KNOW YOUR STUDENTS TO INCREASE DIVERSITY: RESULTS OF A STUDY OF COMMUNITY COLLEGE WOMEN AND MEN IN COMPUTER SCIENCE COURSES

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ABSTRACT

In this paper, we report on preliminary results of an NSF-funded study of California community college students enrolled in introductory programming courses. There are several unique contributions of our study to computer science (CS) education and social science research. First, it involves large numbers of both women and men from 15 community colleges, allowing us to examine differences in gender, race/ethnicity, and other demographic variables in students' interest and intention to persist in CS. Second, we have collected data on multiple levels of influence: individual, relational, and institutional. Third, we have collected longitudinal data that allows for measuring initial intentions, as well as how experiences in the introductory course change those intentions. We report on several factors that relate to intentions to study CS that can guide interventions to increase diversity.

INTRODUCTION

In the US, the rates of women's enrollment in computer science (CS) courses and completion of CS-related degrees have declined over the last 20 years [32]. Efforts to close the gender gap are limited by a lack of longitudinal and theory-driven research on students' pathways to CS-related degrees, and a lack of research on students who enter the CS pipeline in community colleges (CCs). CCs attract high numbers of women (57% according to the US DoE [41]), and in 2003-4, 32% of all CS-related majors at 2-year public institutions across the US were women, compared to 19% at 4-year public institutions [31]. Recent work reporting on gender differences in associate degrees in STEM fields in the US unfortunately does not include the CS category. Even so, in other non-CS STEM fields, modest gains by women in achieving associate degrees are more than offset by large drops in those achieved by men [22]. One important study [40] reports that both Hispanic or older CS and engineering graduates are more likely than other racial/ethnic groups or younger graduates to have attended a CC. In recent years, partnerships between 2- and 4-year institutions have focused on reducing the structural barriers to transfer, including articulation agreements [20] [30]. Unfortunately, little is known about what motivates CC students to take CS courses or the reasons they do/do not transfer as a CS-related major to a 4-year university. Efforts to bridge CCs with 4-year universities would benefit from this information.

In this paper, we report on the preliminary results of a study that tests three widely held beliefs about why so few women pursue CS-related majors. These beliefs are supported by theory, but there has been little research to support them, particularly among CC students. One widely held belief is that women and men have different levels of motivation to pursue these majors [18] [24]. The second belief is that family support plays a critical role in choice of major, and that parents pressure or socialize their children based on gender stereotypes, a conclusion that is based on research on science and math achievement, but not specifically on CS as an educational choice [8][38]. The third belief is that women's under-representation is due to a lack of previous computer use [9], and specifically a lack of computer game play [10][26]. Our preliminary results are mixed with respect to these beliefs and show them to be a simplification of the reasons for women's under-representation.

THEORETICAL BASIS FOR THE RESEARCH AND RESEARCH QUESTIONS

We base our study on theories that suggest there are individual, relational, and structural factors that can explain gender differences in students' educational pathways. The most common explanations for the under-representation of women in STEM focus on the individual factors, specifically motivation. We draw on three theoretical perspectives on motivation. Eccles' expectancy-value model of achievement-related decisions suggests students are directly influenced by two factors when choosing a

college major: the student's expectations for success and the value placed on the course of study [18]. This value is linked to whether they intend to pursue a CS-related career. This model has proven useful for explaining women's educational pathways to non-traditional careers [44], and has been used in a qualitative study to explain their choice of a CS major [39]. In addition, previous studies have found that for women, an interest in programming does not predict intention to pursue the subject if it is not valued [15][21]. Our study is also guided by social learning theory, particularly the concept of self-efficacy, which emphasizes students' beliefs about their ability to perform actions [3]. Self-efficacy beliefs play a central role in the cognitive regulation of motivation, and are found to explain gender differences in interest in math-related college courses [26]. Finally, we draw on self-determination theory, in which motivation is based on students' needs for competence, relatedness, and autonomy [37]. Applications of this theory to education have identified the importance of connections with peers who share an interest in the subject. In particular, women but not men who are CS majors cite peers as one reason they remained in the major [39]. In addition, studies based on self-determination theory cite the need for supportive autonomy from parents [7]. For example, when students' motivation is self-determined rather than externally controlled, there are higher levels of academic achievement [36].

Our study is also grounded in previous research on the role of the family and peers in the educational pathways of students from under-represented groups. The Bridging Multiple Worlds (BMW) model has been used to describe how expectations of family members, peers, and school personnel influence racial and ethnic minority students in the US [12][14][35]. In contrast to a social capital model in which parent support is positively correlated with academic achievement, Cooper et al [13] described how relationships can be both resources and challenges for students' educational pathways. This view of the family is different from the long-held assumption that more support leads to greater achievement, and is consistent with research on barriers to women pursuing information and communications technology careers [9]. Studies of under-represented minorities in CS-related majors are few, but suggest that Latino/a students are more likely to describe the importance of overcoming family challenges in order to persist in the CS-related major [42], a finding that is consistent with research with Latino/a high school students on the pathway to college [13].

