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What Predicts Middle School Girls' Interest in Computing?

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ABSTRACT
Despite strong claims that middle school is a critical period for getting girls interested in computing, there is little research to guide the development of interventions. Many programs that target girls build on Eccles' expectancy-value model, which focuses on expectations for success, values, and support from others. However, there is little research to justify the use of this model to guide efforts to increase interest in computing during middle school. To test the model, I analyzed data from 140 Latina and white girls in a California middle school collected on the first day of an IT-intensive after school program. The strongest direct predictor of girls' interest in computing classes and careers was the extent to which they see value in computing, in particular their technological curiosity. Perceived support from school peers and teachers also had a direct effect, while perceived support from parents had an indirect effect via values. Expectations for success did not explain interest in computing. Implications for interventions are discussed.

KEYWORDS
Girls; computing; careers.

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INTRODUCTION

In 2007, only 0.3% of female college freshmen chose computer science as a probable major (UCLA Higher Education Research Institute, 2008) and women earned only 18.6% of all computer science bachelor's degrees in the US (National Science Foundation, 2008). In 2008, only 25% of the US computer and mathematical operations workforce were female (Bureau of Labor Statistics, 2009). Latinas[1] in particular are vastly underrepresented in computing—in 2005 they earned less than 2% of computer science or engineering bachelor's degrees and 0.2% of all computer science doctoral degrees in the US (National Science Foundation, 2008). In the workforce, Latina women made up 5% of the entry level positions in Silicon Valley high tech companies, and none of the higher level positions (Simard, 2009). There is a clear need for research that includes Latinas in order to understand why women's participation in computing remains so low in the US, and to strengthen existing interventions.

Middle school is a key time to intervene because gender differences in computing goals appear to be well established by high school. Developmental research suggests that between the ages of 11-13, students are making choices about what subjects they like and are good at, and that these choices influence their future options (Fouad, 1995). Most studies find that boys report higher levels of confidence and greater interest in most computing fields than girls (Bleeker, 2006). A recent US survey by the Association for Computing Machinery (2009) found that only 32% of college-bound girls described computer science as a 'good' or 'very good' college major, compared to 74% of boys. Latina girls report a particularly low interest in computing majors or careers. Only 16% said that computing would be a 'very good' major for them or someone like them, compared to 52% of Latino boys (Association for Computing Machinery, 2009). In a different study, middle school girls attending a science-technology-engineering-mathematics event in the US also reported low interest in computing. Only 7% of the Latinas stated an interest in a science, engineering or math career, compared with 15% of the white and 9% of the African American students (Barker et al., 2006). These attitudes and interests during middle school set the stage for career pathways. However, there is little research on the factors that predict girls' interest in computing classes and careers during middle school.

The expectancy-value theoretical model of achievement-related choices may be useful for understanding why some girls and Latinas express interest in computing majors or careers during middle school. This model has been widely used to understand the motivational factors that play a key role in students' career goals (Eccles, 2007). The model suggests that girls in the US are more likely to pursue a non-traditional educational or career pathway when they *value* a topic and have high *expectations for success* in that domain (Eccles et al., 1999). However, there is little research on whether this model is predictive of computing career interests in middle school.

Research on high school and college women provides modest support for this model in the domain of computing. Two syntheses of research studies find that women report consistently lower levels of confidence and expectations for success with computing, both of which are believed to play a role in their decisions about whether to pursue and persist in computing courses and careers (Dryburgh, 2000; Singh et al., 2007). In a recent study, Zarrett et al. (2006) found that expectations for success predicted interest in a computing career among African American and white high school students. However, more research is needed to confirm the connection between expectations and interest in computing (Cohoon & Aspray, 2006).

Little is also known about the factors that explain variation in expectations for success in computing. In one study, access to a computer at home was related to African American girls' expectations, while experiences with gender discrimination partially explained white girls' expectations for success (Zarrett et al., 2006). It is reasonable to predict that high computer use and low levels of traditional gender role expectations would contribute to high levels of expectations for success in middle school, but there is a lack of data to support this.

Subjective task value includes the extent to which students are interested in, and see the importance and the utility of, computing for future goals, and has been found to predict future aspirations. These three aspects of subjective task value have been empirically differentiated in the domain of mathematics (Eccles and Wigfield, 1995) and found to differentially predict aspirations to a highly math-related career (Simpkins, Davis-Kean, & Eccles, 2006; Watt, 2008).

