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Impact of Social and Programmatic Experiences on Students' Interest in Pursuing a Graduate Degree in a Computing Field

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Impact of Social and Programmatic Experiences on Students' Interest in Pursuing a Graduate Degree in a Computing Field

Abstract

There is a substantial shortage of students pursuing graduate degrees in computing fields in the United States [1], and when examining participation rates of minoritized populations the disparity is even greater [2]. In order to attract more domestic students to graduate schools in computing it is important to understand what factors encourage or discourage them from participating. Literature suggests that students' family, friends, school, and society play an important role in their educational paths and self-perceptions. Using social impact theory as the guiding lens, we explored support from family and friends, as well as social and program-related experiences, in this study to assess their impact on undergraduate students' reported interest in pursuing a graduate degree. The research questions that guided this study are 1) Which social and programmatic experiences have the greatest impact on students' interest in pursuing a graduate degree in computing?; and 2) How does a student's gender/racial/ethnic background and their participation in social and programmatic experiences impact students' interest in pursuing graduate degrees? We answered these research questions using data from a survey conducted at three large public universities in Florida which targeted students in computing fields (n=740). Data was analyzed using Kruskal-Wallis and Wilcoxon rank sum tests, as well as logistic regression. The findings revealed that "presenting work to other students," and "research experience" are two experiences which lead to an increase of students' interest in pursuing a graduate degree in a computing field. This study also demonstrated the importance of having same gender friends and reported interest in pursuing a graduate degree in a computing field. These findings provide insight into which experiences may impact domestic students' interest in pursuing graduate programs in computing fields. The results of this study are beneficial for universities to consider what factors may encourage more students to pursue a future in academia or in the workforce after obtaining a graduate degree.

Introduction

Occupational growth for the computing fields, which includes computer science (CS), information technology (IT), and computer engineering (CE), are projected to rise more than 10 percent between 2019 to 2029 [3]. Additionally, as vacancies increase, so too does the need for students with graduate degrees (master's and doctoral level) in the field [4]. However, in the United States (U.S.) participation in graduate schools is more commonly from international students. According to the survey by the Computing Research Association in 2019, almost 70% of the master's degrees in computer sciences and 80% in engineering were awarded to international students [5].

Meanwhile, 62% of the Ph.D.'s in computer sciences were awarded to international students, followed by 67% in engineering [5]. Yet, participation of domestic students pursuing graduate degrees in computing is less than 30% in the U.S. [1]. Moreover, participation rates of those least represented in computing, such as women, Black, Hispanic, and Native American students are even more grim. According to the National Center for Education Statistics, the percentage of Ph.D.'s awarded in computing was 23% for women, and 11% for racial/ethnic minorities [9]. Also, the National Science Foundation (NSF) reported that minorities earned 7.8% of master's and 5% of Ph.D. computing degrees in 2016 [2].

Since graduate degrees are often required to teach at the faculty level, a shortage of graduate students can be particularly problematic in training future generations. Further exacerbating the problem, students that receive graduate degrees often choose to pursue paths in industry, due to other incentives (such as higher earning potential) [6][7]. Given the critical shortage of workers and teachers in academic fields or careers in computing industry, low rates of participation are especially problematic [6]. It is vital to the economy of the United States to attract and retain qualified computing students. It is also important to ensure a diverse faculty that represents the population they serve [8]. To broaden participation in academia, it is important to ensure equitable representation of all students in both undergraduate and graduate schools. As such, it is important not only to consider ways to encourage students to pursue graduate work, but also to find ways to attract minoritized populations to graduate studies in computing fields.

The aim of this study is to better understand how social and programmatic experiences impact students' interest in pursuing a graduate degree in computing. In addition, we want to examine alignment of the students' self-reported race, gender, and ethnicity, with these experiences to learn how it may impact their interest. Specifically, the research questions (RQs) guiding this study are:

> **RQ1**) *Which social and programmatic experiences have the greatest impact on students' interest in pursuing a graduate degree in computing?*
>
> **RQ2**) *How does a student's gender/racial/ethnic background and their participation in social and programmatic experiences impact students' interest in pursuing graduate degrees?*

In this research, we answered these questions using the results of a survey conducted at three metropolitan universities in Florida.

