Gauging the Health of the Computing Research Ecosystem: A National Study of Undergraduate Research Applicant Trends, Interest, and Research Capital

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Her dissertation investigates a multi-level intervention framework that engages undergraduate students, K12 teachers, and K12 students in the design, evaluation, and implementation of generative AI–supported instructional materials. Centered on an undergraduate course, her work examines how students develop AI literacy through artifact creation, how teachers evaluate the quality and classroom readiness of AI-generated materials, and how these materials function in authentic K12 classroom settings.

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1 Abstract

Attracting undergraduate students into computing research is crucial for increasing research productivity, yet funding support for traditional undergraduate research models is highly competitive and under scrutiny. This study focuses on one national computing research program as a lens to gauge the health of the computing research ecosystem. Application trends to the National Science Foundation CISE REU program were examined to understand the computing research pipeline and its potential for expanding research capacity in the US. This study focuses on the demographic backgrounds, initial interest, and research network capital of program applicants and trends over time. Data from 16,733 undergraduate applicants to a competitive national undergraduate research program (2010-2021) were analyzed using descriptive statistics. Applicant demographics were examined using frequencies and Chi-square analysis, with z-tests and Bonferroni correction to assess significant differences between groups. The applicant demographic pool showed little change over time, indicating that the computing research pipeline is not expanding rapidly enough to be competitive globally. Peers and university contacts were strong sources of research network capital, with significant differences observed by gender and race/ethnicity. These findings are considered to provide insights for faculty, academic departments, and funders who want to cultivate robust educational and career pathways to computing research in the US. Implications for expanding pathways into computing undergraduate research programs are discussed.

2 Introduction

Maintaining a robust computing research workforce is crucial for driving innovation, advancing technology, and ensuring global competitiveness [1]. Innovation is fueled by cognitive diversity [2] that encourages multiple perspectives in approaching problems. Ethnically diverse teams have been shown to consider a wider range of options, make better decisions, develop better products, and devise creative ideas [3]. Therefore, it is important that the pathways into computing research are open to everyone and representative of the diverse cultural perspectives our society embodies.

Recent efforts to tighten federal research budgets [4] have raised concerns among research institutions, potentially compromising their ability to sustain a rigorous and diverse research enterprise. Vital funding sources, including the National Council on Undergraduate Research, the National Institutes of Health, and the National Science Foundation (NSF) provide long standing support for universities to provide undergraduate research experiences as a means of recruiting students into academic and professional research careers [5]. With financial support for these programs threatened, the funding landscape is becoming increasingly competitive among academics, or disappearing altogether [6].

Many studies have shown that participating in undergraduate research (UR) sparked new interest in graduate study or reinforced existing plans to pursue it [7]. Therefore, a critical pathway for cultivating a diverse research ecosystem is through expanding undergraduate research experiences [8]. UR programs not only enrich students, they also support the institutional research enterprise [9]. UR programs recruit and prepare students for graduate school [10] and improve their self efficacy and sense of professional identity [11, 12, 13]. These benefits are conferred through various models, with the most common types of UR experiences being course based, traditional apprenticeship, and collaborative models [14].

A prominent avenue for computer science research is provided by the National Science Foundation (NSF) Research Experiences for Undergraduates (REU) Programs. This program provides undergraduate students with opportunities to participate in hands-on, mentored research across a wide range of scientific disciplines through funded summer programs hosted at universities. Students work closely with faculty and graduate mentors on real research problems, gaining technical skills, professional development, and insight into graduate study and research careers. The NSF directorate of Computer and Information Sciences and Engineering (CISE) currently sponsors about 270 REU programs at colleges and universities which host approximately 735 undergraduate students across the US each year [15]. The goals of the NSF CISE REU Program (CISE REU) are to develop undergraduate research and academic skills with the aim of cultivating a research development pipeline for global science and innovation [16]. As a leading supporter of the computer science research ecosystem, the CISE REU program offers a strategic vantage point from which emerging trends about the research pipeline can be gleaned.

