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COMPUTING GOALS, VALUES, AND EXPECTATIONS: RESULTS FROM AN AFTER-SCHOOL PROGRAM FOR GIRLS

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A growing number of programs aim to increase girls' interest in computing courses and careers, but there is little research on their effectiveness. In this study, we describe how girls in an after-school and summer program changed over time. Activities were based on the expectancy-value model of motivation and included computer game programming and career and college exploration via virtual mentors and field trips. Data from 59 (mostly Latina) students who participated for over 50 h show an increase in computing career goals, expectations for success with computing, the value they placed on computing and computing-related jobs, as well as perceived parent support. There was no change in their depth of interest in problem solving, endorsement of gender stereotypes, or perceived support from school-based peers and teachers. Different data sources yielded different findings about girls' stereotypical beliefs about computer jobs. Implications for designing interventions at the middle school level are discussed.

KEY WORDS: *girls, after-school, programs, Latinas, computing*

1. INTRODUCTION

Girls and women continue to be underrepresented in computing courses and careers. In 2009, only 18% of students that took the AP computer science exam were female (DuBow, 2011), and in 2007 women earned only 18% of all computer science bachelor's degrees in the United States (National Science Foundation, 2008). The numbers for Latinas are even lower; although they enrolled in college at higher rates than their male counterparts, they earned less than 2% of computer science or engineering bachelor's degrees and 0.2% of all computer science doctoral degrees (National Science Foundation, 2008). There are also few women in the computing workforce. In 2009, only 20% of computer programmers were female (DuBow, 2011). Latina women made up 5% of the entry level positions in Silicon Valley high tech companies and 0% of the higher levels (Simard, 2009). Clearly, there is a need for interventions to increase the representation of girls, and particularly Latinas in computing.

1.1 Factors that Influence Girls' Computing Goals

Middle school is a key time to intervene in girls' pathways to computing careers. Developmental

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research suggests that experiences in middle and high school shape students' attitudes, expectations, and values, which influence their future information technology aspirations (Zarrett et al., 2006). In fact, a recent survey found that high school is too late—only 32% of college-bound girls described computer science as a good or very good college major, compared to 74% of boys (Association for Computing Machinery, 2009). To be effective, interventions must address a host of psychological and relational factors that are relevant to this developmental period.

The expectancy-value model has been used to identify several psychological factors that influence girls' decisions to pursue computing. The model suggests that girls are more likely to pursue non-traditional educational and career pathways in the United States when they value and enjoy the subject and have high expectancies for success in that domain (Eccles et al., 1999; Goode et al., 2006). In particular, their expectation of information technology (IT) success and the value they place on IT are directly related to their IT aspirations (Zarrett et al., 2006). On the other hand, low confidence and negative attitudes toward technology and IT workers limit girls' interest in computer courses and careers (Creamer et al., 2004; Zarrett, et al., 2006).

Supportive relationships are consistently found to have a strong influence on students' values and expectations for success in computing fields (Zarrett et al., 2006). Studies of high school students have shown that family members, peers, and teachers play a powerful role, and can be supportive; however, they can also undermine girls' interest in computing by sending negative messages (Meszaros et al., 2007). For example, parents who held traditional attitudes about gender roles and careers when their daughters were in middle school had adult daughters that were less likely to pursue non-traditional careers like computing (Chinn et al., 2008). Peer groups also play a key role, and a study of urban youth found that one reason girls were less likely to pursue computing courses in high school was that they were less likely than boys to have a supportive, IT-oriented peer network (Goode et al., 2006). Finally, teacher perceptions affect student performance in the domains of math, science, and engineering (Bouchey and Harter, 2005; Colbeck et al., 2001), and many teachers have low expectations for underrepresented students' success in computing (Margolis et al., 2008). These findings show that the inclusion of key people, such as teachers, peers, and families, is an important ingredient in strategies to encourage girls to pursue computing.