Literature Review

Given the disparity in representation in computing there has been a wealth of literature that has explored and concluded that computing fields are often unwelcoming for underrepresented groups, such as females, Black, and Hispanic students [10][11][12]. Research on minoritized undergraduates has demonstrated that they do not feel like they belong, nor do they feel comfortable with consulting and/or approaching others for help in these fields due to the established climate in computing departments [12]. Thus, it is imperative to increase access,

equity, and inclusion in graduate programs to ensure there are computer science faculty to mentor and serve as role models to combat this exclusive culture in computing. It is also important to build diverse teams that can offer unique perspectives, foster innovation, and to offer valuable insights into different ways of approaching problems [7][13]. Doing so requires first dealing with negative attitudes, and trying to create a more inclusive atmosphere [14]. Stereotypes and exclusion can serve to reduce feelings of belonging in the discipline [15][16][17]. For example, negative comments and jokes about females' technical aptitude can lead to a mental disengagement, and eventually leaving the field, which only further serves to perpetuate gender inequality in computing [14]. However, several practices have been suggested to promote recruitment and retention of minoritized undergraduates towards completion of a master's and doctoral degree [18][19]. Initiatives such as recruiting, hiring, and retaining diverse talent, who can serve as role models which is known to be effective for developing a positive departmental atmosphere [20].

In addition, establishing strong peer mentoring and mentorship opportunities have been discussed widely in the literature [21][22][23]. Peer mentoring is mutually beneficial for both the mentor and the protégé [24][25]. According to the literature, mentors benefit from peer mentoring by gaining in-depth knowledge related to teaching and learning, leadership skills, and experience working with the administrators of the school [24]. Also, the protégés being mentored gain the benefits of psychosocial support, and they can assuage discomfort that may arise from sharing insecurities with others. It can also serve to encourage minoritized undergraduates to persist, and to develop confidence [23]. Traditional mentoring also has a positive relationship with satisfaction, commitment, and involvement in ones' major [26]. Thus, being a mentor or/and mentee have important impacts on students' knowledge, skills, commitment, and participation in their field.

Volunteerism or altruism is another activity and experience students can engage in/with to increase their sense of belonging and to appeal to intrinsic motivation to persevere in computing fields. Participation in volunteer activities allows students to interact with others, and to fulfill their altruistic and egoistic needs [27]. Each individual experiences volunteerism differently, depending on the organization and personal characteristics [28]. However, voluntary self-development activities by students are generally known to serve as an effective act towards sustainable skill development [29]. In other words, there is a positive relationship between campus involvement and overall retention rates for students in higher education [30]. Thus, it is a beneficial experience that students should participate in during their undergraduate education. Further, we explore experiences such as participating voluntarily in community or K-12 outreach programs and events organized by the department on students interests towards pursuing a graduate degree.

The physical and psychological impacts of student involvement, such as attending social events, giving oral presentations, being part of a group, club, organization, etc., have been studied widely by scholars [31][32][33][34]. They have shown a major role in students' self-efficacy and persistence and positively impact students' academic autonomy, career, and lifestyle planning

[32][35][36][37]. “Academic involvement, involvement with faculty, and peer involvement” are the three most powerful involvement forms according to the literature [31]. Likewise, learning in a group is an effective practice in promoting greater academic achievement, promising attitudes toward learning, and increasing persistence through STEM courses and programs [38].

Literature has provided insight into the relationship between students’ research experiences at the undergraduate level and its positive impact on STEM students, specifically underrepresented minorities, undergraduate experience, educational pathways and career outcomes [39][40]. Research experiences are associated with increased persistence of students pursuing an undergraduate degree and increased levels of pursuit of graduate education [41][42]. A recent study also found that undergraduate research experiences increased understanding of how to conduct research, confidence in research skills, awareness of what graduate school is, increased anticipation for a Ph.D., and increased interest in STEM careers in students [40]. As such, we looked at the impact of research experiences on computing students’ interest towards pursuing graduate degrees in alignment with prior works as well.

The importance of family and friends in students’ academic success and achievement has been widely acknowledged [43][44][45]. According to literature, students’ positive attitudes and enthusiasm towards science and STEM fields is positively associated with having parents who support and encourage them towards science [46][47]. Likewise, family and friends have an impact on their peers’ educational outcomes. Amongst all students, Whites’ and females’ experiences with peers in STEM and computing related fields are known to have the greatest impact [48]. Hence, students who receive support from their home environment and friends are more likely to be encouraged to persist towards obtaining a degree in a computing field [49][50]. As discussed, different experiences can contribute to students’ interest in pursuing a graduate computing degree. Although these studies may suggest certain experiences are important, few directly measure how having these experiences can impact students interests toward pursuing a graduate degree in computing fields. The goal of this study is to shed light on how different experiences impact students’ interests towards pursuing a graduate degree.

