Becoming a Computer Scientist: Early Results of a Near-Peer and Social Justice Program with Latino/a Children

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Abstract: This report describes the results of a pilot study of CSteach, an afterschool program designed to get Latino/a students on the pathway to becoming a computer scientist. The hypothesis was that a social justice perspective and the use of near-peer teachers are motivating for elementary school children with little prior exposure to computer science. Using a mixed-methods approach, the study employed pre-post surveys, focus group interviews, observations, and an assessment rubric for student projects. The data show measurable increases in students' computer science identities, capabilities, and networks of support, and provide information that was used to strengthen the next phase of the program. High school-aged near-peer teachers also benefited from the program. They described growth in their leadership and communication skills and recognized their position as role models for the younger students. The paper has implications for designing culturally relevant learning environments.

Deep learning of the kind valued in the learning sciences requires students to be motivated to participate and persist in the face of challenges or uncertainty. This is particularly important in the field of computer science (CS) for two reasons. First, CS is not required or available in most US schools, and stereotypes based on gender and race/ethnicity prevent many students from taking or finishing these classes (Margolis, 2008). Second, learning to think computationally requires cycles of design, test, and revise (Lee et al., 2011), and beliefs about a lack of innate ability prevent many students from persisting when their initial program does not work. This study focuses on Latinos, who are the fastest growing ethnic minority group in the US but are underrepresented in CS. They are 16% of AP test takers, but only 1% of the AP Computer Science test takers; those that took it scored far below their peers (College Board, 2011). In order to increase the numbers of Latinos in CS, we need to create learning environments that excite them about becoming a computer scientist starting in elementary school and motivate them to persist in deep CS learning.

In this paper, we describe research on CSteach, an afterschool program that aims to move Latino/a students down the path to becoming a computer scientist by fostering capacities, identities, and relationships starting in 5th grade. Our Design Experiment involves an iterative cycle of implementation, data collection, and revision that is well-suited to developing programs that aim to avoid a deficit perspective when promoting learning experiences for marginalized populations (Collins, Joseph, & Bielaczyc, 2004). The design of the CSteach program was based on the understanding that CS, like all knowledge, is situated within a cultural context (Nasir & Hand, 2006) and that educational approaches should affirm and draw on intellectual resources in a given culture or community (Bang & Medin, 2010). CSteach draws on research in mathematics that shows that creating learning experiences that are culturally relevant and connect with social justice issues can engage students in learning in a way that is deep, meaningful, and that contributes to the development of a positive identity (Leonard et al., 2010). CSteach is the first known effort to integrate CS and social justice in elementary schools, and it builds off examples of "computing for the social good" in college (Goldweber et al., 2011).

Our hypothesis is that by integrating social justice into a CS curriculum, it would make it more relevant and increase students' motivation to pursue and persist, particularly when faced with challenging CS concepts in an after school setting. Key determinants of motivation and cognitive engagement are the value students place on the subject matter, their feelings of competence, their opportunities for autonomy or agency, and the extent to which their needs for relatedness are met (Blumenfeld et al., 2006). The incorporation of social justice is designed to increase the value of CS, and hands-on, scaffolded computer experiences and projects are designed to increase feelings of competence and opportunities for autonomy and agency. To meet relatedness needs, the classes are led by near-peers—high school students from the same community who teach, offer stories, and build connections that help 5th graders navigate competing expectations across their worlds of home, school, and peers (Cooper, Domínguez, & Rosas, 2005). While a near-peer teaching strategy has been used in educational settings for decades, there is very little research on effective implementation strategies, the benefits for the teachers and learners, and no examples of its use to engage underrepresented students in CS. The relational aspects of learning are well documented, and are part of what Pea (2004) describes as the process of "becoming" as children engage in a mutually influential interaction with the world. CSteach builds on these perspectives in that the teaching approach involves modeling and supporting experiential learning, with limited direct instruction.

CSteach is being pilot tested with Latino students, due to their underrepresentation in computing fields. While there is great variation in the group of students called "Latino/a," studies across regions and samples have led to some consistent themes. The focus of this study is on students of Mexican origin, who make up 63% of the US Latino population and accounted for three quarters of the growth in the US Latino population in the last decade (Ennis, Ríos-Vargas, & Albert, 2011). We use the term "Latino," because it is commonly used in our community.

