Toward a Deeper Understanding of First Generation Students' Success in Computing

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Abstract

The research project described here is extracted from a larger program of research aimed at understanding the diverse experiences of underrepresented students in the field of computing. First generation (FG) college students tend to underperform in the academy and leave college at higher rates than continuing students. As such, it is important to understand correlates, and ultimately, causes of FG students' success in the academy, and in computing-related degree programs specifically. In the current work, we expected that, among students majoring in computing, FG students' academic success (i.e., major GPA) would be positively related to the degree to which they felt welcomed in their department. In fact, this positive relationship was most apparent among FG students who were underrepresented in computing, namely non-White and non-Asian men, and women of all races (URMW students). There was no relationship between feeling welcomed in one's department and academic success among FG Asian and White men. These findings contribute to a growing body of work on FG students' achievement gap in the academy, with special attention to FG students' URMW identity within computing.

Introduction

As technological innovation continues to become an integral part of daily life, the demand for a skilled computing labor force grows ever more important. Indeed, the Bureau of Labor Statistics [12] forecasts an 18% growth in computing occupations between 2012-2022. To meet this growing need, a broad range of young people must come to view computing as a viable career option and be trained to join the computing labor force. The computing labor force will not thrive on volume alone; it also needs to attract employees from diverse backgrounds to be maximally effective. This is because a diverse group of workers promotes a diversity of perspectives, and ensures that computing innovations meet the needs of a wide range of people. In contrast, a lack of diversity in computing has the potential to ignore the needs of significant portions of the population. For example, when early voice activated systems were created, they only worked for men, as women's voices were literally unheard during its development [13] [27]. Diversity within computing also has the potential to increase creativity and competitiveness on the global market. Social science research indicates that group-work with multi-cultural representation is associated with high creativity, innovation, and problem solving ability [26]. There is support for this finding in the field: IT patents issued to mixed-gender teams are cited 26% – 42% more frequently than similar IT patents issued to all-men or all-women teams [6]. Similarly, companies with higher levels of gender and racial diversity tend to have more customers and more sales revenues than those with lower levels of diversity [23].

Despite a recent surge in promoting gender and racial/ethnic diversity in computing, [15] [42] very little attention has been paid to understanding the experiences of first generation (FG) college students. FG students represent a significant portion of the college population (estimates range between 10 – 41% of four-year institutions [30] [38]), and a strong pool of potential

contributors to the computing labor force. Because of this, the current work focuses on understanding the correlates of success in undergraduate students' career preparation, with a particular emphasis on the experiences of FG students.

One measure of success in undergraduate training is students' *Grade Point Average*, or GPA, which is an average of students' grade points earned in their courses. As an index of learning and achievement, students' GPA provides a mechanism to self-assess one's level of success in academic endeavors. Further, strong performance and positive feedback is widely theorized and empirically linked to high motivation and persistence [7] [17] [19]. Importantly, third parties often use GPA to assess students' capacity to succeed in graduate school and professional settings [2] [4] [25]. Thus, GPA serves as an index for both students and third parties to assess academic success and preparedness for subsequent responsibilities and careers.

Given the importance of GPA on self-assessment and assessment by others, it is troubling that some populations in postsecondary education settings do not perform as well as others. One such population is FG students, who tend to underperform on standardized college preparation tests and in college courses, and show high attrition rates in STEM fields [1] [22] [31] [35]. This phenomenon of underperformance among FG students is typically explained in research and theory by a lack of resources, which are more readily available to continuing students. This lack of resources among FG students is often referred to as "capital" [10] [16], and comes in a number of varieties. For instance, FG students tend to lack *social capital*, or relationships with close others who have attended college. This in turn leads to a dearth of *cultural capital*, or information from others about how to succeed in college (e.g., useful courses; time management skills). Finally, FG students often come from low socioeconomic backgrounds, given that employees (i.e., parents) without a college education earn on average 20% less than the median earnings of employees with at least a four-year degree [11]. This means that FG students also lack *economic capital*; they are more likely than their counterparts to juggle financing their education, earning an income, and course responsibilities [21] [35].

Belonging, and its relation to achievement

The need to "belong," or see oneself as socially connected, accepted, and welcomed is now widely theorized to be a fundamental necessity for psychological and physical wellbeing [9] [37]. This psychological need is applicable to all social settings, including academic environments. Thus, research indicates that when students feel a secure sense of belonging, they tend to succeed academically at higher levels than students whose sense of belonging is low [5] [42].