This study examines demographic trends of the applicant pool of the CISE REU program over 12 years, focusing on applicants' initial interest in computing and their research network connections. We explore differences in early interest and research connections by demographic identities (i.e., gender, race/ethnicity, first-generation status, and disability status) as these may indicate opportunities to support a diverse research ecosystem. By investigating patterns across time and within demographic subgroups, we aim to identify shifting and emerging trends to gauge the health of the computing research pipeline and to highlight areas requiring greater recruiting efforts.

3 Background

Examining key features of student early interest in and exposure to research pathways is important for understanding entry-level research access. We consider when students initially develop an interest in computing and their research network capital, i.e. the social connections that support research engagement, as these are central indicators of computing research pathway access. We describe the demographic composition of computing degree programs and highlight the benefits of undergraduate research across student demographic groups.

3.1 Computing Student Population

Considering the time period relevant to our study, undergraduate enrollments in computing, a gauge of the computing workforce, increased dramatically between 2011 to 2021, from 60,636 [17] to 182,810 [18] students, though the representation of marginalized groups has not reached parity with the national population. Women made up 22.3% of the computing undergraduate population in 2021 [18], while Black students represented 3.9%, Hispanic students represented 9.6%, Multiracial students represented 3.5%, and American Indian/ Alaska Native students represented 0.2% of all undergraduates in computing [18] These groups remain underrepresented in computing [19], posing ongoing challenges to broadening participation and building a diverse technical workforce.

3.2 Benefits of Undergraduate Research

Undergraduate research fosters both learning and interpersonal growth and is considered a form of “relationship-rich” education [20]. Participation in research has been shown to increase students’ research skills, such as data collection, analysis, literature reviewing, and scientific communication [10, 11, 21, 12]. Participation in research also fosters transferable skills such as teamwork, communication, problem-solving, independent work, and resilience in the face of failure [21]. These experiences build technical and professional skills and support persistence in computing, especially among underrepresented students [8, 11]. Early engagement in formal research supports a stronger sense of mentorship and belonging in the field, which is especially meaningful for women, Black and Hispanic students [22]. Increases in confidence and STEM career interest for participation in URs were more pronounced for students from underrepresented groups [13]. While empirical literature about students with disabilities and UR experiences is sparse, participating as knowledge producers has been identified as a key factor for enhancing persistence for students with disabilities pursuing STEM fields [23]. Clearly, UR experiences offer valuable educational and career preparation opportunities that connect students directly to the computing community.

4 Inequities in Undergraduate Research Participation

While UR experiences are well known as high impact educational practice, few students engage in these enriching educational opportunities and there are critical differences across student groups. According to the National Student Survey of Engagement (NSSE), just 22% of US seniors reported having had any undergraduate research experience in 2019 (most recent available) [24]. In one study of doctoral granting high research activity institutions in the southeast, 28% of undergraduate students in the sample participated in research [25], and among those, 13% indicated having a disability, and 17% reported a race/ethnicity designation from a group traditionally marginalized in science. Studies of NSSE data from 2013 [26] and 2015-16 [27] both found women were more likely than men to have participated in undergraduate research. There are also racial/ethnic differences in UR participation as Asian and White students engage in UR at higher rates than Black and Hispanic students [28, 26]. UR participation rates for Black students also vary across institutional types as Black students attending HBCUs are more likely to engage in research than their counterparts at predominantly white institutions (PWIs) [26]. Additionally, first-generation students are less likely to participate in undergraduate research opportunities than students whose parents have attended college [29, 28]. Access to undergraduate research is fairly limited and certain groups are excluded. Given the well-known benefits of research engagement, it is imperative to extend these opportunities to all students. Key facets known to motivate and prepare students for research are described to provide context for the study.

4.1 Early Interest in Computing

The educational stage (i.e., elementary school, middle school, high school, and college) at which students initially develop interest in computing plays a key role in fostering engagement in the field, though this may be shaped by access to computer science education, which is stratified across sociocultural lines [30]. Early interest is defined as interest prior to the college years [31], and even earlier exposure has demonstrated educational advantages. Early exposure to computing has been shown to stimulate interest and increases persistence in the field [32, 33], to addresses the social and structural barriers into computing pathways [32], and can reduce stereotype threat [32, 34, 35]. Early exposure to computing builds cumulative learning advantages; without which, their interest and readiness may suffer.