CSteach Strategies

CSteach employs exemplary practices for engaging Latino/a students in CS (Computer Science Collaborative Project, 2012). This includes *culturally-targeted programming*, which makes connections to students' values (Sheridan, Clark, & Williams, 2013) and engages Latino/a youth by building connections to their identity and culture and addressing the needs of the community, not just the individual (Cooper et al., 2005; Solórzano, Villalpando, & Oseguera, 2005). For example, students use technology to research social justice issues, and to identify strategies to address them in their local community. Another strategy is to *challenge the image of CS* including commonly held beliefs that computer scientists are white or Asian, male, geeky, and unconcerned with the social good. To this end, CSteach builds a network of support for 5th grade students through collaboration with their peers, and instruction by high students that understand local challenges (e.g., financial, stereotypes, etc.) and role model an interest and curiosity about CS. Activities are also designed to address CS Standards (Computer Science Teachers Association, 2011). For example, activities both on and off the computer *introduce CS concepts* like algorithms and networks; these are applied in students' final project where they use a child-friendly programming environment to create an animation that informs people about their social justice topic.

The CSteach curriculum was developed by a team of computer science educators and social justice experts to ensure that CS concepts are introduced in an exciting and developmentally appropriate way that is relevant to students' experiences. CS and social justice are integrated in several ways. For example, students identify their own personal network and generate ideas about how that network can help them make positive change; then they learn about computer networks, and how information is transferred within the network in ways that are similar to their own personal network. In another activity, students learn to efficiently and safely do online research about a social justice topic, and then apply algorithmic thinking (a logical sequence of steps) to make a plan to address that problem. In a subsequent activity, they apply algorithmic thinking to create and debug a computer program. In this paper, we examine the effectiveness of these strategies by addressing the following questions:

- Does the pilot data suggest that the CSteach program can increase the computer science identities, capacities, and networks of support of Latino/a students?
- How can we maximize the impact of a near-peer approach on learning and identity development in K-12 computer science?
- How can we integrate social justice with CS principles, and does this motivate Latino/a students to pursue and persist in CS?

Methods

Participants

A pilot study in Spring 2013 included 37 5th grade students (mean age=10) and five high school students (mean age=16) in a class that met 2 hours/week for 12 weeks as part of an afterschool program at two schools. Over half of the 5th graders (68%) were female, and 86% self-identified as Latino/a. More than half (54%) of students had a mother or maternal figure who had not completed high school, and 69% of students' fathers or paternal figures had not completed high school. Most (72%) of the students reported that a language other than English was spoken in their household at least half the time. The five high school near-peer teachers were all female; three seniors, one junior and one freshman; four of them identified as Latina and one identified as African-American.

Research Design and Data Collection Methods

The evaluation of the pilot CSteach program used a mixed-method approach to gather formative feedback on how the program was working, as well as a preliminary assessment of whether the activities were influencing the development of students' computer science identities, capacities, and networks of support to study computing. Findings from surveys, focus groups, student projects, and observations will be presented.

All 5th grade students and high school student near-peer teachers (Tech Teachers) completed a *pre-post survey* that built on and adapted existing instruments to apply to the CSteach focus and population. The scales measured change in students' expectations for success in college and career, perceived support to study

computers, CS identity, beliefs about the value of computing, confidence and ability to use technology to address community needs, expectations for success in computing, and ability to evaluate web-based information. A *focus group* was conducted with the five high school Tech Teachers at the end of the semester and lasted 60 minutes. The questions focused on challenges and how they handled them, how the 5th grade students benefited from the program, how they benefited from the program, and suggestions for improving their training and preparation.

Student *projects* were scored using a rubric that was based on the Computer Science Teachers Association (CSTA) national standards, which include computational thinking, as well as awareness about the community, global and environmental impacts of technology. The projects included a set of Power Point slides and an animation created in the Scratch programming environment. The slides were scored on 4 characteristics (e.g., contains a graph; poses questions about a social justice topic). The Scratch animation projects were scored on 6 characteristics (e.g., keyboard-driven events; moving characters). The raters used a 3-point scale (0=did not meet standard, 1=partially met standard, 2=demonstrated proficiency); two raters scored the projects and discussed discrepancies in scores until agreement was reached.