We expect this link between feeling as though one belongs in computing and academic success to be particularly strong among FG students. This hypothesis is rooted in Walton and Cohen's [42] *belonging uncertainty* explanation for underperformance among underprivileged groups. According to Walton and Cohen, underprivileged populations tend to be in a chronic state of questioning whether they belong in their surroundings. Because of this, they are particularly sensitive to signals in the environment that indicate their belonging status, which in turn affects achievement. In our work, FG students can be conceptualized as an underprivileged group in computing academic settings for a number of reasons. As outlined earlier, FG students lack social and cultural capital in college, which may be disproportionately damaging for FG versus continuing students' self-concept. For instance, while many students struggle in "gateway" courses necessary for a computing major, FG students may be

particularly likely to take poor performance to heart due to a lack of cultural knowledge that struggle is to be expected in these courses. Given their propensity towards feeling like an outsider in computing settings relative to continuing students, we expected FG students to be particularly sensitive to elements of the computing academic environment that signal the degree to which they belong.

Computing: A subculture in the academy

It is important to note that the field of computing is a subculture within the academy that suffers from low gender and racial/ethnic diversity. We expected this dynamic to interact with FG students' experience in computing. Specifically, the majority of students who earn computing degrees are either White or Asian men (58%) [32]. Compared to their representation among people of conventional age to hold a college degree (25-64 year olds) in the U.S. population (35%) [33], White and Asian men are clearly overrepresented in the pool of computing degree earners. What this means is that underrepresented minority men, and women of all racial/ethnic backgrounds (URMW) are vastly outnumbered in computing by their "majority male" (MM) peers (i.e., White and Asian men). Following from this, we honed our hypothesis regarding the link between feeling welcomed in one's computing department and succeeding in one's computing major among FG students. Specifically, given MM's historic over-representation in computing, and cultural expectation that they "belong" therein, we did not expect FG MMs to fall prey to belonging uncertainty. Rather, we expected that only FG students who are also URMW students would show a tight link between feeling welcomed in their computing department and their major GPA, given their underrepresented status in computing.

In what follows, we examine the relationship between feeling welcomed and achievement among students from diverse groups. We expected that FG students' achievement would be positively related to the degree to which they felt welcomed in their department, but this would be most pronounced among FG students whose other identities were underrepresented in computing (i.e., URMW students). That is, FG MM students should not show a relationship between their perceptions of feeling welcomed in their department and their GPA, because a portion of their identity is "privileged" in academic computing settings. In this way, we sought to contribute to an emerging, nuanced picture of successful pedagogical practices in computing education that may be differentially helpful for various student populations.

Method

Student sample: Eight hundred forty eight undergraduate students in their final year of their undergraduate degree program in a computing field voluntarily participated in our study.[1] Students were recruited during an annual data collection initiative at the Computing Research Association (CRA) for three consecutive years (see Procedure for details). Given that our research questions pertained to groups whose numbers are low in computing (e.g., women; men of racial minority; first generation college students), and data were collected via convenience sampling, we present results from an aggregated dataset collected over three consecutive years. This aggregating procedure allowed for sufficient accrual of data from students who are underrepresented in computing in order to run statistical analyses relevant to

[1] Students were eligible to participate in this study if their major fell into any of the following sub-disciplines: computer science, computer engineering, and information science and technology programs.

our research questions (i.e., multiple regression analyses; see Results for details). Within the aggregated sample, 48% of the data were collected during the spring of 2011, 28% during the spring of 2012, and 24% during the spring of 2013.

Students reported the institution from which they were earning their degree, which we categorized into four different department types: departments with a top-ranked PhD program (i.e., approximately the top ranked 20%, see [41]; 22% of students); departments that granted PhDs, but were not top-ranked (33% of students); departments that awarded both Terminal Master's, and Bachelor's degrees (19% of students); and departments that only granted Bachelor's degrees (26% of students).

Within our sample, 222 students (26%) were women and 626 students (74%) were men. Of the men, 117 (19%) were classified as underrepresented (within this group, 31% were Black, 44% were Hispanic/Latino, and 25% were "mixed underrepresented" (see Instrument section for details on our classification system for mixed race students)). As such, 339 students were classified as URMW (40% of our sample), and 509 were classified as MM students (60% of our sample). In our sample, 109 students (13%) were FG and 739 students (87%) were continuing generation. Within FG students, 49 (45%) were URMW, and 60 (55%) were MM. Within continuing generation students, 290 (39%) were URMW, and 449 (61%) were MM.

Procedure

Students who were in their final year in college, and were majoring in a computing field were invited to complete an online survey via (a) an email invitation sent by their department chair or an administrative staff person in their department or (b) a direct invitation from the CRA. Embedded within the survey were questions relating to students' demographic characteristics, their Major GPA, and the degree to which they felt welcomed in their department.