4.2 Research Network Capital

Engagement in scientific education and research are often viewed as elite activities most available to students with educational privilege and who know someone in research [36]. Cultural capital refers to social advantages, e.g. access to information and skills, and is handed down generationally [37]. Science capital, a related concept, is connection with people and and engagement in scientific endeavors [38]. We present a composite of these concepts, *research network capital*, which is indicative of the social connections that support undergraduate research engagement. These connections include faculty [39], peers [40], and family [41]. Social connections strongly influence computing pathways for underrepresented students. Family encouragement and mentors help spark interest [42], while peer support fosters belonging and persistence [43]. For example, family has considerable influence for African American women in their pursuit of computing [44]. Understanding the extent of students' research network capital may illuminate opportunities to provide additional support to bolster the computing research ecosystem.

Early interest and research network capital are intertwined. Interest is characterized by positive experience in the topic and a developing focus of attention, which unless connected to support, such as activities and people, the interest will likely wane [31]. For example, having a parent in CS is a strong prediction of sustained engagement [45]. Women and students from minority backgrounds have been found to develop interest in computing later than White and Asian males [46]. Developing CS interest later, coupled with low social capital may lead to CS attrition [47], which may largely explain the disparity of women and minority students in CS overall. With early interest and access to CS educational opportunities, students are able to obtain more exposure, increase their knowledge sooner, and develop a network of supporters to help drive and sustain their engagement in computing long term.

5 Theoretical Framework

This study is motivated by social cognitive career theory (SCCT) [48], which posits that career interests, goals, and actions are shaped by personal characteristics, background contextual affordances, learning experiences, self-efficacy and outcome expectations, and proximal contextual influences. Specifically, this study addresses how personal characteristics and background contextual affordances (e.g., first interest in computing and research network capital) may influence students' pursuit of UR learning experiences. From this framework, we theorize that engagement in the computing UR pathway is accessed by students who demonstrate early interest in computing and who have the research network capital that supports their engagement.

6 Research Questions

To investigate this hypothesis, we examine longitudinal trend data from the CISE REU program applicant pool over time to discover trends among applicants as an observational lens of the computing research pipeline. This study is guided by the following research questions:

RQ1: What are the demographic characteristics of UR applicants, and how do they vary over time?

RQ2: What patterns are observed for initial interest in computing and research network capital over time and across student identities?

7 Methods

7.1 Data Source

Data for this study were drawn from the CISE REU program applications, which included a total of 50 items to capture applicants' demographic and academic characteristics, research interest, exposure to computing and future goals, and students' access to a network of people involved in research. The application items were created by the faculty managing CISE REU programs via a study of collective CISE REU programs applications [49], to streamline the application process. The application process and data was managed directly by the first author as Principal Investigator of National Science Foundation sponsored research. Only applicants who provided consent to participate in the research were included in the analytic dataset.

7.2 Sample

Applicants were able to apply to multiple UR sites within the same year, and across years throughout their college career; meaning that those students appear multiple times in the dataset. We constrained the sample to unique student entries within each program application year, removing duplicate cases within the same year. The analytic sample includes 16,733 applicants across the 12 years from 2010-2021. The applicant demographics by year and characteristics are shown in Table 1.

Table 1: Proportion of REU Applicant Pool, by Demographics and Year (n=16,733)