Data Analysis

The surveys were analyzed by conducting basic, descriptive statistics, such as frequencies, means, and crosstabs to explore patterns in the data. Additionally, paired samples t-tests, chi-square, and one-way analysis of variance (ANOVA) were conducted to compare students' pre-post responses on survey scales and to measure differences across key demographics like gender, parental education level, and prior computer use. Simple descriptive analyses were used to summarize the results of scoring student projects. The focus groups were transcribed verbatim and analyzed using domain analysis; codes were generated deductively, based on evaluation questions and theoretical constructs from the CSteach program design, and inductively, based on important themes that emerged from analyses. Codes were organized into taxonomies and patterns were compared across interviews. Sample analytic categories identified in the analysis include: Motivation for participating in the CSteach program, Teaching strategies, Challenges faced and how they dealt with them, Beliefs about computing and the social good, Tech Teacher outcomes, and Elementary student outcomes.

Results

The results provide a picture of the implementation and impact of the first (pilot) semester of CSteach, as well as information to guide the next phase of the program. The findings are organized by Research Question

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- Does the Pilot Data Suggest that the Csteach Program Can Increase rhe Computer Science Identities, Capacities, and Networks of Support of Latino/a Students?

Although the sample size is small, we detected modest gains in most of the domains measured by the survey among the elementary students, and received positive evaluations of the impact of the program on both elementary and high school students' identities, capacities and networks of support. The results also provide information about how the program can be strengthened. Based on their surveys, the strongest gains were in 5th grade students' confidence to use a computer to address needs in their community (statistically significant change). There were also increases in self-efficacy to use and study computers, and in their CS identity, specifically the belief that computer science is a creative endeavor. In the focus groups, high school students talked about how the 5th graders changed. Clara [names were changed] stated "They're definitely more confident. They call me over sometimes and say, "teacher look at what I know how to do," and I'm like, "that's awesome." Natalia commented "I think they are more confident. At the beginning of the year, there were some girls that were very unsure of the computers, but like now, I see them helping each other. And they really know how to work the computer and all the programs."

Results from surveys, student projects, and interviews suggests that there were some areas in which CSteach engaged students in understanding and applying CS and social justice concepts. In their surveys, students reported significant increases in the frequency with which they evaluate the credibility of information, such as judging whether internet sites are trustworthy, and in the ratings of their ability to organize and manipulate information. The results of scoring student projects suggest that students developed CS capacities, including proficiency in manipulating data and evaluating information, and in the ability to gather and manipulate data using digital tools. The projects also show that most were able to integrate a social justice topic into a programming activity (83%), and social justice questions into a Power Point presentation (78%). Natalia, a Tech Teacher, commented on students' growing capacity to use technology for academic purposes, rather than just for fun: "Now they know how to make a chart off of data they collected. They know how to do a presentation, they know how to do Power Point, they know how to do a lot of things for middle school, and that will prepare them."

The data also suggest some impact on students' perceived networks of support to pursue computing. For example, the Tech Teachers described how students began to see their peers as tech savvy. Sofia, another Tech Teacher, said that students began to see one another as knowledgeable and capable in computing: "When they use Scratch, one thing that's good is that sometimes I'll admit that I don't know how to do it, and there's always someone who gets it and I'll send them to go help another student. So then they're like teaching themselves."

Similar to the 5th grade students, the Tech Teachers' largest gains were in their ability to use computers to address community needs, and in their identity as computer scientists. Several important themes emerged in interviews, including the development of leadership skills, influences on career and educational paths, and career preparation and personal growth. Alisa said "The CSteach program benefited me by outfitting me with knowledge and skills involving computers, leadership and overall abilities to interact with others, that I didn't know I had in the first place." The Tech Teachers also developed an identity as role models to the 5th graders, which increased their confidence to be teachers and leaders, as well as their motivation to do so. Ana said: "The fact that you're older, it gives you a sense of leadership. Since they're younger, they're like, 'Oh, she's older, so I'm just gonna look at her as a role model or a leader.'"