1.2 Latina Girls

The expectancy-value model may be a particularly useful framework for understanding Latinas girls' underrepresentation in computing. Among Latino college students, valuing school was related to academic achievement (Perez et al., 2009). However, valuing is not enough; while the vast majority of Latinos placed a high value on a college education, only slightly more than half of Latino high school students planned to obtain a bachelor's degree or more (Lopez, 2009). Similarly, although college-bound Latinos expressed a stronger interest in majoring in computer science than African Americans or Whites (Association of Computing Machinery, 2009), they were much less likely to complete the degree (Anderson and Kim, 2006). There is some research that suggests the gap between goals and achievement may be related to expectations for success. For example, Gándara and Contreras (2009) reviewed several studies of Latino students, including their own, and found that student self-perceptions of ability played a critical role in shaping their academic performance. This is particularly true in science, technology, engineering, and mathematics fields, where low self-efficacy (among women) and lack of pre-college preparation resulted in attrition from those majors (Marra et al., 2009; Seymour and Hewitt, 1997). To date, only one other published article (from the same study) applies the expectancy-value model in a sample of mostly Latina girls (Denner, 2011).

1.3 Promising Practices

One promising strategy to bridge this gap between aspirations and achievement might be to increase students' opportunities to experience success with computing. However, several pre-college factors appear to limit girls' expectations for success in computing. These include few role models, the absence of challenging curriculum, and guidance counselors with little information about IT careers (Margolis et al., 2008; Rivera and Gallimore, 2006; Tornatsky et al., 2006). Poverty and low parent education also limit students' access to computers and the Internet at home (Mossberger et al., 2006), resulting in fewer opportunities to build skills and experience success. Some communities lack mentors or role models to spark or support a student's interest in or access to advanced computing activities. Therefore, increasing advanced computing opportunities prior to college may raise students' expectations for success with computing.

As indicated, existing research suggests that interventions should aim to increase how much students value computing and offer opportunities for girls to experience success with increasingly challenging computing activities. Data collected from adults have been used to identify promising practices for engaging and increasing girls' and underrepresented minorities' expectations for success in IT (Colbeck et al., 2001; Liston et al., 2007). These practices include offering hands-on activities, creating opportunities to work in small groups, and allowing time for exploration. Practices that were likely to impact values include linking activities to real world issues, exposing girls to a variety of IT careers, and utilizing staff that are comfortable and positive with girls. In addition, Barker et al. (2006) suggested that girls be encouraged to bring a friend to computing class in order to counter the dominance of boys in these classes. Because the Latinas in that study were less likely than White or African American girls to use computers at home, Barker et al. (2006) suggested introducing them to computing using informal learning methods where the girls can "tinker with and explore the computer on their own." Finally, programs must be responsive to the needs and interests of key stakeholders, such as family members and teachers (Hobbs and Sawer, 2009; Rivera and Gallimore, 2006).

The program that is the focus of the current study is the first one to not only employ all of these recommended approaches with a group of primarily Latina girls, but to also conduct research and report the results. The Girl Game Company (GGC) program was designed to apply many of the effective practices found in this prior research. A detailed description of the program can be found in Denner et al. (2009). An evaluation was conducted to examine whether girls with long-term participation in an after-school and summer program based on the practices described above experienced a significant change in their values and expectations for success in computing. The details of the research-based program are described below.

This is the first known study to apply the expectancy-value framework to understand how interventions can increase the participation of Latina girls in computing. Data were collected to assess change in key psychological and relational factors that previous research has identified as important for increasing girls' participation in computing. We use the broader construct of interest in computing careers as a proxy for the extent to which girls value computing. Specifically, we examined how participants changed over time in several key areas; i.e., interest in computing careers, expectations for success in computing, understanding of computing jobs, and perceived support to pursue computing.

