Broadening Participation in Computing: The Role of Upward Transfer

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ABSTRACT

Broadening participation in computing (BPC) has received increasing attention within the computing education community. Yet, much of the existing research on this topic focuses primarily on students who follow traditional pathways to four-year computing programs. This multi-institution study addresses this gap in the literature, providing insight into how upward transfer students (i.e., students who transfer from community colleges to four-year computing programs) fit into the larger BPC narrative. Specifically, I use survey data from computing majors across 15 universities to examine how the characteristics and experiences of upward transfer students differ from those of other computing majors. Findings reveal that while upward transfer students tend to be more diverse than other computing majors in terms of race/ethnicity, socioeconomic status, and other background characteristics, women are even more underrepresented among upward transfers compared to computing majors who began their degree at four-year institutions. These and other findings are discussed, focusing on implications for how institutions can support upward transfer students as part of their larger BPC efforts.

CCS CONCEPTS

- Social and professional topics~Computing education programs

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1 Introduction

Despite increasing efforts to broaden participation in computing (BPC), inequities persist in undergraduate computing programs [3; 18; 22]. To address these persistent inequities, there has been a recent call within the SIGCSE community to center community colleges and community college transfer in efforts to more effectively broaden participation [10; 11]. Indeed, STEM education researchers have documented the important role community colleges play in reducing gender and racial/ethnic disparities in STEM [2; 26; 27]. Yet, very little research examines community college transfer students specifically in computing or how community college transfer fits into BPC efforts. The present study addresses this gap in the literature, focusing specifically on the characteristics and experiences of upward transfer computing students (i.e., computing majors who previously transferred from community colleges to four-year universities).

1.1 Upward Transfer

Community colleges are a primary entry point to higher education for students from underrepresented groups, particularly those from low-income backgrounds [17; 29]. At the same time, community colleges provide a critical pathway for women seeking four-year STEM degrees [23]. As such, community college transfer is a significant component of college access, and understanding community college transfer is critical to closing participation gaps in STEM [2]. While researchers have begun exploring equity in community college STEM transfer more broadly [e.g., 27], community college transfer students have been largely neglected in the BPC conversation until quite recently [see 10; 11].

1.2 Broadening Participation in Computing

While other STEM fields have made progress toward broadening participation, computing fields remain markedly undiverse. Women make up just 18% of bachelor's degree recipients in computing, while Black, Latinx, and Native students collectively represent only 21% of bachelor's degree recipients in the field [18; 19]. Some experts posit that the limited progress of BPC efforts is due to the fact that much of the existing BPC literature considers gender and/or race as single dimensions, rarely considering students' multiple identities and experiences [6]. As a result, initiatives to broaden participation are limited because they often

only target the most privileged students from underrepresented groups (e.g., white women with college-educated parents). Indeed, recent research reveals that women in computing who are the first in their family to attend college tend to experience more precarity across outcomes compared to other groups [6]. Therefore, it is imperative that future BPC research consider the experiences of students who are not only underrepresented due to their gender and/or racial/ethnic identities but who may *also* come from low-income backgrounds or are the first in their family to attend college. Given the important role community colleges play in providing access for low-income and first-generation college students, future BPC efforts must consider the role of community college transfer.

1.3 Objectives

The present study addresses an important gap in the literature by using data from the BRAID Research Project to explore the characteristics of computing students who transfer from two-year institutions to four-year research universities. Specifically, I examine how the demographic composition and background characteristics of computing students might differ as a product of upward transfer status, providing important insights into how BPC efforts can expand to include upward transfer students. Next, I examine how upward transfer students differ from other students across key computing experiences (e.g., peer support in computing). The following questions guide this work:

1. What are the demographic and background characteristics of upward transfer students in computing majors, and how do they differ from those of students who began their computing degree at four-year institutions?
2. Do upward transfer students have markedly different undergraduate computing experiences than students who began their degrees at four-year institutions?

2 Theoretical Framework and Hypotheses

The present work merges literature on BPC with research on community college transfer [see 14; 24; 25]. Wang's [25] theory of upward STEM transfer provides a frame for the variables that are included in this study. Specifically, Wang's model outlines the background characteristics, contextual factors, and experiences that shape STEM career attainment and success. Guided by this theory, I focus on several demographic and background variables capturing gender, race, socioeconomic status, and family characteristics. Notably, Wang's model also "highlights the need to support STEM [transfer students] beyond access to four-year STEM majors" and emphasizes the importance of understanding the characteristics and experiences of students after they transfer to four-year institutions [25, p. 53]. To examine post-transfer computing experiences, I focus on four composite variables that capture 1) support from computing classmates/peers, 2) mentorship to pursue computing, 3) computing department support, and 4) family support to pursue computing. These measures of computing experience were selected because they are

each documented predictors of sense of belonging and success in undergraduate computing [5; 21].