Social learning theory [3] suggests that others' expectations can influence choice of a CS-related major. Based on this theory, many have assumed that gender role stereotypes can explain gender differences in career pathways; however, there is currently no empirical support for this belief. Although traditional gender role expectations by parents and others regarding who is good with computers can undermine girls' access to and confidence with computers [4], these beliefs have not been linked directly to choice and persistence in a CS-related major. One qualitative study found that among CS students, men report higher levels of encouragement from parents than women [39]. A previous study of Canadian students in college science and technology programs found that parent autonomy but not involvement or structure predicted persistence in those fields [24]. Instead of just support, a balance of autonomy and support, particularly for women, to pursue non-traditional educational pathways, might be ideal.

The BMW model suggests that some relational and institutional challenges such as poverty and sexism can motivate students to pursue certain pathways on behalf of their families or to prove others wrong, but only if there are other sources of support such as peer social networks. While studies show how peer groups and feeling comfortable or attached to the college influence student adjustment [1, 2], studies of students in CS classes are limited. Some studies suggest that peer support via the use of pair programming [29] and the presence of same-sex peers have been positive influences on retention in CS-related majors [11], however, it is not known if or how peers influence whether or not under-represented students enter the major. Other institutional challenges, such as a lack of female faculty, may limit women's interest in a CS-related major [6] but may be overcome when students have support from same sex peers [33] or learn to program with a peer [29]. The BMW model has been used to describe pathways to college eligibility and math course taking among under-represented groups, but has not been applied to computer-related outcomes.

There is little understanding of how playing computer games may relate to intent to pursue a CS-related major. Retrospective interview studies have found that male CS majors are more likely than females CS majors to cite an interest in computer games as a source of motivation and preparation [28][39]. Unfortunately, these previous studies of the role of computer use in choice of major are

limited by a lack of theory to guide the research questions and the interpretation of data. One study of middle school girls that drew on Eccles' Expectancy-Value model, as well as self-efficacy theory, found that computer game design is an effective strategy for engaging girls in IT fluency-building activities [17][43]. In particular, students who play certain types of computer games may have more tinkering experience and be more familiar with the cycles of problem solving and failure that are a part of learning to program [17][28]. While playing first-person shooter games has been shown to increase spatial cognition skills, which are important in many math and engineering fields [19], a recent study[33] found frequency of game play was associated with choice of CS major for men, but not for women. This may be because certain types of computer games, such as those that take a long time to learn and master, are more likely to promote the kinds of thinking and problem solving skills that prepare students to succeed in CS classes [16]. Recent data suggest women are using computers and playing games in equal numbers but in different ways [23][25].

Based on the theories described above, findings for groups similar to those studied here, and lack of studies of CC students, this study addresses the following three research questions.

1. What is the relationship between CC student characteristics and CS-related major choice?
2. What are the unique contributions of motivational and familial factors and previous computer use (especially gaming practices) in predicting whether CC students who have shown an interest in computing (i.e., they are enrolled in an introductory computer programming course) declare or intend to declare a CS-related major?
3. Are the contributing factors the same for female and male students and across racial/ethnic groups?

OUR STUDY: METHODS AND PARTICIPANTS

We approached 1723 students at 15 CCs across the state of California at the start of the fall 2010 semester, called time T1, and invited them to participate in a longitudinal study. We chose introductory programming students because they are showing a clear interest in CS. Of the students that were invited, 741 students completed the online survey (43% of the students we reached at T1). We had participation rates of 72% or more at four of the 15 CCs, because some teachers allowed students to complete surveys in lab classes. The online survey measures demographics and students' intentions to pursue a CS-related major at a 4-year university as well as motivational factors (such as value placed on computing, expectations for success with computing and future priorities); familial factors (such as family support, parent occupation and education of maternal and paternal figures); and computer use (such as digital gaming interest and experience and computer use in childhood and now); and other constructs (such as perceptions of sexism, faculty-student interactions, and interactions with other students).

The second data collection period (T2) occurred in spring 2011. We used email reminders and gift card enticements to increase participation. We received T2 surveys from 583 students, 79% of the students surveyed at T1. The data in Table 1 gives values for students matched at T1 and T2.

Table 1: Descriptive Analyses Results by Gender – the asterisks show where there were significant differences between women and men: *p<0.05, **p<0.01, ***p<0.001.

	women/n=166	men/n=417	range
T1 intent to pursue CS at 4-year univ ***	3.17	3.69	1(definitely not)-5(definitely)
T2 intent to pursue CS at 4-year univ ***	2.85	3.62	1(definitely not)-5(definitely)
Age*	26.16	24.16	15-61 years
Currently employed	55%	47%	
Mom has BA/BS	37%	32%	
White race	49%	49%	
Asian race	37%	32%	
Latino/a ethnicity	19%	20%	