Instrument

Gender: Students indicated their gender by indicating whether they were female or male.

Race and ethnicity: Students indicated their race/ethnicity by selecting all that applied from the following list of groups: American Indian/Alaska Native; Asian; Black or African American; Hispanic/Latina/o/Spanish; Native Hawaiian or Pacific Islander; and White or European American. Because students were able to specify membership in more than one race/ethnic group, we developed a coding scheme for students of "mixed" background. Students who indicated that they were both Asian and White were coded as "mixed majority". Students who indicated that they were more than one race, and at least one of those races was of a minority racial group in computing (i.e., American Indian/Alaska Native; Black or African American; Hispanic/Latina/o/Spanish; Hawaiian/Pacific Islander) were coded as "mixed underrepresented".

Generation status: Students were asked to report up to two parents' highest education level, including: Less than high school; High school graduate or GED; Some college; Bachelor's degree; Master's degree; PhD; and Professional degree. Students whose parents' education level was either (a) less than high school or (b) high school graduate or GED were coded as FG college students. All other students were coded as continuing generation students. If

students listed education levels for two parents, we applied our coding system to the parent who had the highest education level.

Major GPA: Students were asked to report their GPA in their undergraduate computing major using the conventional 4-point scale used in the academic system.

Feeling welcomed in the department: Students were asked to rate "How welcomed or unwelcomed do you feel in your home department?" using *a (1) Very unwelcomed* to *(4) Very welcomed* scale. This four point Likert-type item is included in our analysis as an interval variable.

Results

We examined the relationship between (a) students' group identities, (b) feeling welcomed in one's department (i.e., Welcomed variable), and (c) major GPA via a multiple ordinary least squares (OLS) regression analysis. Specifically, we regressed major GPA on Demographic Group (MM=0, URMW=1), Generation Status (Continuing=0, FG=1), Welcomed (continuous variable; mean centered), their two-way interaction terms, and their three-way interaction term. Our regression equation is shown in Equation 1 below.

Equation 1. Regression equation.

$$\text{Major GPA} = \beta_0 + \beta_1 \times \text{Demographic Group} + \beta_2 \times \text{Generation Status} + \beta_3 \times \text{Welcomed} + \beta_4 \times \text{Dem} \times \text{Gen} + \beta_5 \times \text{Dem} \times \text{Wel} + \beta_6 \times \text{Gen} \times \text{Wel} + \beta_7 \times \text{Dem} \times \text{Gen} \times \text{Wel}$$

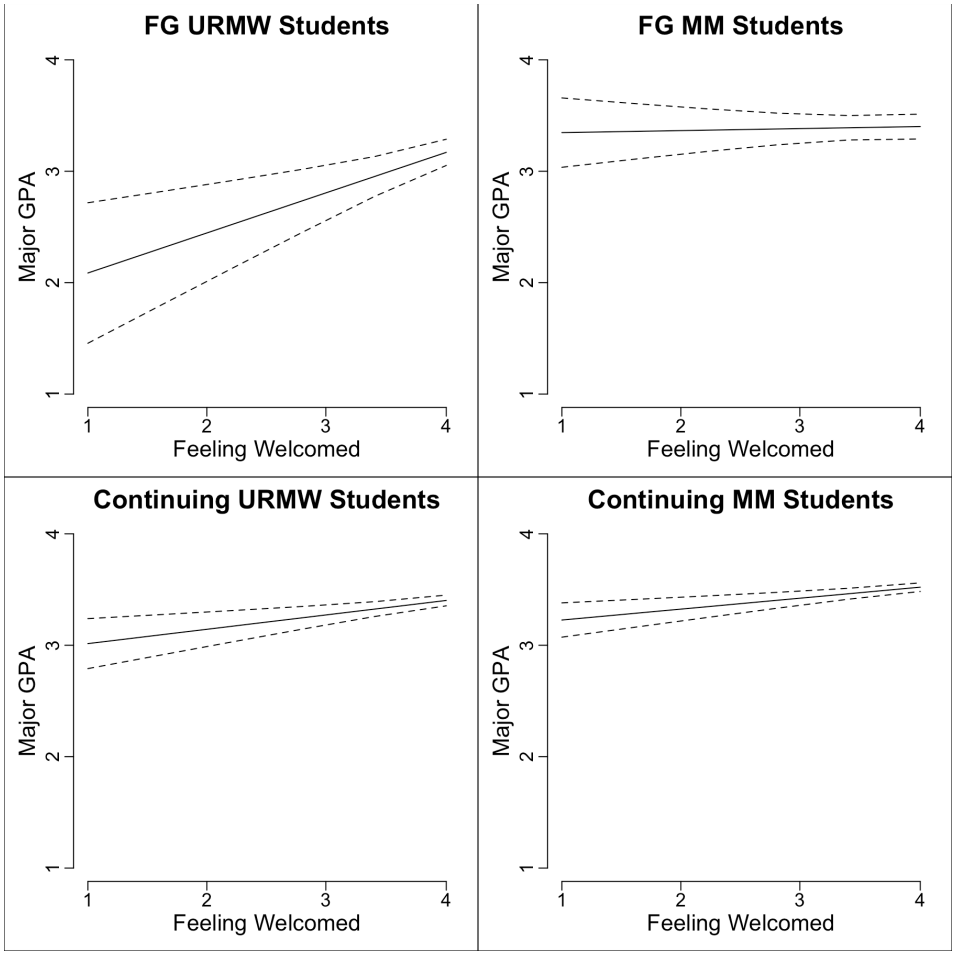
Given the presence of interaction terms in our model, lower order coefficients and their standard errors have limited interpretability. This is because the interpretation of any given lower order coefficient is relevant only to groups coded as zero for categorical variables, and at the mean value of Welcomed.[2] As such, in what follows, we only discuss the three-way interaction term, which is central to our research question.