Among high school students, career aspirations in computing are predicted by what Eccles (2007) calls the 'interest value', or extent to which students enjoy and express interest in the domain (Creamer et al., 2004; Zarrett et al., 2006). Perceived relevance, or what Eccles (2007) calls 'utility value', has also been found to explain why some women pursue computing as a career (Anderson et al., 2008; Ceci et al., 2009; Dryburgh, 2000). Utility is determined by the value of computing for fulfilling other goals. While the link between subjective task value and interest in computing seems obvious, few studies confirm this connection during middle school.

Building on Eccles' model, we have identified technological curiosity to be a key aspect of the 'interest' component of subjective task value of computing. This construct refers to students' interest in going beyond *using* technology to an interest in understanding how it works, including working through the challenges of learning new technologies. Studies of adult programmers find that women express less interest than men in learning new technologies or finding out more about the technology they work with (Burnett et al. 2010) and they are less likely to use tinkering (playful exploration) as a strategy to learn new software features (Beckwith et al., 2006). The implication from these studies is that these preferences may partially explain the gender gap in computing. Although technological curiosity offers a partial explanation of why adults pursue and persist in computing, there are few studies of children. One qualitative study described girls' interest in being intrepid explorers (e.g., seeing challenges as opportunities to learn), as a key factor in increasing girls' active participation in computing (Denner & Bean, 2006). To date, no known studies have used quantitative data to explore the connection between students' technological curiosity and their interest in computing.

Retrospective studies of female computer science undergraduates suggest that subjective task value is determined, in part, by parents, teachers, and peers (Tillberg & Cohoon, 2005). Similarly, high school girls who express interest in a computing career are more likely to believe their parents support this choice (Creamer et al., 2007; Zarrett et al., 2006), and fathers in particular are the key influencers of their daughters' choice of computing careers (Adya & Kaiser, 2005). These expectations have long-term effects. Parents who hold less traditional attitudes about gender roles and careers when their daughters are in middle school have adult daughters that are more likely to pursue non-traditional careers like computing (Chhin et al., 2008). As family members, peers, and teachers play such a powerful role, they can undermine girls' interest in computing careers by sending negative messages (Meszaros et al., 2007). Expectations at the peer and adult level serve to reinforce social cliques that are based on race/ethnicity and social class, and membership often determines students' educational trajectory (Bettie, 2003). Indeed, one reason girls are less likely than boys to pursue computing courses in high school is their relative lack of a supportive, computing-oriented peer network (Goode et al., 2006). More research is needed to understand the extent to which perceived support from key people during middle school has an influence on their computing-related interests.

In summary, this study aims to fill a gap in our understanding of how to increase the interest of middle school and Latina girls in computing careers by studying the factors that prior research on older students suggests will predict girls' interest in computing classes and careers. The expectancy-value theoretical model of achievement-related choices has not been examined in the domain of computing with middle school or US Latina girls. We are extending this model to see how well it applies to middle school girls, Latinas in particular, in the area of computing interests, and examining additional predictors based on prior research. Research conducted outside the US suggests that while values influence career choice in certain North American cultures, career goals in other cultures are based more on exam scores and what others think they can or should be, rather than on what the person wants or thinks they would be good at (Trauth et al., 2008). To my knowledge, no prior studies have examined whether computing-related values or expectations explain variation in middle school Latina girls' interest in computing.

METHOD

Participants

The setting for this study is a town in central California (population 50,000) where many work in the agricultural industry. In 2007, the town's per capita income was $16,888 (half the US per capita income), 75% of the population was Latino (primarily Mexican migrants and immigrants), and almost 51% of residents had no high school diploma. Data from the three middle schools in this study indicate that the majority of families were low income (79%, 82% and 78%), there were high numbers of English language learners (44%, 46%, and 34%), and few parents had graduated from college (22%, 18%, and 31%).

The students in this study 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 data are from 140 online questionnaires completed on the first day of the program. The majority of the students were Hispanic/Latina (74%) or white (17%). The average age was 10.9 years, and ranged from 10-13 years. At home, 19% spoke only English, 11% mostly English, 63% half English/half another language, and 7% mostly or only another language (usually Spanish).

Data Collection

The questionnaire data were collected via a self-directed, online survey completed during class time. Some scales were created for this study, and others were drawn from prior research, as noted below. The dependent variable, *Interest in Computing Classes and Careers,* is a 5-item scale (alpha=.67), with items such as 'I would like to take more computer and technology classes', and 'I would like a job working with computers or technology'. Responses ranged from 'strongly agree' (5) to 'strongly disagree' (1).