Theoretical Framework

The theoretical framework guiding this study is *social impact theory,* as illustrated below (Figure 1). Social impact theory is a way of predicting the effects of social pressure [51][52]. According to Latane (1981) this theory specifies the effect of other people on an individual [51]. In other words, this theory proposes that the amount of influence a person experiences in group settings depends on power or social status of the group, physical or psychological immediacy of the group, and the number of people in the group exerting the social influence [51]. Thus, the impact of source (family, peers, school, etc.) on a target person (student) is a function of the source’s strength, immediacy, and number [53][54][55].

Social impact theory declares that multiple sources have more influence on a target than a single source, meaning that multiple people exert more influence than does the same message presented by a single person. Relative to other social influence theories, only social impact theory includes strength and immediacy as variables. According to Latane (1981) *strength* is defined by the "[…] source's status, age, occupation, socio economic status, and prior relationship with, or future power over, the target."; for example adults with prestigious jobs have more strength than young college students [51]. *Immediacy* means the "[…] closeness in space or time and absence of intervening barriers or filters." In other words, less distance means more immediacy [54].

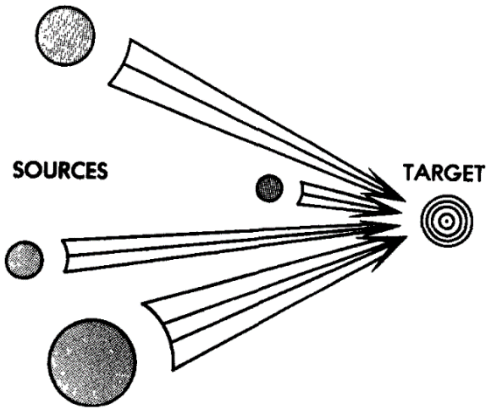

Figure 1: Social Impact Theory (Latane, 1981)

Social impact theory is important when thinking about the impact a person can have on another [55]. Along these lines, it is important to consider how social influences, individuals interests, and how social experiences, and those students face throughout their education, can impact their attributes as well [56]. This theory predicts how sources will influence a target; it predicts how people's personal attitudes, behaviors, and perceptions congregate together based on strength, immediacy, and number at the group level [51]. This theory has been used in divergent disciplines including STEM, and areas of social psychology (e.g., consumer behavior). We apply this framework as an analytical lens to better understand the impact of experiences and social support on students' interest in pursuing a graduate degree in a computing field. More specifically, using this framework gives us the opportunity to examine how individuals get impacted by different sources (e.g., family, school, friends, etc.) with varied proximity and numbers (e.g., having two friends in computing versus eight, etc.) towards pursuing a graduate degree in computing. Students with different races, ethnicities, genders, and experiences completed the survey, answering questions about their social experiences, and social support.

Methods

For this study we applied logistic regression, Wilcoxon rank sum tests, and Kruskal-Wallis tests to analyze survey data collected during the Fall 2020 semester. We present details of the methods in the *Dataset* and *Data Preparation* and *Analysis* subsections.

Dataset

Our research group designed and developed a survey containing 39 questions that was approved by our Institutional Review Board (IRB) which was validated and tested for reliability [57] [58]. Using the Qualtrics survey system, the questions were distributed to computing students at three large public universities in Florida. The survey contained questions about the students' gender, social experiences, computing program related experiences, encouragement towards computing from family, friends, etc. The questions used for the purpose of this work are shown in Table 1.