													Z-Test Proportion (2010 vs. 2021)	
Category	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Z**	**p-value**
Gender (n=16,567)														
Male	71.4	72.0	68.8	71.7^{a}	72.4^{a}	74.0^{a}	68.2^{a}	68.1^{a}	69.9^{a}	65.5^{a}	65.1^{a}	63.5^{a}	1.994	$0.047*$
Female	28.6	28.0	31.3	28.3^{a}	27.6^{b}	26.0^{b}	31.8^{a}	31.9^{a}	29.3^{a}	33.7^{b}	33.5^{b}	35.4^{b}	-1.7257	0.084
Non-binary	0.0	0.0	0.0	0.0^{b}	0.0^{c}	0.0^{c}	0.0^{b}	0.0^{b}	0.9^{b}	0.9^{c}	1.4^{c}	1.1^{c}	-1.3434	0.180
Race/Ethnicity (n=16,343)														
White	57.8^{a}	50.7^{a}	45.8	56.0^{a}	53.8^{a}	53.7^{a}	48.1^{a}	49.1^{a}	50.2	46.7^{a}	43.9^{a}	45.5^{a}	2.9641	$0.003**$
Asian or Multiracial Majority	8.1^{b}	11.4^{b}	21.1	13.7^{b}	17.1^{b}	16.2^{b}	19.1^{ab}	22.5^{b}	20.3	21.8^{b}	23.4^{b}	28.6^{b}	-5.5926	$< .00001**$
BLIM	34.2^{a}	37.8^{a}	33.2	30.3^{a}	29.1^{ab}	30.2^{a}	32.8^{b}	28.4^{a}	29.5	31.5^{ab}	32.7^{b}	25.9^{a}	2.2356	$0.025*$
Intersectional Groups (n=16,208)														
White Men	45.6	38.5	31.8	41.5^{a}	40.3^{a}	40.7^{a}	34.0	34.6^{ab}	36.3^{a}	31.7^{a}	28.5^{a}	29.0	4.3145	$< .00001***$
White Women	12.5	12.0	13.2	14.1^{a}	13.4^{ab}	12.8^{abc}	13.9	14.4^{ab}	13.0^{a}	13.2^{ab}	14.1^{ab}	15.5	-1.0134	0.312
White Non-binary	0.0	0.0	0.0	0.0^{abcd}	0.0^{ab}	0.0^{abc}	0.0	0.0^{b}	0.7^{b}	0.6^{ab}	1.1^{c}	0.8	-1.1689	0.242
Asian or Multiracial Majority Men	5.6	7.5	17.7	9.4^{cd}	11.0^{ab}	10.8^{bc}	11.7	13.9^{ab}	13.1^{a}	13.0^{ab}	15.3^{b}	18.4	-4.0589	$< .00001***$
Asian or Multiracial Majority Women	2.5	4.0	4.1	4.5^{bd}	6.0^{ab}	5.3^{c}	7.4	8.5^{ab}	7.1^{a}	8.9^{b}	8.1^{ab}	10.2	-3.1524	$0.002**$
Asian or Multiracial Majority Non-binary	0.0	0.0	0.0	0.0^{abcd}	0.0^{ab}	0.0^{abc}	0.0	0.0^{ab}	0.1^{ab}	0.1^{ab}	0.2^{abc}	0.1	-0.3363	0.728
BLIM Men	20.0	26.0	20.9	20.8^{a}	21.4^{ab}	22.5^{ab}	22.4	19.7^{ab}	20.5^{a}	19.8^{ab}	21.3^{b}	16.4	1.1609	0.246
BLIM Women	13.8	12.0	12.3	9.6^{ac}	7.9^{b}	7.9^{bc}	10.6	8.8^{ab}	9.1^{a}	11.5^{b}	11.4^{b}	9.4	1.7544	0.080
BLIM Non-binary	0.0	0.0	0.0	0.0^{abcd}	0.0^{ab}	0.0^{abc}	0.0	0.0^{ab}	0.0^{ab}	0.2^{ab}	0.2^{abc}	0.2	-0.5828	0.562
First-Generation Status (n=16,665)														
Continuing Generation Students	73.5^{a}	77.1	87.1	83.2	82.8	83.4	82.4	84.0^{a}	82.6	81.6	78.5^{a}	80.9	-1.9376	0.0524
First-Generation Students	26.5^{b}	22.9	12.9	16.8	17.2	16.6	17.6	16.0^{b}	17.4	18.4	21.5^{b}	19.1	2.2728	$0.023*$
Disability Status (n=15,954)														
Students w/o Documented Disability	98.1	98.4	96.3	96.4	96.4	95.9	95.8	95.9	95.6	95.5	95.1	94.6^{a}	1.8878	0.059
Students w/ Documented Disability	1.9	1.6	3.7	3.6	3.6	4.1	4.2	4.1	4.4	4.5	4.9	5.4^{b}	-1.8953	0.057
First-Interest in Computing (n=16,661)														
Elementary School	30.2^{a}	22.9	22.7	23.8^{a}	22.6	22.3	20.5^{a}	19.9	20.8	19.9	17.1^{a}	20.2	2.9625	$0.003**$
Middle School	37.0^{ab}	36.3	35.1	31.7^{ab}	31.3	32.1	30.1^{a}	31.3	33.6	32.1	34.4^{b}	32.9	1.0455	0.294
High School	25.9^{b}	26.9	28.9	31.5^{b}	32.7	32.2	33.2^{a}	34.0	33.5	35.3	36.3^{b}	34.4	-2.1863	$0.029*$
Colleges	6.8^{b}	13.9	13.4	13.0^{ab}	13.4	13.4	16.2^{b}	14.8	12.1	12.7	12.2^{ab}	13.4	-2.0986	$0.036*$