Expectations for success in computing were measured using two scales. One is a 10-item *Computer Confidence* scale (alpha=.67) with items such as 'I could probably teach myself most of the things I need to know about computers' and 'Computers are difficult to use' (Cotten & Tufekci, 2005). Responses ranged from 'strongly agree' (5) to 'strongly disagree' (1). The second is a 14-item *Computer Skills* scale (alpha=.91) and assessed perceived ability for tasks like 'Search the internet to find information' and 'Use art programs to create illustrations, slides, or pictures'. Responses ranged from 'I don't know what this means' (0) to 'I can do this so well that I can teach someone how to do it' (4).

The extent to which students Value Learning or Using Computers was measured with two scales. *Relevance of Computers* is a 5-item scale (alpha=.65) that measures utility value. Items included 'Learning about computers is worthwhile', and 'I expect to have little use for computers in my daily life'. *Technological Curiosity* was a 3-item scale that measures interest value. The items were 'When I use technology I think about how it works', 'I like the challenge of learning how to use a new technology', and 'I don't want to learn any more about computers than I need to make them work' (reverse coded: alpha=.70). These scales were drawn from Cotten and Tufekci (2005), and responses ranged from 'strongly agree' (5) to 'strongly disagree' (1).

Students' Perceived Support from Parents to attend college and pursue science and/or computing careers was measured using an 8-item scale with statements 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). Responses ranged from 'strongly agree' (5) to 'strongly disagree' (1). In addition, students' *Perceived Support from School-based Peers and Teachers* was measured with eight items, including 'My teachers at school encourage me to learn about computers and technology' and 'I have friends who are interested in computers' (alpha=.79). Responses ranged from 'very true' (5) to 'not at all true' (1).

Frequency of Computer Use is an 11-item scale (alpha=.85) with items such as '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'. Responses ranged from 'never' (0) to 'nearly every day' (4). *Gender Stereotypes* were measured with a 5-item scale and included items such as 'Girls can do technology as well as boys' and 'Men make better computer scientists than women do' (reversed: alpha=.73). This scale was drawn from Cotten and Tufekci (2005), and responses ranged from 'strongly disagree' (5) to 'strongly agree' (1).

Data Analysis
Descriptive statistics were computed for each scale, including Chronbach's alpha, means, and standard deviations. Analyses of variance were run to identify any group-level differences in key constructs across age, language use at home, and race/ethnicity. For the primary analysis, we ran a stepwise multiple regression with Interest in Computing Classes and Careers as the dependent variable. Step one contained demographic variables: age, language at home, race/ethnicity, and frequency of computer use. Step two contained Perceived Support (from Parents, and from School Peers and Teachers) as well as Gender Stereotypes. Step three contained Expectations of Computing Success (Computer Skills and Confidence), as well as Computing Value (Relevance and Technological Curiosity). An alpha level of .05 was used for all statistical tests, analyses were conducted using SPSS version XVI.

RESULTS
The girls in this study reported a range of interest in computing. Scores on the dependent variable, the interest in computing classes and careers scale, ranged from 9-25 (M=19.22, SD=3.28), suggesting that, on average, most girls agreed that they were interested in taking more computing classes and pursuing a computing career. There were no significant group-level differences in the key constructs (interest in computing classes and careers, expectations for success, or subjective task value).

As shown in Table 1, in the third step of the regression there were three variables that made statistically significant independent contributions to explaining the variance in girls' interest in computing. The strongest predictor was technological curiosity – more curiosity about computers was associated with a greater likelihood of wanting to pursue computing courses or careers ($ß=.50$, $p<.001$). The effect of perceived support from peers and teachers at school was also significant -- higher levels of perceived support were associated with greater interest ($ß=.19$, $p<.05$). The extent to which students saw relevance in computing predicted higher levels of interest in future classes or jobs (ß=.19, p<.05). Expectations of success did not predict interest in future computing.