Relevant Items for Work from Questionnaire	
Questions	**Responses**
Question A: Which of the following **social** experiences/professional experiences, if any, have you had at your institution **with respect to computing?** *Mark all that apply.*	▪ Helping other student(s) with school/coursework (e.g., being a Learning Assistant, teaching assistant, tutor), ▪ Being helped by other student(s) with school/coursework (e.g., being a Learning Assistant, teaching assistant, tutor), ▪ Helping other student(s) about career/personal issues, ▪ Being helped by another student(s) about career/personal issues, ▪ Being part of a computing group, club, etc., ▪ Attending social events organized by the department, ▪ Presenting work to other students (not classwork), ▪ Community or K-12 outreach (voluntary or for a course), ▪ Interacting with students in different year(s) (lower year or more senior students), ▪ Research Experience
Question B: Which of the following people, if any, have helped you **with classwork**? Mark all that apply.	▪ Students in the class ▪ Students outside the class who have taken it before ▪ Teaching or Learning Assistants ▪ Faculty/Instructors ▪ Advisors ▪ Other
Question C: How supportive is your home environment towards computing?	Not at all supportive 0, 1, 2, 3, Extremely supportive 4
Question D: How many friends do you have in computing programs?	0, 1-2, 3-4, 5-6, 7-8, 9-10, More than 10
Question E: Which of the following describes the **majority of your friends** in computing programs? *Mark all that apply.*	▪ Same gender as you, ▪ Same race as you, ▪ Same cultural ancestry as you, ▪ Not at all similar to how you identify

Table 1: Relevant items for work from questionnaire

Demographics

In total, *n*=740 students completed the survey, all of which were computing students from CE, CS, and IT majors. Among these participants, 147 identified as female, 488 identified as male, and 15 identified as agender, transgender, or "a gender not listed." The race and ethnicity affiliations of

the students were: 42.2% White, 8.4% Black or African American, 14.9% Asian, 1.1% Native Hawaiian or Pacific Islander, 0.4% American Indian or Alaskan Native, 32.7% were Hispanic, Latinx, or Spanish origin.

Data Preparation and Analysis

After the data was collected, it was loaded into R studio for cleaning and analysis. While there are multiple ways of imputing missing data, one way to handle missing values is to exclude them from the data set [59]. Given that the data had a limited number of missing values (NAs), we chose to exclude the missing values from the dataset.

To answer RQ1 and RQ2 we employed logistic regression from generalized linear models. Logistic regression is a useful model for predicting a binary outcome from a set of continuous predictor variables [60]. We also applied Wilcoxon rank sum tests, which are used to compare a set of values to another value, and in our case, we examined minoritized students relative to those not in the group [63]. In our work, they were used to examine if the experiences differ by gender. In this study, we also wanted to predict the interest in pursuing a graduate degree using the experiences students reported. To answer RQ2, we applied a Kruskal-Wallis test; it is a ranked based test which can determine if there are statistically significant differences between two or more groups of an independent variable on a dependent variable [61]. We used this test to examine if having friends with the same gender/race/ethnicity (our independent variables) have a statistically significant impact on students' self-reported interest in pursuing a graduate degree (dependent variable). It worth noting that we set our threshold for statistical significance at 0.05.

Results

In order to answer RQ1, we examined the relationship between social and programmatic experiences and students' interest in pursuing graduate degrees using logistic regression. We considered 10 different experiences from Question A in the survey as described in Table 1. The results of the logistic regression revealed that there is a significant ($p< 0.01$) positive relationship between "Presenting work to other students" (Estimate = 0.82) and "Research Experience" (Estimate = 0.83) and students' interest in pursuing a graduate degree in a computing field. Conversely, there was a significant ($p< 0.01$) negative relationship between pursuing a graduate degree in computing and "Being helped by other student(s) with school/coursework" (Estimate = -0.43).

We used several methods to answer RQ2, and to examine how a student's gender/race/ethnic background and their participation in these significant social and programmatic experiences impacted their interest in pursuing graduate degrees. First, we used Wilcoxon rank sum tests to compare if the impact of experiences differed by gender, race, and ethnicity, since a student's self-reported background may have influenced which experiences had the greatest impact [62]. In these

tests, we only considered the experiences which had a significant (positive or negative) impact on students in pursuing a graduate degree in computing.

There were no significant differences by race or ethnicity. In addition, there were no gender difference for "Presenting work to other students" nor "Being helped by other student(s) with school/coursework." However, according to our analysis, on average, females reported having research experience 23% of the time, as compared to only 0.11% of those that identified as "not females."