Note. Superscripts indicate significant differences between years at $p < .05$.

Note. * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

7.3 Variables and Measures

Demographics: Gender was reported as male, female, and non-binary[1]. Race/ethnicity was provided as a checkbox of options that mirrored the categories of the CISE REU program. While we recognize that demographic groups have different experiences, for the purposes of this statistical analysis, an aggregated applicant group was created of students who have been underrepresented in computing: Black, Latinx/Hispanic, Indigenous (Native American, Native Hawaiian, and Pacific Islander), and multiracial students with any of the aforementioned identities. This group is referred to by the term "BLIM". Thus, three racial/ethnic categories were created: (1) White students, (2) Asian or Mixed-majority students (those who identify as White and Asian), and (3) BLIM. Intersectional groups were created using gender*race, yielding nine groups. "Prefer not to specify" was an option for both gender and race/ethnicity. Variables representing students' first-generation or continuing generation status, and if they identified as having a disability, were also examined.

Computing Interest: In one item, students indicated when they were first interested in computing, either in elementary, middle school, high school, or in college.

Research Network Capital: Students answered four (yes/no) questions about whether they had an immediate family member, other family member, a non-faculty university contact, or friends involved in research. The research network capital scale is a composite scale of the number of "yes" responses given to these four items. Research network capital questions were also analyzed individually (e.g., examining who responded affirmatively to having relationships with non-faculty members or peers in research).

7.4 Analysis

The demographic characteristics of applicants were investigated using frequencies and two-way cross tabulations with Chi-square analysis. Z-tests with the Bonferroni correction were used to assess significant differences between groups (e.g., gender, race/ethnicity) and to determine significant changes in proportions over time for all variables of interest, from the first year of data, 2010, to the most recent year available, 2021 (Table 1). Differences in research network capital were investigated using frequencies and two-way cross tabulations with Chi-square analysis (Tables 2 and 3).

7.5 Limitations

While there is value in examining applicant pool demographic trends as an indicator of potential diversity in the computing research pipeline, it is important to acknowledge the limitations of this study. Since this data only examines applicant data, we cannot draw conclusions about who was actually selected for and participated in the research experiences. Findings from this study speak only to who was interested in participating in the CISE REU program, not to the actual diversity of the program. Also, we recognize this is not an intersectional study, but rather a study of intersectional populations [50]. The intention was to understand how the academic backgrounds

[1] The addition of non-binary identities was first introduced in 2018, so applicants prior to 2018 were limited to a dichotomous gender.

and aspirations of population groups may yield insight into strategies for expanding access to research pathways. Lastly, a limitation of the instrument is that it did not ask about research connections to university faculty; however, applications to the UR program required at least one faculty recommendation letter. Also, it is possible students had more than one individual person represented in each of the four groups of contacts.

8 Results

RQ1. The first research question sought to understand the overall demographic characteristics of CISE REU program applicants and how these may have varied over time. Below, we discuss specific changes observed across the UR applicant demographic characteristics (all data shown in Table 1).

Gender. The gender diversity of the applicant pool has varied in the 12 year period as the proportion of women has fluctuated from 28.6% in 2010, to a low of 26% in 2015, and to a recent high of 35.4% in 2021, although these changes were not statistically significant. However, there has been a significant decline in the proportion of men applying to UR programs, from 2010 (71.4%) to 2021 (63.5%). Additionally, the proportion of non-binary applicants is quite low and has not significantly changed since 2018 when non-binary option was first introduced as a selection.