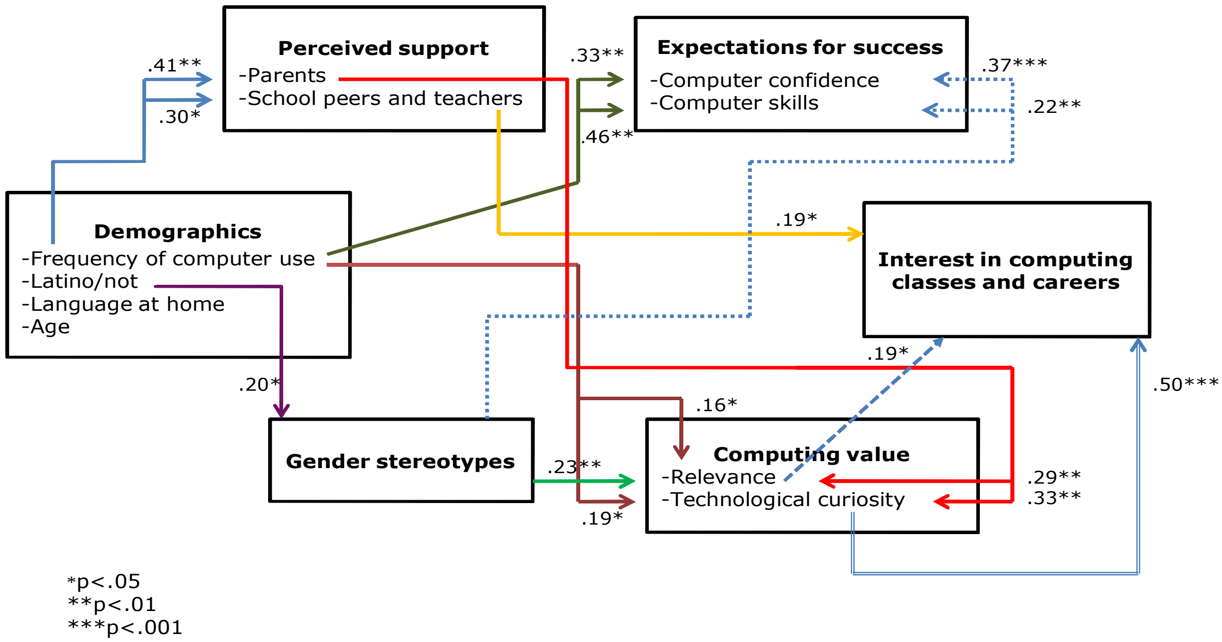
Table 1. Summary of Step 3 of the multiple regression analysis for variables predicting interest in computing classes and careers

Variable	B	SE B	ß	p	95% CI for B
Demographics					
Frequency of Computer Use	-.04	.03	-.11	.16	-.08-.02
Psychosocial Factors					
Parent Support	-.06	.05	-.12	.23	-.12-.05
Support from School	.09	.04	.19	.04	-.01-.17
Expectations for Success					
Computer Confidence	.01	.05	.03	.77	-.08-11
Computer Skills	.04	.03	.13	.14	-.01-.09
Subjective Task Value					
Relevance of Computing	.17	.08	.19	.04	.00-.32
Technological curiosity	.65	.11	.50	.00	.41-.85

Note: R^2=47. df=(8,129).

Additional analyses were run to identify mediating pathways. As shown in Figure 1, several factors predicted computing value, including parent support, gender stereotypes, and frequency of computer use. Similarly, gender stereotypes and frequency of computer use predicted both measures of girls’ expectations for success in computing. The more that a girl rejected traditional stereotypes, the higher her expectations for success, and the greater the perceived relevance of computing. Age and language spoken at home did not explain any of the variance in the model, while being Latina was related to holding more traditional gender stereotypes about girls’ participation in computing. Frequency of computer use predicted perceived support from both parents and school peers/teachers. In summary, computing value and especially technological curiosity, explained the most variance in girls’ interest in computing classes and careers. Support from peers and teachers at school also explained some of the variance in interest. Perceived support from parents, as well as gender stereotypes had indirect effects, via values and expectations.

Figure 1. Path diagram of girls' interest in computing courses and careers.



DISCUSSION

The findings have implications for understanding which factors predict Latina middle school girls' interest in pursuing computing in the future. They also provide information about the importance of key concepts like perceived support, expectations for success in computing, and subjective task value for understanding Latina girls' computing interests during middle school. Certain aspects of the expectancy-value model of achievement-related choices proved useful for understanding the girls in our study. The extent to which students report valuing computing, but not their expectations of success, predicted the students' interest in pursuing computing courses or careers. In addition, perceived support from school peers and teachers, but not from parents, directly predicted interest in computing. These findings are discussed in the context of prior research, and implications for interventions in middle school are described.