2. METHODS

2.1 Participants

The setting for this study is a small town surrounded by agricultural fields, which provide work for a large proportion of the residents. In 2007, the town's per capita income was $16,888 (half of the United States per capita income), and 75% of the population was Latino (primarily Mexican migrants and immigrants). In the three middle schools in this study, there were high numbers of English language learners (44, 46, and 34%), the majority of families were low income (79, 82, and 78%), and few parents had graduated from college (22, 18, and 31%).

Students were voluntary participants in an after-school and summer program designed to increase girls' interest and capacity to pursue courses and careers in computing. The classes met for 16 months: 2 days/week for 1.5 h after school, and during the summer every day for 5 h/day (for 3–4 weeks). There were 204 applications to the program across two cohorts, and 72% said they had a computer at home they could use. Out of 100 applications (this question was only asked for cohort 2), 58% had a computer that was connected to the Internet. Teachers were chosen for their familiarity with the population, and none had studied computing.

Participation ranged from 2 to 272 h. A total of 165 students enrolled in the program, and 79 completed 50 h or more. Because the program activities extended for more than a year, only 63 students were still actively involved at the time of the post-test, and four had completed much less than 50 h. This study focuses on the 59 students who both participated for 50 or more hours, and for whom pre- and post-test data were collected. Based on their pre-test questionnaires, 75% were Hispanic/Latina, 18% were White, and the rest were Asian or African American. Age ranged from 10 to 12 years, and the average age was 10.6 years. At home, 24% spoke only English, 14% spoke mostly English, and 56% spoke half English/half another language. There were some differences between the 59 students that are the focus of the current analysis, and those that participated for fewer hours. The 59 students were younger ($p < 0.001$), had significantly stronger English language skills ($p < 0.05$), and reported holding less traditional gender role stereotypes ($p < 0.05$) at pre-test than the students who completed less than 50 h.

2.2 Intervention

The GGC used a three-pronged instructional approach to make computing careers more appealing. This included leveraging existing interests in computing, building cultural connections, and challenging negative stereotypes about computing jobs via virtual mentors and career exploration (Denner et al., 2009). The GGC leveraged girls' interests in computing by teaching them to program original computer games. This approach was designed to engage girls who came with a range of interests, from graphics to programming, while also teaching some fundamental computing concepts and skills. In addition, the GGC built cultural connections by being responsive to students with a range of English language proficiency, fostering parent involvement, and offering access to virtual mentors, which included students and professionals in computing fields. There were also career and college exploration activities designed to challenge negative stereotypes about computing. These included field trips to technology companies and higher education institutions. Approximately 70% of the time was spent doing hands-on activities on the computer, 15% on field trips, and 15% on other non-computer-based activities (e.g., worksheets, planning events).

The GGC was also designed to increase girls' belief that they could be successful at computing activities. Success was promoted via hands-on learning, adult scaffolding of independent problem solving, and collaborative peer learning. The majority of hands-on learning and problem solving occurred in the context of computer game programming: students used Creator by Stagecast, Inc., a child-friendly, visual programming language that uses picture-based rules. Although the Creator interface is simple to use, it incorporates some key programming concepts, such as conditional execution, a form of subroutines using graphical read/write rules, iteration, and variables. Pair programming (where two students share a computer) was a fundamental part of the program, and has been found to increase retention and performance at the college level (Werner et al., 2004). Students also interacted with peers in an online community, where they got recognition for their games and their identity as a game programmer.

2.3 Data Collection

2.3.1 Interest in Computing Careers

This construct included students' career goals and the extent to which they value computing. Students' career goals were assessed upon entry into the program, and again 10–14 months later (the variation was due to student absences on data collection days). To enroll in the program, students filled out an application that included the following question: "What do you want to do when you grow up?" Of the 59 students that completed 50+ h, 53 had also completed an application. The source of follow-up data varied and included a graphic where students wrote their career goals and goals after college, as well as a workbook on college and future goals and an online journal where students answered the following question: "What is your dream job?"