Based on my conceptual framework and literature on the composition of community colleges [see 17; 29], I hypothesize that students who transferred from two-year institutions will be significantly more diverse than the students who began their programs at four-year institutions. Because initiatives to foster more supportive computing environments have primarily focused on introductory course interventions [see 21] and less attention has been paid to the role of upward transfer, I also hypothesize that upward transfer students will report significantly less support relative to other students.

3 Methods

3.1 Sample

This descriptive study relies on existing data collected by BRAID Research. Specifically, The BRAID Research team administered a survey to all computing majors and minors from 15 participating research universities across the United States. The survey was administered during the 2016-2017 academic year and had a response rate of approximately 22%. For the purposes of this study, I restricted the sample to include only computing majors, resulting in an analytic sample of 3,989 students, approximately 18% of whom indicated that they had previously transferred from a two-year institution. Sample demographics are discussed in the findings section. Notably, the sample was diverse in terms of class standing, with approximately half of the students indicating that they were third- or fourth-year students and the other half indicating that they were first- or second-year students. Importantly, upward transfer students in the sample were much more likely to be third-year or fourth-year students, which is not surprising, given that most upward transfer students would have transferred directly into advanced coursework at their four-year institution.

3.2 Variables

3.2.1 Upward Transfer Status. To measure upward transfer status, students indicated on the survey if they had previously transferred from a two-year college to their current institution.

3.2.2 Demographic and Background Variables. Students self-reported their demographic characteristics on the survey. In accordance with my conceptual framework, I was particularly interested in gender, race/ethnicity, first-generation college status, family characteristics (e.g., marital status), socioeconomic status, and other measures capturing how students financed their education. To measure gender, students indicated their gender identity as woman, man, or non-binary. Due to a small number of students indicating a non-binary identity, the present work focuses only on gender differences between self-identified women and men. Students reported one or more racial/ethnic identities and responses were aggregated into the following categories: Asian/Asian American; Black/African American; Latina/o/x;

Native (including Native American, Alaska Native, Native Hawaiian, and other Pacific Islander); White; and “Other”. To measure first-generation status, students indicated the highest education level of up to four parents; students who had no parent with a bachelor’s degree or higher were coded as first-generation to college.

Students self-reported the socioeconomic status of their family when they grew up as poor; below average; average; above average; or wealthy. To get additional insight into students’ current socioeconomic status and financial resources, they were also asked to indicate how they were currently funding their college education by selecting one or more of the following: full-time employment; part-time employment; employer support; military or veterans benefits; federal student loans; private student loans; scholarships, fellowships, or grants; or family support. Additionally, students were asked if they had ever experienced a financial/economic hardship that led them to take a leave of absence since beginning college (0=no; 1=yes).

Students were also asked to indicate their marital status; to simplify analyses, students were aggregated into two categories: currently unmarried and currently married. Finally, students indicated their number of children (if any), and responses were aggregated into a dichotomous variable indicating whether students had no children or at least one child.

3.2.3 College Computing Experiences. To examine how computing experiences varied as a product of whether or not students transferred from a two-year college, I relied on four composite variables, focusing on peer support in computing, mentorship, departmental support in computing, and family support to pursue a computing degree.

To measure peer support in computing, I used an established four-item composite variable that is a documented predictor of sense of belonging [21] and leadership confidence in computing [5]. This variable was made up of students’ reports about the availability of the following types of support from computing classmates: someone to hang out with; someone to confide in or talk about your problems; someone to get class assignments for you if you were sick; someone to help you understand difficult homework problems. Students responded to each item on a five-point scale, and responses were added together to create a scale that ranged from 4 (low peer support) to 20 (high peer support). These items had a Cronbach’s alpha of .894, indicating reliability.

Mentorship was measured using an existing four-item composite variable [5] asking students to indicate the extent to which they had a mentor who provided the following types of support using a five-point scale: helps you improve your computing skills; shows compassion for any concerns and feelings you discussed with them; shares personal experiences as an alternative perspective to your problems; explores career options with you. Items were added together to create a scale ranging from 4 (low mentorship) to 20 (high mentorship). This measure had a Cronbach’s alpha of .924, indicating reliability.