Predictors	Estimates	SE	z-Value	Sig.
Intercept	0.37	0.13	2.84	**
Helping other student(s) with school/coursework	0.31	0.17	1.73	ns
Being helped by other student(s) with school/coursework	-0.43	0.18	-2.33	*
Helping other student(s) about career/personal issues	-0.85	0.19	-0.43	ns
Being helped by another student(s) about career/personal issues	0.11	0.20	0.57	ns
Being part of a computing group, club, etc.	-0.04	0.18	-0.25	ns
Attending social events organized by the department	0.05	0.20	0.27	ns
Presenting work to other students (not classwork)	0.82	0.30	2.70	**
Community or K-12 outreach (voluntary or for a course)	0.56	0.30	1.82	ns
Interacting with students in different year(s)	-0.10	0.19	-0.52	ns
Research Experience	0.83	0.26	3.17	**

ns: not significant; ** $p < 0.01$; * $p < 0.05$

Table 2: Logistic regression analysis on social experiences and students' interest in pursuing graduate degrees

Experience	p-value	Not Female Mean	Female Mean
Research Experience	***	0.11	0.23

***p< 0.001

Table 3: Wilcoxon rank sum test on Research Experience for Female and Not Female students

Then, we used Question E from Table 1 to explore how the friends' backgrounds may have influenced the decision to pursue a graduate degree in a computing field (e.g., CE, CS, or IT). We applied a Kruskal-Wallis test, looking at the intent to pursue a graduate degree as the outcome. The results revealed that there is no significant relationship between having same race or cultural ancestry (intended to consider their ethnicity) friends and interest in pursuing a graduate computing degree. However, there is a significant relationship between having same gender friends in the discipline and pursuing a graduate degree in computing fields. To understand the size of the

impact, we used Epsilon-Squared (ϵ^2) [64]. The results of the test revealed that having same gender friends had a small effect on students' interest in pursuing a computing graduate degree ($\epsilon^2 < 0.08$).

	Majority of Friends		
	Chi-Square	**p-value**	**df**
Same gender as you	5.15	*	1
Same race as you	0.84	ns	1
Same culture ancestry as you	0.58	ns	1
Not at all similar to you	0.03	ns	1

ns: not significant; * $p<0.05$

Table 4: Kruskal-Wallis test on majority of friends and pursuing graduate degrees

Additionally, we wanted to know how specific forms of social support such as peers, faculty, advisors, etc. (Question B), and family (regarding how supportive students reported their home-environment was towards computing- Question C) impacted students' interest towards pursuing a graduate degree in computing. Furthermore, given the importance of same gender friends in computing (which we observed to be significant), we additionally wanted to examine if the number of friends in computing was important as well (Question D) towards interest in pursuing a graduate degree in computing. Thus, we applied logistic regression and examined the impact of each of these aspects of social support/experiences on students' interest. Results revealed that there were no significant impacts of any experiences mentioned and students' reported interest in pursuing a graduate computing degree.

Limitations

The data for this study is limited in several ways. It was solely based on undergraduate students' self-reports in an online survey. Therefore, the experiences were open to interpretation, and since we only used quantitative analysis, we could not delve deeper. In the future, we suggest a qualitative analysis to complement this study, and to obtain a comprehensive look at these experiences. Also, while it was beyond the scope of this investigation, further studies should consider intersectionality rather than separating out the data by race, gender, and ethnicity.

Furthermore, our methods may have been limited in that we set the cutoff for statistical significance at 0.05. While this is within accepted limits, it is possible that we obtained these findings occurred by chance. In addition, we used backwards elimination to build our model for regression, and while we followed statistical levels for doing so, variations in the results may have been subject to decisions made.

Discussion

The findings demonstrated that multiple experiences may affect students' decision to pursue a graduate degree. In particular, students were positively influenced by presenting work to other students (oral presentation) and research experience, when considering pursuit of a graduate degree

in computing fields. According to the literature there is a correlation between academic achievement and oral presentations [65]. Oral presentation skills contribute to students' success in academic performance and in their social life [66]. As such, our research confirms existing literature.

Our finding on undergraduate research experiences also aligns with others in the field and confirms that undergraduate research experience improves the intentions of pursuing a graduate computing degree [67]. It has been previously demonstrated that undergraduate research experience can enhance students' sense of belonging, motivation, confidence and persistence in the field, as well as increase graduate school enrollment and career interest [68][69]. Gaining practical experience with computing concepts and skill development during Research Experiences for Undergraduates (REU), have demonstrated an important role in self-efficacy and professional identity development [70]. However, the impact of such experiences is different for women and underrepresented racial/ethnic groups, which the authors attribute to cultural contexts at the REU sites [70]. Experience with REUs may provide familiarity with additional occupational option that students did not realize existed before learning more about research. However, due to the prior work showing an interest for minoritized populations, we must consider that not all research experiences are equal, and other factors may mediate this interest.