The extent to which students valued computing was assessed in the pre/post questionnaires, which were administered on the first and last day of the program. Attitudes toward computers and computer careers were assessed by a 10-item scale (alpha = .85) with items that included "Careers in computers and technology are exciting" and "I positively do NOT want to have a job that uses a lot of technology" (reversed). Depth of interest in problem solving was measured by a three-item scale; e.g., "When I use technology I think about how it works" (alpha = .70). These items were drawn from Cotten and Tufekci (2005), who used them with 976 students from a range of socioeconomic backgrounds. In their sample, the alpha was .84 for the attitudes scale, which had one fewer item. We used only three of the nine items in their problem-solving scale, which reduces the comparability.

2.3.2 Expectations for Success with Computing

This construct was measured using questionnaires administered on the first and last day of the program. Pre/post data were available from 59 students who completed 50+ h. Confidence with computers was measured by a 10-item scale (alpha = .75) that included "I could probably teach myself most of the things I need to know about computers" and "computers are difficult to use" (reversed). Eight of these items were drawn from Cotten and Tufekci (2005), who had a reliability of alpha = .76. Computer skills were measured with a 14-item scale (alpha = .90) about perceived ability to do things like "search the internet to find information" and "use art programs to create illustrations, slides, or pictures." Frequency and range of computer use was measured with an 11-item scale (alpha = .88); items included "Please tell us how often you used a computer in the last month to do the following activities: draw a picture, design a webpage, or write a journal or blog."

2.3.3 Understanding of Computing Jobs

This construct was measured using several sources; i.e., a questionnaire, drawings, and a written activity. The beliefs about computer jobs scale included five items, such as "People who have 'computer jobs' just sit in front of a computer all day" and "Working with computers means working on your own, without contact with others." Because the scale had low reliability (alpha = .41), items were assessed individually. In their sample, Cotten and Tufekci (2005) had slightly higher reliability (alpha = .54).

Students' beliefs about computer science and the people who work in computing were assessed with an in-class activity where they were asked to "Draw a Computer Scientist," and to write a response to the question "What is Computer Science?" These data were collected from all students at the end of the program, and 30 of these students also did the activity one year prior, in order to assess change in their drawings. The teacher instructed the girls to draw an image of what they believed was a computer scientist, and told them that they could make any type of drawing they wanted. The students were told that they could draw a person alone, or a person doing something, and they could decide whether or not to include a lot of detail. No explanation or examples were given.

2.3.4 Perceived Support to Pursue Computing

Students' perceived support from parents to attend college and pursue science and/or computing careers was measured using an eight-point scale with items such as "They expect me to go to college," and "They would be disappointed if I got a job working with computers or technology" (alpha = .87). In addition, students' perceived support from school-based peers and teachers was measured with eight items, which included "My teachers at school encourage me to learn about computers and technology" (alpha = .78).

2.4 Data Analysis

The questionnaire data were analyzed using *SPSS* to identify alphas, means, and standard deviations, and to run paired sample t-tests to compare pre- and post-test responses. The multiple sources of qualitative data were coded using a multistep procedure, following existing guidelines (Auerbach and Silverstein, 2003; Miles and Huberman, 1994). First, research questions and expected themes were identified, and two researchers separately read through the data to identify categories or themes. In subsequent readings, the researchers sorted the data into key themes and categories and entered these codes into an Excel spreadsheet. Each code was reviewed by both researchers until 100% agreement was achieved.

Career goals were coded as computing related or not computing related. Some of the goals, such as crime scene investigator, could potentially be computing related; however, they were not counted as such unless computers were explicitly mentioned. Because we had several sources of data on career goals from most students, they were coded as having a computing-related goal if they described one goal, regardless of whether or not they had other career goals.

The drawings of a computer scientist were coded using the scheme described in Chambers (1983) to identify stereotypical images (e.g., eyeglasses) and alternative images (e.g., female). The drawing in Fig. 1 illustrates how coding occurred. Five attributes were present in this drawing (lab coat, eyeglasses, computer, female, and positive expression) and coded as strong indication. Five attributes were coded as no indication because they were not present in the drawing (facial hair, symbols of science research, symbols of knowledge, eccentric appearance, and male). The presence of braces and glasses in the drawing resulted in a coding of some indication for geeky or nerdy appearance.