The factor that explained the greatest amount of variation in computing interest was technological curiosity, a construct that measures the value students place on computing. There are many studies of curiosity and it has long been cited as a motivational factor for learning (Lowenstein, 1994), as well as a critical component of innovation in science and technology (National Science Board, 2010). Clearly, students pursue fields that match their interests, so it is not surprising that students who want to be challenged and understand how computers work are more likely to aspire to a career in computing. What is potentially important about this type of technological curiosity however, is that it is likely to lead to the kind of experimentation and problem solving that college professors rate as the most important characteristic of a computer science education (Commission on Professionals in Science and Technology, 2005). Problem solving is driven by curiosity about how things work. Despite the obviousness of this, technological curiosity is not commonly measured in research studies or addressed in middle school interventions. Our finding suggests the importance of providing opportunities that motivate girls to dig deeper into the technologies they already use.

Like others have found among high school and college women, the middle school girls in this study were more likely to express an interest in computing if they saw value in it (Anderson et al., 2008; Goode et al., 2006). Conversely, those who viewed computing as less important for their lives also reported lower interest in computing courses and careers. This finding is also consistent with decades of research by Eccles (2007) and her colleagues on math and science that suggest it is more important to help girls see how a particular career is relevant to their interests than to raise their confidence or perceived skills. Relevance may be particularly important for Latina students, who express a desire to pursue higher education but also to give back to their families for their sacrifices (Bettie, 2003; Cooper, Domínguez, & Rosas, 2005).

The findings challenge other studies that found an association between expectations for success and computing career goals. The girls in this study were no more likely to state a computing-related career if they had high computer confidence or greater perceived skill. This finding is in contrast to research on computing (Zarrett et al., 2006) as well as outside the field of computing that suggests that confidence plays a critical role in shaping the academic performance and aspirations of Latino students (Gándara and Contreras, 2009). However, it is consistent with Dryburgh's (2000) review of research that finds the strongest motivation for both women and men to enter a computing field is interest, and that men are more motivated by self-confidence, while women are more motivated by positive experiences with computing. It may also be that values are more important than expectations during middle school. More research is needed to determine whether expectations for success become increasingly important as students enter high school and face increasing challenges as they take more difficult computing courses with fewer and fewer female students.

Unlike previous studies of high school girls, frequency of computer use did not directly predict interest in computing (Meszaros et al., 2007). Instead, frequency of use was mediated by several factors. Higher computer use predicted higher levels of perceived support from both parents and peers/teachers, as well as higher levels of computing value. Frequency of use also predicted expectations for success: not surprisingly, girls who had higher usage reported more confidence and skills. The simple conclusion is that getting girls more frequent access to computers would increase their interest in computing. However, other studies suggest that it is not just the frequency, but how girls use the computer that is important (Jones & Clark, 1995). One study of middle school students suggests that greater access and frequency of computer use is associated with greater breadth and depth of creative production activities with technology - the kinds of activities that are believed to build technological fluency (Barron et al., 2010). Future studies should include measures of both frequency and breadth to determine the unique contribution of each of these factors.

Consistent with prior research, perceived support from peers and teachers at school to pursue computing is associated with girls' interest in computing. This finding is consistent with studies of African American and Latino high school students that show the importance of building supportive peer networks for recruiting girls into computing classes (Goode et al., 2006). Clearly, increasing girls' networks of peer support is critical, and Barker et al. (2006) suggest that middle school girls be encouraged to bring a friend to computing class in order to counter the dominance of boys in these classes. The findings also highlight the importance of teachers in girls' interest in computing, a finding that is consistent with studies in high schools (Margolis et al., 2008; Zarrett et al., 2006). In particular, teachers' perceptions of students' ability has been found to affect Latino student performance in the domains of math, science, and engineering (Bouchey & Harter, 2005; Colbeck et al., 2001). As many Latino parents do not have the resources or expertise to support their children on a computing pathway, the role of teachers and other adults is particularly important (Gándara & Contreras, 2009). Teachers often play an emotional role - Valenzuela (1999) found that Latino students' concepts of *educacíon* meant that they must have a caring relationship with an adult at school in order to be engaged. Clearly, it is critical for teachers to provide emotional support as well as high expectations in order to increase students' interest in computing.