- How do we maximize the impact of a near-peer approach on learning and identity development in K-12 computer science?

In the pilot study, the near-peer approach involved five female high school students that had participated in other technology-based after school programs; they were divided across the two pilot school sites to balance their experience and teaching confidence. Observations and focus group interviews were used to evaluate the effectiveness of the near-peer approach and identify ways to strengthen it. For example, we tested a model where the Tech Teachers led 30% of the activities at the beginning of the semester, and then slowly transitioned to leading 70% by the end of the semester. Although this helped to ease the Tech Teachers into their role, it also set up an expectation by both the 5th grade and high school students that the adult teacher was the primary authority, and reduced the message that the near-peers were tech savvy role models. We now have the Tech Teachers leading most of the class activities starting at the beginning of the semester; the adult teacher introduces each activity to set the tone and expectations, and the Tech Teachers take the 5th graders through each step and provide support. This helps to clarify their role vis-à-vis the adult teacher.

In addition to increasing the leadership of the high school students, the pilot study suggested other ways to strengthen the near-peer component are to create a targeted recruitment strategy and provide more training. For example, some of the high school students were motivated to participate because they liked computers and wanted to get younger children excited about them, but several did it just for the money. The ideal near-peers would have a stronger orientation to computers, and be excited about sharing their passion. The high school students also needed additional training (e.g., in Scratch) to have the confidence to help the younger children. As Sofia said, "They're more tech-savvy. They were introduced to these things sooner than we were." Others gained a greater appreciation for what it means to teach: "After this, I feel totally sympathetic to all my teachers. This stuff is hard!" The data were used to inform what was covered in the next round of high school student recruitment and training, the adult teacher training, and in the curriculum.

- How can we integrate social justice with CS principles, and does this motivate Latino/a students to pursue and persist in CS?

CSteach aims to increase the relevance of CS by integrating it with social justice issues in two ways. First, we aim to motivate students to deeply engage in CS concepts and use them to create a project on a topic that is meaningful to them and their community. Topics so far have included bullying, drugs and alcohol, animal cruelty, poverty, among other issues. The Tech Teachers thought that the social justice aspect really was motivating for the children. Adriana said: "I know a lot of people feel really passionate about their thing…about their social justice thing." But they also thought it would be more motivating if the students presented their projects to others: "I think that would be pretty cool if their parents could come, and they could tell them, 'Hey, this is what I think is wrong in our community, and this is what I think we should do.'" The analysis of their projects also suggested that the topic was motivating: over half used event-driven dialogue (one of the more complex features) to either raise awareness or propose ways to address their social justice topic.

The second way that CS was integrated with social justice was to use information technology to showcasing the issue and the steps to address it, including the strengths of their community. Most students could apply algorithmic thinking to both address the social justice issue and to create a programming project about that topic. However, the Tech Teachers suggested adding more reflection about what they were learning, as well as more explanation about why they were learning it: "Show them stuff that they can do with this knowledge, that's what I wanna do. Like you can do this or you can build this, but you need to learn the basics first." To this

end, we rewrote the curriculum to clearly describe all the CS principals that were addressed in each activity, as well as how to reinforce them in a language that the 5th grade students could understand. This meant letting go of some CS topics, like vector graphics, because they were more difficult to explain by linking to a social justice principle.

Conclusion

The results suggest that the CSteach program has the potential to support Latino/a youth on the path to becoming computer scientists. The pilot study suggests that combining near-peer teaching and computing for the social good was motivating, and has the potential to increase students' CS identities, capacities, and networks of support; a necessary step toward deep learning. However, additional work needs to be done to increase students' engagement with CS (e.g., include fewer CS concepts and address them with greater depth), strengthen the social justice component (e.g., scaffold final projects to more strongly reflect how technology can be used to address community needs), and maximize the impact of the near-peers (e.g., more targeted recruitment and training). These results are being used to inform the next stages of implementation, and the curriculum continues to be revised based on input from the near-peers, the adult teachers, and the partnering afterschool program. In the 2013-14 school year, CSteach is being implemented in 8 schools with 160 elementary and 17 high school students.

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