Racial/Ethnic Groups. Examining proportional changes by racial/ethnic group reveals a significant decline in the proportion of white students (from 57.8% in 2010 to 45.5% in 2021). In 2010, BLIM students comprised more than one-third of applicants (34.2% precisely), however these percentages have fluctuated over the 12 year period, from a high of 37.8% in 2011 to 28-32% from 2013-2019. Notably, the proportion of BLIM applicants reached a low of 25.9% in 2021, down from 32.7% in the prior year. Overall, there was a significant decrease in the proportion of applications from BLIM groups from 2010 to 2021. These declines in White and BLIM students are offset by the clear and significant increase in the proportion (more than three times) of students identifying as Asian or Multiracial majority (Asian and White). This group increased more than three fold, from 8.1% of applicants in 2010, to 28.6% in 2021.

Gender/Racial/Ethnic Intersections. We also examined trends in applicants by their intersecting gender and racial/ethnic identities. The proportion of applicants identifying as White men has significantly declined from 2010 (45.6%) to 2021 (29%) and the proportion of White women has been relatively consistent at 12-14%, though it peaked at 15.5% in 2021. Comparing gender differences across racial/ethnic groups, we see there had been comparable representation of White women and BLIM women among applicants in the early years from 2010-2012, though in the years since the representation of BLIM women has decreased to a low of 7.9% in 2014-2015, and it remains low at 9.4% in 2021.

First Generation Students. Trends for first-generation students compared to continuing generation students whose parents or guardians had attended college showed that in 2010, more than one-quarter (26.5%) of applicants were first-generation students. This number fell below 13% within two years, and stabilized to 16-18% from 2013 to 2019. Slightly more applicants indicated first-generation status in 2020 (21.5%), which dropped slightly to 19.1% in 2021.

Overall, a significant decline in the proportion of first-generation applicants was found from 26.5% in 2010 to 19.1% in 2021.

Students with Disabilities. There has been a steady upward trend in the proportion of applicants who identify as having a disability, increasing from 1.9% in 2010 to 5.4% in 2021, though this change was not statistically significant.

RQ2. The second research question aimed to understand when students initially become interested in computing, and the extent to which students have sources of research connections.

Initial Interest in CS. We examined initial interest in computing (Table 1). In the early years of the program, more than two-thirds of applicants had developed an interest during elementary and middle school. Initial interest in computing is shifting later, with significant decreases in elementary interest from 2010 (30.2%) to 2021 (20.2%), and significant increases in students who first became interested in computing in high school (increased from 25.9% to 34.4%) or in college (increased from 6.8% to 13.4%).

Research Network Capital. As shown (Table 2), nearly one-quarter of applicants (22.2%) did not have any research connections. Approximately one-third (34.6%) reported having one connection to someone involved in research, while one-quarter (26.2%) of students reported two research connections. Fewer applicants reported having three connections in research (11.5%) and even fewer reported four connections (5.4%). Thus, a majority of students (60.8%) had only one or two connections in research when they applied for the UR program.

Table 2: Proportion of Students by Research Capital Connections and Demographic Characteristics (n=16,574)