The qualitative data from the “What is Computer Science?” activity were coded inductively, using 10% of the written responses to define key categories, which enabled us to conduct structured coding of the remaining 90%. As outliers emerged during subsequent coding, we created new categories and themes.

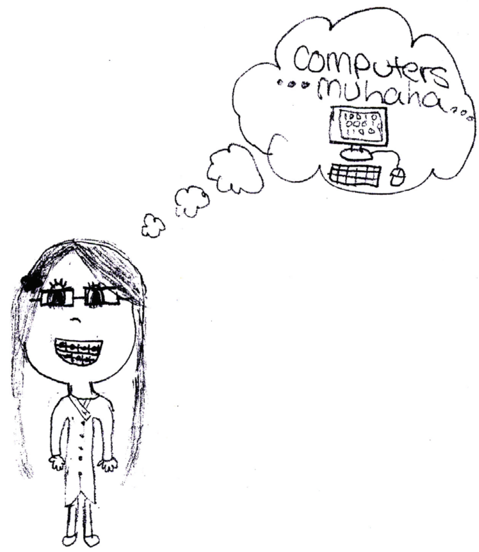

FIG 1: Sample drawing of a computer scientist

3. RESULTS

3.1 Interest in Computing Careers

Analyses of the data on career goals and attitudes showed increases in students’ interest in computing. Based on self-report of career goals, more girls were interested in computing-related jobs at the end of the program than they were in the beginning. When they filled out their applications, six (11%) stated a computing-related goal (four game designers, one computer engineer, one animator). At the end of the program, 17 (29%) stated a computing-related career goal; nine wrote game designer, and the rest wrote something non-specific such as work with computers or work at Google. Of those six who stated a computing-related goal on their pre-program application, five maintained that goal, while one changed to detective or lifeguard at the end of the program. Many students described multiple goals, and many had other goals in addition to a computing-related one. The most popular other career goals at program end were doctor/nurse (19%), lawyer (13%), veterinarian (11%), detective (9%), and fashion designer (7%).

The questionnaire was used to measure changes in students’ values, or the extent to which they think positively about computer science and the people who work in it, as well as their interest in problem solving. Between baseline and program end, the increase in students' positive attitudes toward computers and computing careers approached significance [$t(58) = 2.01$, $p = 0.05$]. There was not a significant change in depth of interest in problem solving.

3.2 Expectations for Success with Computing

Analyses of the questionnaire data showed a significant increase in several aspects of expectations for success in computing. There were significant increases in self-reported computing skills [$t(58) = 7.97$, $p < 0.001$], confidence with computers [$t(58) = 3.03$, $p < 0.01$], and self-report of frequency and range of computer use [$t(58) = 6.63$, $p < 0.001$].

3.3 Understanding of Computing Jobs

This construct was measured using two sources of data to determine whether students' understanding changed over time, and they revealed conflicting findings. In the questionnaire, completed between 10 and 16 months apart, there were significant increases in students' endorsement of the stereotypes that "People who work with computers make really good money" [$t(58) = 3.09$, $p < 0.001$] and that "You have to be brainy to work with computers" [$t(58) = 2.21$, $p < 0.05$]. However, in students' drawings of a computer scientist done one year apart, there was a decline in the number that drew stereotypical images of computer scientists. As shown in Table 1, at the end of the program students were less likely to draw a lab coat, eyeglasses, facial hair, or symbols of science research (e.g., test tubes), and more likely to give the person a positive expression. The biggest change was in the decline in the number of drawings that included a geeky or nerdy appearance. In addition, there were fewer images that were either explicitly male or explicitly female, suggesting a shift to more gender neutral images of computer scientists; the images were no more likely to look like female computer scientists. Overall, the questionnaire data showed an increase in some stereotypical views, while the drawings suggest that stereotypical images of computer scientists decreased.