Contrary to prior studies outside the domain of computing, perceived support from parents to pursue college and computing was not directly associated with middle school students' computing interests. Instead, parent support had a mediated effect via computing value: the more support girls perceived from their parents to pursue computing, the higher the perceived relevance of computing, and the greater their technological curiosity. Qualitative data from this sample reported in another paper (Denner, 2009) show that the girls do view parents and other family members as the greatest influence on their career interests and goals. However, like others have found (Gándara & Contreras, 2009), the nature of that support appears to be emotional (based on high expectations and encouragement to pursue their dreams), rather than instrumental (providing information about how to achieve their goals). Future research would benefit from a more sensitive measure of parent support that can distinguish between these different types of support, in order to further explore the relationship with students' computing interest. Indeed, Larose et al. (2008) found that only certain kinds of parent support predict students' persistence in technology. To better understand the role of parents in Latina girls' computing interests, subsequent research should also include a measure of family socioeconomic status, such as parent education.

Gender stereotypes had an indirect influence on girls' computing interests. The more they rejected traditional stereotypes about girls' ability with computers, the higher their expectations for success, and reported perceived relevance. Latina girls were less likely than non-Latina girls to reject the stereotypes, suggesting these beliefs may be one factor that limits Latina girls' interest in computing. These beliefs may be due to the fact many girls still struggle with traditional gender role expectations at home (Gallegos-Castillo, 2006) and some Latino parents encourage gender-specific jobs (Ginorio, 2007). The findings are especially powerful because the gender stereotype scale had limited variability: most rejected the idea that boys are better than girls when using or learning to use a computer, a finding that is consistent with studies of a broader sample of high school girls (Howe et al., 2007). This suggests that educational and occupational aspirations in computing are indirectly influenced by even modest endorsement of gender stereotypes. There is clearly still a need for interventions, such as role models or media images, that challenge perceptions that men make better computer scientists than women (Goode et al., 2006).

Although the findings fill a gap in our understanding of computing interests during middle school, there are limitations to the study. In particular, the dependent variable did not distinguish between interest in what Zarrett et al (2008) call 'soft' computer jobs (e.g., internet journalism and telecommunications) and 'hard' computer jobs (e.g., programming and network administration). In addition, the findings may not be generalizable beyond populations of girls who are voluntary participants in IT-intensive after school programs. Despite the variation in their responses, overall, the girls reported a high level of interest in computing, and a rejection of traditional gender stereotypes. The study should be replicated with a broader group of female middle school students. In addition, the dependent variable had a relatively low reliability, and future studies should explore ways to improve the measurement of this construct.

Despite these limitations, there are several implications for designing interventions for middle school girls, particularly Latina girls. First, the findings suggest that middle school interventions should aim to have a positive impact on girls' values related to computing. They support the claims by Eccles (2008) who suggests that promoting confidence is not enough. Programs should also focus on increasing girls' knowledge of how computing can fit with their values and interests, which for Latinas includes increasing their perception of computing as financially secure and as a helping profession (Marlino & Wilson, 2006). Currently, few interventions focus on showing the relevance or utility of computing for meeting girls' interests or goals.

The findings also suggest that more research is needed on girls' technological curiosity, with corresponding interventions that encourage exploration. There is a large body of psychological research on the determinants of curiosity (Lowenstein,

1994) that could be applied to understanding and increasing girls' motivation to pursue computing. Experiences that allow girls to tinker and modify software to meet their own interests can engage girls and build critical computing fluencies (Denner & Bean, 2006; Hayes & King, 2009).

CONCLUSION

The findings from this study are consistent with existing 'promising practices' guides to engaging girls and underrepresented minorities in computing (Colbeck et al., 2001; Liston, Peterson, & Ragan, 2007). These practices include offering hands-on activities, creating opportunities to work in small groups, and allowing time for exploration. Program practices that are likely to impact values include linking activities to real world issues, exposing girls to a variety of computing careers, increasing teacher and peer encouragement, and utilizing staff members that are comfortable and positive with girls. Media interventions such as Dot Diva (www.dotdiva.org) are designed to change the image of computing to show the important role that young women have and need to play in computing in order to make the world a better place. Finally, although girls endorse less traditional gender stereotypes than a generation ago, these beliefs have a powerful connection to their expectations for success, as well as the extent to which they see computing as important or relevant to their interests.

ENDNOTES

[1] Latinos in the US are a heterogenous group, including people whose families originated in Mexico, Central America, South America, parts of the Caribbean, and Puerto Rico.

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