We also found that "Being helped by other student(s) with school/coursework" had a significant negative impact on pursuing a graduate degree. These findings contrast with prior work on the importance of positive peer experiences in shaping computer attitudes and construction of self-image [71]. However, we hypothesize this may be due to discomfort from needing to ask for help, which has been shown to be intimidating [72]. Alternatively, receiving help may reduce future interest in proceeding in the field since students perceive their own skills as insufficient, and perceive it as an indication of their own lack of ability [71][73].

We then tested the significant experiences on gender. We observed that there were no significant relationships between "Presenting work to others" and pursuing a graduate degree. Thus, we only reported the significant relationship between "Research Experience" and pursuing a graduate degree in computing. These results align with the literature that female students are more likely to participate in research experiences in general [74].

Next, we narrowed our analysis to examine the impact of friends. Earlier our results demonstrated there was no significant impact of having friends in computing fields on students' interest in pursuing graduate degrees. However, we wanted to understand how friends with different backgrounds (in the context of gender, race, and ethnicity) impact students. According to the literature, all students in computing do not receive the same impact from friendships [48]. A recent study demonstrated same-sex friendships positively link with self-esteem and academic performance [77]. As such, we analyzed how having friends of the same gender, race, or culture

impacted students' interest in pursuing a graduate degree in computing fields. The results confirmed that there was a statistically significant, and positive, correlation between same-sex friendships and students' interest in pursuing a computing degree.

As discussed earlier, varied influences -such as society, parents, learning assistants, faculty, school, peers, socio economic status, and culture- can impact students' educational paths [48][75][76]. However, when examining the social experiences students report, such as receiving help from teaching and learning assistants, advisors, faculty, or peers, having a home environment supportive of computing, and number of friends, we did not find any significant relationship between students' social support and their reported interest in pursuing graduate degrees. While peer support does not have a direct effect on interest in graduate school, this does not preclude the possibility that it has an indirect effect. Yet, we did not take into consideration other factors such as students' socio-economic status, learning environments, family size, friendship life spans. More in-depth understanding is required, and likely the importance of peer support and influence could be better teased out through qualitative analysis.

Conclusion and Future Work

In summation, our study demonstrated that social support could impact students' interest in pursuing a graduate degree in computing fields, using a quantitative methodology. We described that students are most influenced by "Presenting work to other students" and "Research Experience." We also found same-sex peer relationships have a significant impact on their peers' education relative to other types of friendship. Therefore, having friends of the same-sex, and having research and oral presentation experiences can motivate students to pursue graduate degrees in these fields.

Based on these findings, we recommend that departments promote activities such as Course-Based Undergraduate Research Experience (CURE) classes. CURE are a form of classroom offering, that gives students the opportunity to gain hands on experience and to generate new knowledge within their discipline [78]. Additionally, they should create or promote a "undergraduate research day" to allow students an opportunity to present their work [79]. Furthermore, we suggest increasing opportunities for students to attend and participate in seminars, workshops, and academic gatherings (e.g., a journal club) to increase engagement and help to ingratiate them into the computing community [80]. Likewise, they should encourage undergraduates attend conferences, presenting work and/or building their professional and peer network. To help defray the costs that might otherwise deter students, departments should present information related to fellowships, scholarships, and research opportunities offered by different organizations to attend conferences like Association for Computing Machinery (ACM), Institute of Electrical and Electronics Engineers (IEEE), or Grace Hopper Celebration (GHC). They could also set aside funds to support students directly to participate at these meetings as well. Finding friends and connecting to peers at college (undergraduate) level is an exceedingly complex phenomenon, and dynamics vary in

respect to students' social and educational background, family, personality, etc. [81]. While departments cannot force students to mingle, there are ways they can help to create opportunities for students to gather and interact. To this end, we recommend departments host social events, student club meetings, and teatime meetings where students have the opportunity to meet and connect with more peers of varied backgrounds; rather than limiting students to only the peers they meet in their classes (post-COVID-19) [82].

Since there is an extensive need for more graduate students in the computing fields in the U.S., departments and colleges need to encourage students' enrollment and persistence. Developing welcoming environments for students to build friendships, gain experience with research, and allowing them to present their research to others can all be beneficial. Going forward, we encourage educators to offer increased opportunities in alignment with the work described here, to foster student interest, and to broaden participation in graduate fields.

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