TABLE 1: Image of computer scientists

Image	Time 1 July 2008 ($n = 30$)	Time 2 July 2009 ($n = 29$)
Stereotypical image		
Lab coat	30%	24%
Eyeglasses	63%	44%
Facial hair	20%	14%
Symbols of science research	20%	7%
Symbols of knowledge	3%	3%
Geeky or nerdy appearance	50%	17%
Eccentric appearance	20%	21%
Computer(s)	53%	90%
Male	40%	34%
Alternative image		
Female	57%	48%
Positive expression	46%	58%

Table 2 is a summary of responses to the question about what is computer science for the students that completed it as a class activity one year apart. Most described a scientist rather than science, perhaps because they answered this question after drawing the picture. Two illustrative examples are "A computer scientist is a person who does science and that uses computers to do it," and "I think computer science is where people work in computers to study science." Most students indicated that computer science has something to do with computers, but the lack of specificity suggests they were not clear what that is. Another common response was that computer science had something to do with creating things, whether it was creating something on the computer or designing an actual computer. At the end of the program, there was an increase in responses that computer science is studying science using a computer, and a decrease in responses such as programming, or creating things on the computer.

TABLE 2: Responses to: What is computer science?

Response	Time 1 July 2008 (n = 30)	Time 2 July 2009 (n = 29)
Describes a computer scientist rather than computer science	57%	55%
Studying science using a computer	23%	52%
Works on or uses computers	20%	28%
Someone who knows a lot about computers; studies computers	33%	28%
Creating things on the computer	17%	3%
Creates or designs computers	20%	0%
Improves technology/computers	10%	7%
Programming	20%	0%
Helps people to better (more easily) use computers	10%	0%
Fun; interesting	10%	3%

3.4 Perceived Support

Perceived support from parents and from school-based peers and teachers was assessed using the pre- and post-test questionnaires. There was a significant increase in perceived support from parents to attend college and pursue science and/or computing careers [$t(58) = 2.10$, $p < 0.05$], but there was no change in perceived support from peers or teachers.

In summary, these data show that participants in an all-female, after school program report a significant increase in their interest in computing careers, expectations for success, and perceived support from certain people to pursue computing. At program end, students reported more positive attitudes toward computers and computer jobs, higher expectations for success in computing, and were more likely to state a computing-related career goal. There were mixed results in the extent to which they understood computing workers and careers. They were less likely to depict negative stereotypes in their drawings of computer scientists, but more likely to endorse narrow stereotypes about people who work with computers in their responses on a questionnaire. The results are reported for the entire group, but the analyses were run separately for the 44 Latina girls, and the direction of the results remained the same, although the smaller sample size reduced the significance level of the change in confidence and made the change in attitudes not significant.

4. DISCUSSION AND CONCLUSIONS

During a developmental period when most girls' values of and expectations for success in technical fields are declining, participation in computing-intensive out-of-school programs has the potential to reverse this trend. Significant increases in participants' computing-related career goals, expectations for success, valuing of computing, and perceived support from parents were promising, and suggest the need for more focused and rigorous studies of program impact. The finding that negative stereotypes about computer science decreased was also promising, but the lack of knowledge about computer science suggests the need to strengthen this aspect of the program. Below we discuss the implications of these findings for developing after school programs for girls, with a special focus on Latina girls, who made up the majority of our sample.

4.1 Interest in Computing Careers

Interest was relatively high at the end of the program. Over one-third of the girls stated a computing-related career goal, a number that was three times higher than at the beginning of the program, and higher than the 2% of middle and high school girls in another study that chose a computer-oriented career goal (Junior Achievement, 2010) or the 26% of college-bound girls in a third study that said computer science would make a good or very good career choice (Association for Computing Machinery, 2009). Clearly, the girls in our sample represent a subset of the population—one that was interested enough in computing to voluntarily enroll in the program. However, at enrollment only 11% of those who completed the program stated a computing-related career goal, compared to more than 33% at the end of the program. Desire to pursue a computing career was clearly not the primary motivation to participate, a finding that is supported by other program data that suggests some girls were driven by an interest in working on the computer, while others were more focused on the social opportunities (Denner and Martinez, 2010). However, prior research on the gap between goals and achievement among Latinos suggests the importance of not only increasing those goals, but also providing systems of institutional and individual support to help students sustain and achieve those goals.

