Making changes: Counteracting Latina Young Women's Negative STEM Experiences through Culturally Responsive Physical Computing

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Abstract: We show how non-traditional approaches to engaging young women in computing and engineering can impact their sense of what STEM is and who can do it. We designed and implemented a four-day Animal Investigators camp in which rural youth designed technologies for the animals in their lives. We wanted to understand the ways in which young peoples' prior knowledge about and experiences with animals and animal care could serve as a pathway into engineering and computing, particularly for non-dominant individuals who might not otherwise see themselves as belonging in these disciplines. Here, we present a single case study of Latina adolescent to address the following question: How did engagement in the Animal Investigators camp affect Latina adolescents' perceptions of what STEM is and who can do it? In the discussion, we address what we can learn from the adolescent's experiences about designing STEM environments that increase identification with STEM disciplines.

Introduction and background

Given the increased recognition of the importance of computational participation (Kafai & Burke, 2014), and computational thinking (Brennan & Resnick, 2012) for all youth and the simultaneous persistence of women and minorities' under-representation in STEM and computing (NSB, 2018), a number of efforts are underway to engage *all* youth in computing. Culturally responsive approaches to physical computing and making have been shown to be especially promising. By combining computing content with heritage and vernacular cultural practices that are familiar to youth participants (Eglash, Bennett, O'Donnell, Jennings, & Cintorino, 2006; Franklin, Conrad, Aldana, & Hough, 2011), culturally responsive approaches support multiple possible points of entry into computing and provide a vehicle for addressing youth's intersectional identities (Scott, Sheridan, & Clark, 2015).

In addition to supporting youths' intersectional identities through a culturally responsive approach, extending computing beyond the screen allows youth to see possibilities for expressing themselves, connecting with others, and questioning what is (Brennan & Resnick, 2012). Physical computing merges screen-based code with devices that do real work in the world, such as light-up clothing or physical game controllers.

Building on prior work in culturally responsive physical computing and making, we explored the ways in which animals and animal care routines could provide a meaningful context for doing computing and engineering. Somewhere between 49% and 68% of American families have at least one pet and research suggests that humans have strong emotional connections to their pets (e.g. Kruger & Serpell, 2006), which can improve physical health and psychosocial well-being (e.g. Walsh, 2009). Animals also play a crucial role in youth socialization, in the form of stuffed animals, images on clothing, room décor, and characters in favorite books, television series or movies (e.g. Hirschmann & Sanders, 1997; Melson, 2001). Thus, we designed the Animal Investigators camp to leverage participants' prior knowledge about and emotional connection to the animals in their lives as a context for doing computing.

Drawing on prior work around STEM identity and culturally responsive computing (e.g. Scott, Sheridan, & Clark, 2015), we designed and implemented a week-long Animal Investigators camp for rural youth. We investigated how animals could provide a meaningful context for doing computing and engineering, given humans' strong emotional connections to their pets (e.g. Kruger & Serpell, 2006). Here, we present a case study of a Latina young woman's experiences in the Animal Investigators camp. We examine her identification with STEM and computing. Specifically, we are guided by the following research question: How does engagement in the Animal Investigators camp affect Latina adolescents perceptions of what STEM is and who can do it?

Methods

During the summer of 2018, we piloted a week-long Animal Investigators camp in which young people in a rural

community in the Intermountain West designed technologies for the animals in their lives, such as a pet treat dispenser and a light-up dog collar. Fourteen young people between the ages of 9 and 17 years-old participated in the camp. The majority of participants were female (n=11) and all but three participants identified as members of non-dominant groups, including Latinx (9/14), Asian (1/14), and multiracial (1/14). Here, we focus specifically on the experience of one Latina participant and the ways in which participation in camp activities impacted her beliefs about what STEM is and who can do it. Participants engaged in four half-day sessions of Animal Investigators Camp for a total of 16 hours. All human participant names are pseudonyms.

We collected a range of qualitative data with a focus on (1) participants' making processes and (2) participants' beliefs about their abilities to make and program an animal-centered technology. Data sources included video- recorded camp sessions of each table (3-5 participants/table), photo documentation of design processes and design artifacts, daily fieldnotes, and final, audio-recorded reflective interviews with all but one participant who was not present on the last day of camp. Interviews were then transcribed. Drawing primarily on video data and reflective interviews, we developed case studies (Stake, 2008) for each of the participants. Due to space constraints, here we focus on the experiences of one Latina young woman, Monica.

Findings

We present a qualitative case study of changes in a Latina young woman's conceptualizations of STEM and in her own STEM identities through participation in the Animal Investigators camp. The participant described prior negative experiences in STEM, especially in computer science. Several aspects of the camp, including facilitator support, learning to troubleshoot, and physical computing assisted Monica in beginning to see herself as more likely to be successful in computing and engineering in the future.

Monica

Monica was a high school sophomore at the time of the study. Because of prior negative experiences with coding, Monica was nervous about her ability to succeed in the Animal Investigators camp. Reflecting on her high school computer science class, she said, "The teacher, she was nice, but because there were so many kids there, she didn't have the opportunities to come around and actually teach you individually. They were like [*snaps*] that fast, because she had to come here, there, there, that. It was just frustrating. Sometimes you never got—you didn't understand it very well" (Interview, 7/12/18). Thus, Monica was nervous about whether the Animal Investigators camp would provide a supportive environment. She recalled thinking, "Are they going to help me? Will they have the time?" (Interview, 7/12/18).