Departmental support in computing was also measured using an established four-item variable [see 21]. Specifically, students indicated their agreement with the following items on a five-point scale: I feel a sense of community in the computing department; the department cares about its students; the environment in the computing department inspires me to do the best job that I can; the department is not very supportive of its students (reverse-coded). These items had a reliability of .821, indicating reliability. Thus, items were added together to create a scale ranging from 4 (low departmental support) to 20 (high departmental support).

Family support was measured using a three-item variable [5]. Specifically, students indicated their agreement with the following items using a five-point scale: my family encourages me to pursue a computing degree; my family emphasizes the value of earning a computing degree; my family recognizes my accomplishments in computer science. These items had a Cronbach’s alpha of .783, indicating that it is a reliable measure. As such, items were added together to create a scale ranging from 3 (low family support) to 15 (high family support).

3.3 Analysis

To examine the first research question, I used chi-square tests to identify significant differences between the demographic and background characteristics of upward transfer students and those of other students in the sample. Next, to examine the second question, I used t-tests to compare mean scores of peer, departmental, mentorship, and family support as a product of whether or not students transferred from a two-year college.

4 Findings

4.1 Differences in Demographics and Background Characteristics

As shown in Table 1, findings reveal that upward transfers are markedly more diverse than other students with one notable exception: women were even more underrepresented among upward transfer students, making up just 22% of upward transfers, compared to 27% of other students in the sample.

In terms of racial/ethnic diversity, upward transfer students were less frequently Asian/Asian American and more frequently Latinx or Native American. Upward transfer students also more frequently selected an “other” racial/ethnic identity relative to their peers who began their degree at four-year institutions. There were no differences in the proportion of white or Black students in the sample.

The most significant and consistent differences emerged in relation to first-generation status, socioeconomic status, family characteristics, and how students financed their education. Notably, upward transfer students were more frequently first-generation to college, from lower SES backgrounds, and paying for college by working and taking out student loans. On the other hand, students who did not transfer from a community college

more frequently reported financial support from their families and support in the form of scholarships, fellowships, and grants. Particularly concerning, 15% of upward transfer students reported having experienced an economic hardship that led them to take a leave of absence from school, compared to 4% of other computing majors.

Table 1. Background Characteristics by Upward Transfer Status

	Percent Among		Sig.
	Non-Transfer	Upward Transfer	
Gender			
Women	26.8	22.4	*
Men	73.2	77.6	*
Race			
Asian	36.4	30.5	**
Black	6.2	7.2	
Latinx	11.0	18.8	***
Native	1.6	2.0	*
White	51.6	49.9	
Other	0.7	2.0	**
First-Generation College Status			
Continuing Generation	71.8	52.8	***
First-Generation	28.2	47.2	***
Socioeconomic Status			
Poor	5.6	11.1	***
Below Average	15.8	24.6	***
Average	39.2	43.7	*
Above Average	36.0	18.6	***
Wealthy	3.3	2.0	
Financing College			
Full-Time Work	6.2	11.4	***
Part-Time Work	31.9	40.4	***
Employer Support/Benefits	1.7	3.2	**
Military/Veterans Benefits	2.8	5.1	**
Federal Loans	42.7	56.7	***
Private Loans	12.2	14.9	*
Scholarships, Fellowships, and/or Grants	53.6	44.3	***
Family Support	55.9	36.5	***
Savings	36.0	37.5	
Economic Hardship			
No	96.3	84.8	***
Yes	3.7	15.2	***
Marital Status			
Unmarried	97.1	87.1	***
Married	2.9	12.9	***
Children			
No Children	97.8	90.6	***
At Least One Child	2.2	9.4	***

Note. * $p < .05$; ** $p < .01$; *** $p < .001$. Proportions of students in each racial/ethnic group and the breakdown of how students reported paying for college add to more than 100% because students were able to select more than one category.

Interestingly, upward transfer students more frequently reported being married and/or having children, which is consistent with prior research on upward transfer in STEM [28]. Importantly, additional analyses reveal that upward transfer students were also significantly older than their counterparts, which may explain the significant differences in family composition.