The students' other career goals were similar to those found in a national sample of Latino/a college freshman. In that study, the most popular goals for males and females included an attorney/judge, doctor, nurse, teacher/administrator, business executive, or an engineer (Hurtado at al., 2008). All of these goals require advanced training and degrees, suggesting that despite the low socioeconomic status of most families in their community, the girls in this study have high educational aspirations. Longitudinal data are needed to provide a true indication of whether and why this group of students will actually pursue college and computing-related careers in high numbers.

There were mixed findings about change in students' interest in using computers in the future, and in the kinds of problem solving that are a fundamental part of many computing careers. Positive attitudes toward computers and computing careers increased, suggesting a shift in how they thought about computing. However, there was no change in students' interest in deep problem solving, which may be due to the relatively low number of items and reliability or to the real challenge of promoting independent and in-depth problem solving in an after school setting.

4.2 Expectations for Success with Computing

Participants had high expectations for success with computing, and this increased over the duration of the program; girls reported higher levels of perceived computer skills, confidence, and usage at program end. At pre-test, the average response to questions about their computer skills was that they could do things okay, and at the end the average response was that they could do them well. There were similar increases in confidence. When they entered the program the average response was that they were uncertain about what they could do on the computer, and at the end the average response was to agree that they were capable of things such as making the computer do what they want it to. Also, the girls' frequency of computer use shifted from almost never to almost two times a month, on average.

4.3 Understanding of Computing Jobs

The findings contribute to an understanding of how girls are thinking about computing, and about computer science in particular. Overall, they had positive attitudes toward using computers in their future, but many still held traditional stereotypes about who actually has a computing career. For example, their drawings suggested that many do think of computer scientists as geeky or brainy, as shown in the frequent inclusion of eyeglasses, or a geeky or eccentric appearance in their drawings. This finding supports the Eccles (2005) description of the role of the cultural milieu, which includes socially shared gender and cultural stereotypes, in shaping children's achievement-related experiences and their perceptions of gender roles and activities. It is also similar to the results of a study of college-bound freshman that found girls were more likely than boys to describe computer science with the words boring, hard, or nerd (Association for Computing Machinery, 2009). However, in the current study, these negative stereotypes of computer scientists were less common in the drawings at the end of the year. In contrast, students reported more stereotypical perceptions of people who work with computers on their questionnaires. The significant increases in the belief that being brainy and making a lot of money reflects narrow stereotypes may not necessarily be negative to girls.

At program end, girls were no more likely to think of a woman in the role of a computer scientist, due in part to the fact that two-thirds originally drew a female. These female images were more common than what was found in other studies. In other samples of female middle school students that drew a picture of a scientist, 26% drew a female scientist (Nuño, 1998) and 50% drew a female scientist (Steinke et al., 2007). Similarly, Mercier et al. (2006) found that only 33% of sixth grade girls and 10% of eighth grade girls drew female images of computer users. The depiction of females is not surprising, given that these were girls who chose to enroll in an all-female computing program. Similar to our findings, Mercier et al. (2006) also found more gender-ambiguous images among their older girls.

