change in score between 1 and 4 points.

Research question 5: How does YWIC develop a learning ecology supportive of computing identity development for undergraduate staff and participants?

The author held multiple focus groups with undergraduate student staff following the online implementation of the outreach programs at NMSU.The table below summarizes the findings from those interviews, with emphasis on considering how the implementation of staff-led curriculum with an emphasis on community building influenced the online learning ecology of YWIC.

	Implementing High Quality Computational Thinking Lessons Online
Staff development and ownership	Undergraduate staff develop and implement curriculum with use of past curriculum units as models- they develop passion for their proejcts as they develop them for use with youth. Weekly meetings of undergraduate staff before program and daily meetings following camp allowed for collaboration and support of each curricular unit while maintaining ownership by the "lead." Intentional recruitment of staff at multiple levels (freshmen-graduate school) to mentor one another in computing, and in outreach supported individual and collective ownership of curriculum and program implementation. Similarly, the intentional recruitment of former participants as staffers ensures staff have a sense of the norms of the learning environment as designed. Institution's fulltime program staff attend, are on hand during programming for support and during planning meetings/ debrief meetings. The full time staff are more senior staff members and typically have a supervisory role over staff members. They message to staff that they are available for support and guidance.
Lessons are designed with youth choice and voice in mind	Curriculum was structured with "low floor, high ceiling, wide walls" opportunity to fulfill initial expectations or go beyond them during "open-build" time (Resnick, 2017) High numbers of staff create opportunity for one on one support as needed for youth participants during lessons, for those who need extra help meeting initial requirements and for those who choose to extend their work. This translated online with felxible use of breakout rooms in Zoom, where youth could receive one on one attention in the virtual learning space from staff.

	The ending showcase creates space to direct how and what youth participants share with others, and creates opportunities for youth participants to choose to learn from their peers' efforts. These shwocases translated into virtual showcases and webpages that would be available beyond the time of the program so that youth could share their work with others beyond the program.
Building community	Structure of undergraduate staff time routines created multiple opportunities to collaborate- "lead and co-lead" structure for implementation creates teams of undergraduate staff who get to know one another. This collegiality supports youth relationship development. Flow of each day in youth programming includes social time for youth AND undergraduate staff, for youth reflection as a group, and undergraduate staff "debrief time." This was accomplished through synchronous participation in online meeting spaces.
Multiple ways of knowing/ multiple paths towards improved computational thinking	Multiple interests/sets of expertise were modeled by undergraduate staff- double majors, as many bring in their interests to curriculum development. Reflection prompts were designed to elicit information about how technology was relevant to each youth participant and 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). In the final online camp iteration, the portfolio prompts became website content shared within and beyond summer outreach, modeling multiple pathways through computing; Showcase and individual websites create a space for displaying each studnets' overlapping learning ecologies - including youth culture, not just "static" traditional cultural practices and norms.

Impact of leading YWIC for undergraduates

The NMSU computer science department, through staff connections and collaborations, leveraged their grants to build financial, social, and academic support for undergraduate women in computing at the undergraduate level. The YWIC program served as a space for leadership and technical skill development of undergraduate leaders—at the same time, the undergraduates served as "near peer" role models for the campers who attended in person and online. In this section, we describe the impact of the combined S-STEM scholarship and staffing the outreach program for three young women at NMSU.

One YWIC staff member, "Rachel," described how her experience at school shifted when she earned the S-STEM scholarship and was hired by the outreach program to develop curriculum. She describes how she went from working at a low-wage job unrelated to computing to serving as a mentor for Latinas in computing.

> *"*I worked nearly 30 hours a week, close to that, at a fast-food restaurant because I needed to pay for school."

Rachel got connected to staff in the department through her engagement in the S-STEM scholarship, and learned of a job with YWIC. She applied and earned the position. She described how the role supported her academically as well as financially.

> "Even I though work for YWIC, it's not crazy hours and it relates to my major. So sometimes it doesn't even feel like I'm working, so that helps. But the financial help has definitely been very beneficial."

Rachel's YWIC peer and S-STEM scholar, "Kaya", was surprised at the leadership role awarded her early on through the YWIC program. She notes her experience as a camper as instrumental in her taking up the role.

> "It's kind of weird sometimes. Like last summer was my first summer with YWiC and I was new there. I barely started in the spring of 2021 and I got put as the lead for all of our summer camps. … and I was like, 'what? I don't know how to do this' and they were like, 'you were in them when you were in high school, you remember.'"

Kaya described how she enjoyed the work of leading summer outreach for young women through the same program she attended as a K12 student. She found it rewarding and felt it was a developmental experience alongside her academic trajectory in computing.

> "At first, it was really scary but once I got into the teaching of it and actually did the summer camps, it was so much fun and it was honestly a reward for myself to know how I'm impacting the lives of these younger women. …It's like I've evolved."

An alumna who also served as YWIC staff and S-STEM scholar described her pathway in computing in the NMSU computer science department. "Laney" described the importance of her social networks developed as part of her work in YWIC. As a beginner in computing, she found her peer networks vital to her success in the degree program.

> "If I hadn't had the support network I did, I probably wouldn't have continued… (one support system included) my group with YWiC, Young Women in Computing. They were my coworkers, but mainly became my friends and it felt we were all in it together. So, it was through them, and then the various friends that I made in the CS department as well."

Conclusion

Just as in past years, when programming was held in person, students show statistically significant growth on nearly all identity and skill development survey items from before to after camp, indicating the program as effective at building computational thinking skill, knowledge, and interest. The biggest changes for participants across all camp types are in self-reported skill. Interview data indicate that students develop knowledge of computing over the course of the camp—all the sampled interview pairs showed growth from the first day of camp to the last day of camp. Participants were pleased with online implementation of YWIC—they found the camp to compare favorably or at least on par with other online learning experiences. The experience was more interactive and more organized than similar learning opportunities online. Staff focus groups suggest the individual ownership of modules by staff, intentional recruitment of past campers for staffer roles, the ample opportunity to communicate virtually with multiple types of participants (e.g., staff with staff, youth with youth, staff with youth), and the project-based elements of the program allowed for it to succeed online. The connections across funded programs and the intentional recruitment of near-peer leaders, some whom had been campers themselves, is a strength for developing a learning ecosystem that spanned face to face and online modalities and was supportive of young women developing in computing.

Acknowledgements

The authors acknowledge the support from NMSU staff members Mari Langford, Raena Cota, Adan Delval, and all of the YWIC staff who supported data collection and analysis for this paper. This material is based upon work supported by the National Science Foundation under Grant #1833630.

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