4.2 Differences in College Experiences

As shown in Table 2, upward transfer students reported significantly less support from computing peers, mentors, and the department relative to their peers who did not transfer from a two-year college. No significant differences were observed in family support scores.

Table 2. Mean Support by Upward Transfer Status

	Mean (SD)		t	Sig.	DF
	Non-Transfer	Upward Transfer			
Peer Support	13.5 (4.3)	12.0 (4.6)	8.3	***	3778
Mentorship	10.6 (5.0)	10.1 (5.1)	2.5	*	3784
Departmental Support	14.2 (3.3)	13.9 (3.4)	2.4	*	3792
Family Support	12.8 (6.2)	12.3 (5.6)	1.9		3684

Note. * $p < .05$; ** $p < .01$; *** $p < .001$. Standard deviations are shown in parentheses. DF=degrees of freedom.

A careful reader may wonder if significant differences in peer support, mentorship, and departmental support may be confounded with the fact that the demographics and background characteristics of upward transfer students look significantly different than those of their peers who began their degrees at four-year institutions (i.e., the results of Research Question 2 may be confounded with the results of Research Question 1). To test for this possibility, I ran four regression models to examine the relationship between upward transfer student status and the college experiences of interest, this time controlling for gender, race, socioeconomic status, financial variables, and family characteristics (i.e., all variables included in Table 1). As shown in Table 3, even after controlling for all other demographics and background characteristics, upward transfer students reported less peer support, computing mentorship, and departmental support than their peers who did not transfer from two-year institutions.

Table 3. Regressing Upward Transfer Status on Peer Support, Mentorship, and Department Support

Dependent Variable	B	SE	Sig.
Peer Support	-1.1	0.2	***
Mentorship	-0.5	0.2	*
Department Support	-0.3	0.2	*
Family Support	-0.3	0.3	

Note. * $p < .05$; ** $p < .01$; *** $p < .001$. This table summarizes the results of four regression models predicting the support variables. SE=standard error. Each regression model controls for all variables shown in Table 1.

4.3 Summary

Findings from this study reveal that, while women are starkly underrepresented among all computing students, they are particularly underrepresented among upward transfer students in computing. With the exception of women's underrepresentation, upward transfer students tend to be more diverse than other computing majors, at least in terms of race/ethnicity, socioeconomic status, and the other characteristics included in the present study. Unfortunately, compared to their counterparts who began their degree at four-year institutions, upward transfer students reported lower levels of support from peers, mentors, and computing departments, revealing a missed opportunity for computing programs to support and foster success among this diverse group of students pursuing computing.

5 Limitations

Before drawing conclusions from the present study, it is important to recognize some limitations. First, this study included a sample of students who were enrolled at one of 15 research universities across the United States. Therefore, findings may not be applicable to upward transfer students at other institution types. Further, all 15 participating institutions are part of the BRAID Project to broaden participation in computing. Notably, many of the diversity efforts at BRAID institutions focus on fostering more inclusive and supportive environments in introductory courses. Thus, it is possible that the gaps in support between upward transfers and other students may be due to the fact that many upward transfer students may not have equitably benefitted from the specific interventions employed at BRAID institutions.

Additionally, this study relies on survey data, which could be biased by survey non-response. While there is no reason to believe that non-response bias would have skewed the results of the present study in a meaningful way [see 9], non-response bias is possible in any survey research with a response rate of less than 100%.

Finally, while this descriptive study provides important insight into upward transfer students in computing majors at four-year universities, longitudinal research is also needed. For example, future research should examine the barriers students face before and during the transfer process that may lead them to feel less supported post-transfer.

6 Discussion and Implications

6.1 Supporting Upward Transfer Women

Results from this study reveal that women are even more underrepresented among upward transfer students than they are among students who follow traditional pathways from high school to four-year institutions. This suggests that there is not currently a viable pathway for women who begin their degrees at community colleges to pursue four-year computing degrees. One explanation for this finding is that women who transfer from community colleges experience multiple types of discrimination

in computing spaces, as they are marginalized due to their gender identity and their status as upward transfer students. This is somewhat consistent with recent literature on first-generation college women who are doubly disadvantaged in computing, reporting lower sense of belonging and self-efficacy in computing than women with college-educated parents [6]. Building on this and other prior research, findings from the present study suggest that there is a need for BPC efforts to specifically consider the intersectional experiences of upward transfer women (as opposed to supporting women and upward transfer students separately). For example, while some previous efforts to broaden women's participation have focused on building community through identity-based groups that target women in computing majors, such groups must be explicitly inclusive of upward transfer women; likewise, groups for upward transfer students in computing must be explicitly inclusive of women.