Computer scientists study the foundations of computing and information. A small percentage of the students understood that, as shown in their responses that included using computers, studying computers, and creating computers. Unlike prior studies of undergraduates (Martin, 2004), few said that computer science equals programming. Overall, although certain stereotypes decreased, students did not convey an increased understanding of what computer science is at the end of the program. This was probably a result of the teachers' limited knowledge of the field or their lack of attention to computer science specifically. They focused instead on a broader presentation of jobs in computing, and on helping students program their computer games, rather than helping students link both the programming and design aspects of their work to what professionals, such as computer scientists, do. Teachers felt that it was more important to introduce girls to the creative and social aspects of computing, which prior research suggests will attract greater numbers of girls. In addition, the virtual mentor activities were limited in the extent to which they could increase girls' understanding of computer science due to the limited number of interactions and structured activities, as well as the fact that many were students or worked in IT companies but were not necessarily computer scientists.

4.4 Perceived Support to Pursue Computing

Retrospective studies have shown the importance of support from parents, teachers, and peers in student decisions to pursue and persist in computing-intensive courses. In this study, the increasing levels of perceived support from parents to pursue a computing career and go to college were encouraging. Although parent involvement in the day-to-day functioning of the program was limited, it is likely that parent buy-in played a critical role in keeping students involved over more than 50 h. Additional research on the role of parents in girls' participation in computing-intensive programs is needed. There is also a need for additional research on how to engage school-based peers and teachers in supporting girls to pursue computing-related classes. The lack of change in perceived support from people at their school is not surprising, given that comprehensive and long-term efforts are required to change the institutional culture of a school. Although this is an important part of increasing the number of girls in computing, it requires a separate and intensive effort that was beyond the scope of the current program.

4.5 Conclusion

This study begins to fill several gaps in the knowledge base of how to increase the participation of girls in computing. First, little has been reported about girls' career goals, and how they think about computing jobs during middle school. At the end of the program participants reported greater interest in computing jobs and fewer negative stereotypes; however, the majority were not interested in computing jobs even after participating for more than 50 h. Second, despite the growing number of programs and interventions designed to engage girls in computing, these efforts are rarely studied. Although there are limitations to the current research design, the findings show some promising shifts in girls' interest in computing, expectations for success in computing, understanding of computer jobs, and in their perceived support from parents to pursue computing.

Studies often conclude that a key barrier to girls' participation is their low interest and low expectations for success in computing careers, and that programs should try to engage girls in the creative and social aspects of computing, such as web design and web development (Bleeker, 2006). Future programs should do this, but not at the expense of also teaching about fundamental aspects of computer science, which has attracted large numbers of women in countries outside the United States. To this end, Eccles (2007) emphasized the importance of teaching girls what computing jobs are really about in order to challenge negative stereotypes and help them get adequate preparation.

There are several limitations to the study findings. The sample was self-selected, and not necessarily representative of all girls, or all Latina girls; thus, the findings may only be applicable to girls who choose to participate in a long-term computing-focused program. In addition, there was some variation in the timing and nature of data collection. For example, due to the length of the program and inconsistent attendance, post-test career goals were collected at slightly different points in time, and the question was worded slightly differently. It may be that the increase in computing careers is due, in part, to phrasing the question in terms of their dream job. Another limitation of this study is that. although we looked at change in the drawings of computer scientists and perceptions of computer science, only eight students completed this activity at two time points; the rest had missing data at one time point. Thus, conclusions about change over time were based on data from overlapping, but different, groups of girls in the program. Although promising, the research design does not allow us to conclude that the changes were due to participation in the program. In fact, a separate analysis showed that the number of hours a student participated was unrelated to how students' scores changed (Ringstaff, 2010). An independent evaluation of a subgroup of program students and a comparison group is underway, and will yield more information about whether the participants would have changed without the program. In order to improve the design and implementation of interventions to increase middle school girls' interest in computing—particularly those that focus on Latina girls—future studies should aim to identify which of the many program components were responsible for the significant change.

Despite these limitations, the findings begin to fill the gap in our understanding of how girls who participate in long-term, computing-intensive programs may change over time. Further research is needed to more directly improve existing and future interventions. New studies should include a comparison group, and carefully vary the components of the intervention in order to determine what kinds and intensity of activities are needed in order to impact different outcomes.

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