As expected, we found a significant three-way interaction, $B = 0.37$, $SE = 0.15$, $p < 0.01$, such that the relationship between feeling welcomed and major GPA depended on students' demographic group and generation status. To evaluate this relationship, we calculated the simple slopes for the relationship between feeling welcomed and major GPA for each of our four student groups.[3] We found that FG URMW students showed a particularly strong positive relationship between feeling welcomed in their department and their major GPA, $B = 0.43$, $SE = 0.12$, $p < 0.001$. Although continuing students also showed a positive relationship between feeling welcomed and major GPA, the slopes of their respective lines were less steep than that of FG URMW students (continuing URMW, $B = 0.15$, $SE = 0.04$, $p < 0.001$; continuing MM, $B = 0.12$, $SE = 0.03$, $p < 0.001$). There was no statistically significant relationship between feeling welcomed and major GPA for FG MM students, $B = 0.02$, $SE = 0.07$ $p = 0.75$. See Figure 1 for simple slopes.

[2] For further discussion of conditional interpretation for interaction terms, see [3][8][24].

[3] For more information on calculating simple effects for interactions in multiple regression, see references in footnote 2.

Figure 1. Simple effects of feeling welcomed on major GPA by demographic group and generation status.



Note. Each panel presents the estimated relationship between feeling welcomed (x-axis) and major GPA (y-axis) for a particular student category. Dashed lines represent the 95% confidence intervals

Discussion

Our findings highlight the interrelationship between students' perceptions of their environment and their performance therein, particularly among students who are "at risk" in the academy. Specifically, we found that among FG college students who are also URMW students in computing, major GPA was *particularly* positively associated with the degree to which they felt welcomed in their department.

We acknowledge that the current work cannot make a causal claim about department dynamics on FG URMW students' achievement, because our data were obtained at a single point in time and are therefore correlational. Further, we did not manipulate the degree to which departments were welcoming in a controlled study. However, our data do show students' *perceptions* of their academic environment matter – particularly among students who have reason to doubt their sense of belonging in computing due to their identity. That is, in computing, FG URMW students are not only disadvantaged due to relatively low access to

capital by nature of their FG identity. These students also continually experience a dearth of peers and role models who "look like them" because of their URMW identity. Our data suggest that perceptions that one is a welcomed member of one's home department, regardless of the accuracy of these perceptions, tends to be particularly helpful for students who are likely to fall prey to chronically questioning whether they "fit" in their department.

We view our work as an important extension of existing computing education research aimed at fostering greater diversity and a broader talent pool than is currently the case in the computing labor force. By focusing on FG students' achievement in computing, and drilling down further to asses achievement patterns as a function of FG students' other identities, we can hone our understanding of who succeeds in computing, and why. Although the current research is correlational, it serves as a good starting place to test interventions targeting URMW FG students in computing and other STEM disciplines that also suffer from low diversity. For instance, educators might make the computing environment more inviting by going out of their way to alert URMW FG students to informal study activities, such as study support groups. Doing so would concurrently provide encouragement from faculty and increase students' knowledge of tools to succeed in college (i.e., cultural capital), which is particularly important for FG students.

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