6.2 Missed Opportunities to Broaden Participation

Upward transfer students pursuing a computing major are a diverse group of students. Specifically, they are more racially and ethnically diverse and more diverse in terms of socioeconomic status and family backgrounds compared to students who began their degree at four-year institutions. Further, the sizable presence of upward transfer students in the computing major creates an exciting opportunity to broaden participation by developing targeted efforts to support this diverse group. Yet, the fact that these students also reported significantly less support from classmates, mentors, and the computing department suggests that we are currently missing out on opportunities to support upward transfer students. Notably, upward transfer students may not benefit from popular interventions to foster more supportive computing environments, particularly those that target introductory computing courses, as these students may not take introductory computing at the four-year university. Therefore, future BPC efforts should also foster inclusive and supportive spaces in advanced coursework, which would benefit all students, including upward transfers.

6.2.1. Increasing Visibility and Challenging Stereotypes. Another consideration in efforts to support upward transfer students relates to the visibility of this group. Depending on institution size and other characteristics, upward transfer students may be a largely invisible group in computing courses. That is, instructors may not know whether or not a student previously transferred from a community college. While it may be difficult to know the status of individual students, instructors must explicitly recognize that upward transfer students do, in fact, exist (i.e., they were 18% of computing majors surveyed at the BRAID institutions); therefore, language should be inclusive of this population and not assume that all students began their degree at their current institution or another four-year school. For example, when referencing prior knowledge gained from earlier coursework, instructors of advanced courses should acknowledge that students may have taken comparable courses at community colleges. Understanding the specific computing curriculum and transfer processes from local and state community colleges would further

enhance instructors' abilities to draw connections to prior coursework. Such efforts may also make instructors more accessible to upward transfer students.

In order to better support this group, it is important for instructors to deconstruct false stereotypes about community college and upward transfer students. Upward transfer students in computing are a diverse group, and prior research suggests that upward transfers are often among the highest achieving students, performing at least as well as their peers [7; 13]. Therefore, within any advanced computing course, there are likely sizable numbers of upward transfer students who excel and challenge any negative stereotypes about their preparation and potential. Explicitly acknowledging these facts might go a long way in challenging stereotypes and eventually fostering more supportive computing environments for upward transfers.

6.2.2 Considering Financial Needs. Findings from this study show that upward transfer students are more likely to report experiencing a financial hardship that led them to take a leave of absence from school. This is not surprising given that these students also more frequently pay for college through loans, relative to their counterparts who more frequently report receiving scholarships, grants, and other support that does not result in accrued debt. Given these inequities, more scholarships should specifically target upward transfer students in computing; in developing targeted scholarships, it is important to recognize that upward transfer students require support beyond the cost of college attendance, given that they tend to be older and more frequently have children.

In addition to their greater propensity to take out loans, upward transfers more frequently report that they are paying for college through part-time or full-time employment. While empirical studies of the impact of student employment have found mixed results [20], prior research generally suggests that while off-campus employment is sometimes associated with negative student outcomes [1; 8; 12], on-campus employment may benefit students by increasing their engagement on campus [15; 16]. At the same time—though not always treated as paid employment—internships are consistently associated with positive academic and career outcomes [4]. Given prior research and the present findings, it is imperative that institutions provide upward transfer students with high impact employment opportunities. Specifically, computing departments should work with local communities and their institutions to provide upward transfer students with paid internships (and other field-relevant work experiences) and meaningful, fairly compensated on-campus jobs.

7 Conclusion

Findings from this study reveal that upward transfer students are a diverse group and that they differ from students who began their degree at four-year institutions in several key ways. For example, compared to their counterparts, upward transfer students are more frequently Latinx, first-generation to college, from lower-income backgrounds, and parents. Upward transfers also report

less support from computing classmates/peers, mentors, and departments. Further, upward transfer students have unique financial needs, as they are more likely to take out student loans, pay for college through employment, and experience financial hardships. Contending with these inequities may be an effective way to broaden participation in computing by increasing support among this diverse group of students. However, it is notable that women are incredibly underrepresented among upward transfer students. Thus, efforts to broaden participation for upward transfers in computing should also focus on creating a pathway for upward transfer women, recognizing that upward transfer women may encounter unique challenges in computing spaces.

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