In addition to her concerns about the availability of facilitator support, Monica also highlighted a lack of identification with STEM when she discussed the pace at which she learned in relation to others in the class, "You feel more timid at school, because of all the kids. Some of them are a higher progress than you are." (Interview, 7/12/18)." In this reflection, Monica implies that she was one of the slower students and that being in that position caused her to feel like she was less capable of doing computer science.

Figure 1. (L to R) Monica and her partner investigate available materials for their treat dispenser, Monica and partner program their Micro:bit, and Monica with completed treat dispenser.

During the Animal Investigators camp, Monica experienced several shifts in her identification with STEM. For instance, when she was building a pet treat dispenser with her partner, Monica noted that there were several steps in the process she did not understand. One of the facilitators helped her and her partner work through the process.

I got frustrated once …because I was thinking and thinking so hard, but nothing that I could

> think—in my mind, nothing worked. Because I was like, "Well, this consequences, and this consequences, and this consequences." At the end, I was like—one of the [facilitators]….She helped me. She was like, "Let's figure it out step by step." We do it. (Interview, 7/12/18).

Through working through the problem step-by-step with the facilitator, Monica gained a better sense of how to work through a problem and was able to apply this to working with her partner to produce a functional treat dispenser. In her interview, she reflected that after being unsure how to use the servo motor to control the dispensation of treats:

> It turned out good. How we did the process of cutting the bottle, and sticking it up a box, or putting the position so it would come out. There were some difficulties. The food got stuck, or it spread all over. Then if you just focused on one and fixed one, then the other one became clearer. Then that's how we did until it worked (Interview, 7/12/18).

Here, we see a shift in how Monica approached the problem of building a functional treat dispenser. Rather than being stressed out by all of the possible solutions and problems, Monica emphasized focusing on and fixing one problem at a time. Through the process, she and her partner were able to build a pet treat dispenser that "turned out better than expected" (Interview, 7/12/18). Monica later identified the engineering aspects of the project as the most fun part of the week. She reflected, "I liked building the stuff, and figuring out how it was going to work, and what were the problems. You have to think about it really hard. Then you tried, and you got something at least. It was pretty fun working" (Interview, 7/12/18). Monica also experienced success with the coding aspects of the camp. For her final project, she wanted to make a scarecrow that would shake and scare away animals intent on eating things in the garden. Initially, she struggled to understand how the code worked, but a facilitator helped her. Monica reflected:

> We did the process on the computer of then forever all [forever loop] the words to combine them. At the end, it could do the whole functioning. [Name of facilitator] helped me with that. She was really helpful, 'cause she explained to me. 'Cause there were some parts that I didn't understand. Then she came. Then she's like, "Oh, you did this." She drew it, too. That helped me a lot more…She drew the flipchart, yeah. 'Cause sometimes I was like, "Wait. Is it less than five milliseconds? Then it's going to go dark?" I was just like, "Oh no. It's like this." Then she drew it. Then she explained it to me. It made lots more sense like that. Yeah (Interview, 7/12/18).

The flipchart, filled with the code helped Monica to make sense of the code and better understand how her project code worked. Monica also benefitted from other physical aspects of the computing experience. While working on her final project when Monica first got her servo to spin by shaking her microbit she was very excited and said "That's so cool." She then shook her project several times to show the facilitators her accomplishment. Afterwards she was able to show how she coded it with one of her tablemates. When we asked Monica if she learned anything about coding, she returned to her experiences in the computer science class at school and compared them with her experiences at camp. She reflected:

> Oh yes, I did! (laughs). I did a lot. I seen some things at school, but I didn't go so far in experiencing them as I did here. For example, at school, we just did, "Oh, you have to put this word with this word to make him [character on the screen] go right or left," but instead of here, there were a little bit better, because you actually got to work with something, not just on the screen of a computer screen. That was pretty cool (Interview, 7/12/18).

Experiencing the results of her coding in the real world afforded a different kind of connection to the code than Monica was not able to experience in her CS class and made her feel like she had learned something. Overall, feeling supported by the camp facilitators, learning how to troubleshoot, and creating both a functional pet treat dispenser and a functional scarecrow increased Monica's sense of belonging in and identification with computing and engineering. Initially, she was scared about how much support she would receive and the pace of instruction. By the end of the camp, she enjoyed building things and thinking through problems. She also enjoyed seeing her code manifested in her scarecrow project.

Discussion

Connecting to youths' pre-existing interests has long been held up as a means for improving youth learning and engagement (Ito et al., 2013). What has yet to be explored is the ways in which culturally responsive making and computing holds the potential to counteract prior poor experiences with STEM learning. Like other participants in our Animal Investigators' Camp, Monica articulated long held beliefs that she lacked interest and ability in computing and engineering. She then articulated how particular aspects of the camp experience, such as facilitator support, physical computing, and learning how to approach computational practices like testing and debugging (Brennan & Resnick, 2012) shifted her perspectives. Further, designing for animals afforded participants an opportunity to identify authentic needs around them for which they could problem solve and construct. For instance, Monica did not design for an animal per se, but designed an animated scarecrow to keep animals out of her family's garden. While we can certainly not suggest that a one week camp can counteract years of negative STEM experiences, Monica's experiences highlight several important aspects of designing for culturally responsive computing. As designers of STEM experiences, we often focus on finding engaging, relevant context, like the use of animals here. However, for Monica, it was less the context and more the one-on-one support and explicit problem solving guidance, particularly the amount of time spent going at her own pace, that made a significant difference. Future research should continue to explore the possible affordances of making to undo the damage done to youth STEM identity through traditional approaches to STEM fields, especially computing.

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