Table 1: Descriptive Analyses Results by Gender – the asterisks show where there were significant differences between women and men: *p<0.05, **p<0.01, ***p<0.001.			
Speaks a language besides English at home at least some of the time	49%	48%	
Grew up only in the USA	70%	72%	
Mom works in computing field*	15%	9%	
Dad works in computing field	20%	16%	
Has an academic degree ***	30%	15%	
Has had a programming mentor*	29%	21%	
Prior programming experience**	31%	43%	
Had a female professor in intro class	31%	31%	
Freq. of game play in a typical week***	2.14	2.87	1(never)-5(every day)
Enrolled in the class to use programming to address social problems	1.68	1.76	1(not at all imp)-3(very imp)
Motivation: value of computers	6.18	6.08	1(strongly disagree)-7(strongly agree)
Motivation: expectations for success**	3.21	3.35	1(strongly disagree)-4(strongly agree)
Comfort talking with professor	3.17	3.22	1(strongly disagree)-5(strongly agree)
Other students encourage me**	1.97	2.26	1(never)-4(often)

Table 1 shows the ways in which the participants are different from the typical 4-year university student who is the focus of most research on pathways to computing careers. Our participants are older, more likely to have a job, less likely to be white (students could check more than one category for race/ethnicity), more likely to have already earned an academic degree, and less likely to have a mother with a bachelor's degree. A summary of the findings, as well as significant gender differences follows.

- Men have a greater intention than women to pursue CS at a 4-year university at both T1 and T2.
- Women are older, more likely to say their mother works in a computing field, more likely to have already earned an academic degree, and to report having had a programming mentor.
- More men than women report having prior programming experience, and they learned it in different ways. Of those that report prior programming, men were more likely to have learned it before college either in a class or by themselves, while women were more likely to have learned it in a college class (48% of the women and 21% of the men learned it in college).
- Men report more frequent computer game play, more encouragement from students in their computing classes to continue in CS-related degrees, and higher expectations for success in computing.

SUMMARY OF RESULTS

We performed hierarchical linear regression analyses predicting student intention to pursue a CS-related degree at a 4-year university at time T2. The following is a summary of the significant results. Unless noted otherwise, these results hold for both genders.

- Students that were not working had a greater intention to pursue computing at a 4-year university than employed students. In our sample, students who were not working were also significantly younger than those who were (average age of 23.79 years compared to 25.75 years).
- Students who had programming experience before taking an introductory programming class had a greater intention to pursue computing at a 4-year university.
- Students who spent more time playing computer games in a typical week had greater intention to pursue computing at a 4-year university.
- Greater levels of value placed on computing (doing well in CS courses enhance career opportunities, the rewards of a CS degree outweigh the sacrifices, and computers are useful tools) were associated with greater intention to pursue computing at a 4-year university.

- Students who received encouragement from other students in computing classes to continue as a CS major had a greater intention to pursue computing at a 4-year university.
- Men who were more comfortable talking with the professor indicated greater intention to pursue computing at a 4-year university. For women, there was no association between comfort and intention. We did some exploratory analyses to see if the gender of the professor made a difference and found, using simple correlations, that the association between comfort and intention held true for males with male professors, but there was no connection for males with female professors. For women, comfort was not associated with intention, regardless of professor gender.
- Although not quite significant, students who enrolled in an introductory programming course because they wanted to use computer programming to address social problems indicated greater intention to pursue computing at a 4-year university.

The following is a summary of the non-significant results of the regression analyses:

- Having a mentor was not related to intention to pursue a 4-year CS-related degree. This may be due, in part, to the fact that only 23% (48 women/ 89 men) had a mentor at one point in their lives, only 14% (80) still have a mentor at time T2, and only 13 women have had a female mentor. We have additional survey responses about mentoring to explore if there are some conditions that matter.
- Several items addressing the students' experience in the introductory programming course were not significant. The gender of the teacher was not linked to intention for either men or women; perhaps because few of the teachers were female (69% of the participants had a male teacher). The frequency with which the teacher encouraged them to pursue a CS-related major, gave the student advice on how to succeed in CS, or made positive comments about their work was not related to their intention.
- Most family indicators were not significant. Having a mother or father that worked in a computing career did not relate to intention to pursue CS, perhaps because this was true for only 17% of fathers and 10% of mothers. In addition, levels of mother and father support to pursue college, or whether their parents had traditional ideas about gender roles, were not significant.

NEXT STEPS

We have one more student survey planned for Spring 2012. We also plan to conduct additional analyses of data collected at all time points, building on prior research about the barriers and supports for women's pursuit and persistence in CS-related fields. We found that frequency of computer game play was strongly predictive of intention, but we have not explored what it is about game play that makes a difference. We will do this by looking carefully at our data on gaming behavior and preferences to see whether certain types of game play (e.g., mobile, puzzle, action, Internet) are more predictive, and for whom. We also want to explore additional demographic characteristics, since our covariate screening process suggested that students who grew up (at least part time) in a country outside the US had a greater intention to pursue a 4-year CS-related degree. In addition, we plan to look closely at the findings for women from under-represented minority groups, to address these important questions for these populations [34] although our sample sizes will be relatively small. We conducted a survey of the course teachers on teaching methods that are most likely to engage and retain women in CS-related majors [5].

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