	Number of Research Network Connections				
	0 (n = 3,680, 22.2%)	1 (n = 5,736, 34.6%)	2 (n = 4,354, 26.2%)	3 (n = 1,905, 11.5%)	4 (n = 899, 5.4%)
Gender					
Male	22.4	33.8	26.8	11.7	5.3
Female	21.9	36.2	25.2	11.0	5.6
Non-binary	19.7	39.4	25.4	9.9	5.6
Race/Ethnicity (n=16,188)					
White	21.1	34.3	26.3	12.5	5.8
Asian or Multiracial Majority (White & Asian)	19.3	32.2	27.0	14.0	7.5
BLIM	26.0	36.9	25.8	8.0	3.2
Intersectional Groups (n=16,058)					
White Men	22.0	33.5	26.4	12.6	5.5
White Women	18.9	36.2	26.0	12.3	6.6
White Non-binary	18.5	40.7	25.9	9.3	5.6
Asian or Multiracial Majority (White & Asian) Men	20.1	30.0	27.7	14.5	7.8
Asian or Multiracial Majority (White & Asian) Women	17.9	35.4	26.2	13.5	7.0
Asian or Multiracial Majority (White & Asian) Non-binary	16.7	83.3	0.0	0.0	0.0
BLIM Men	24.6	36.7	27.0	8.5	3.2
BLIM Women	29.2	37.5	23.4	6.9	3.0
BLIM Non-binary	12.5	12.5	37.5	25.0	12.5
First-Generation Students (n=16,574)					
Continuing Generation Students	19.9	33.5	26.9	13.3	6.4
First-generation Students	32.9	39.8	23.3	3.2	0.8
Students with a Documented Disability (n=15,805)					
Students without a disability	22.3	34.8	26.1	11.5	5.3
Students with a disability	22.0	31.8	29.2	11.1	5.9
First-Interest in Computing or Technology (n=16,573)					
Elementary School	21.3	31.4	27.8	12.8	6.8
Middle School	21.2	34.0	27.3	12.1	5.4
High School	22.7	35.7	25.9	10.9	4.7
College	25.0	38.5	22.1	9.4	5.0

Note. This table represents all students in the sample.

Next, we examined differences in the number of research network connections by student demographic characteristics (Table 2). The prevalence of these connections was similar across gender identities, but there were notable differences by race/ethnicity and by the intersections of gender by racial/ethnic identity. A higher proportion of BLIM students reported having fewer research connections (nearly 63% had 0 or 1) while a greater proportion of Asian or Multiracial majority students reported having more research connections (73% had 1-3 connections). Additionally, a greater proportion of first-generation students reported no (32.9%) or one (39.8%) research connection, compared to continuing generation students of which only 19.9% reported no research connections, and 33.5% reported one. Students who develop initial interest in computing earlier have more research capital than students who become interested later (i.e. high school or college).

Investigating the sources of this research network capital revealed interesting patterns (Table 3). Among all applicants, the most common source of research capital was friends, as 69.5% reported having friends in research. Next, 42.6% of applicants indicated research connections in non-faculty university contacts. One significant gender difference in sources of research connections was found: a higher proportion of men reported non-faculty university contacts compared to women and non-binary students. Significant differences in the sources of research network capital were found by race/ethnicity, the intersection of gender by race/ethnicity, first-generation status, and initial interest in computing. Significantly fewer BLIM students reported immediate or other family connections in research compared to their White and Asian counterparts. Accordingly, a greater proportion of BLIM students reported that non-faculty university contacts and friends as sources of research capital compared to their peers from other racial-ethnic groups. Similarly, a greater proportion of first-generation students reported non-faculty university contacts and friends as sources of research capital.

Table 3: Proportion of REU Applicants Indicating Research Capital Networks

	Research Capital Networks			
	Immediate Family	**Other Family**	**Non-Faculty Contact**	**Friends**
All Students	15.6	15.7	42.6	69.5
Gender (n=16,567)	$p = .683$	$p = .744$	$p = .017$	$p = .113$
Male	15.7	15.8	43.4	69.1
Female	15.4	15.6	41.0	70.3
Non-binary	12.7	12.7	39.4	77.5
Race/Ethnicity (n=16,343)	$p < .001$	$p < .001$	$p < .001$	$p < .001$
White	17.1	17.2	43.2	70.2
Asian or Multiracial Majority	19.5	18.7	47.2	73.1
BLIM	10.0	11.0	38.4	66.1
Intersectional Groups (n=16,208)	$p < .001$	$p < .001$	$p < .001$	$p < .001$
White Men	17.1	17.1	43.4	68.8
White Women	17.4	17.8	42.7	73.7
White Non-binary	11.1	13.0	38.9	79.6
Asian or Multiracial Maj. Men	19.9	19.2	48.9	72.1
Asian or Multiracial Maj. Women	18.7	18.0	44.9	74.9
Asian or Multiracial Maj. Non-binary	0.0	0.0	0.0	83.3
BLIM Men	10.3	11.2	39.7	67.9
BLIM Women	9.3	10.5	35.4	62.2
BLIM Non-binary	37.5	25.0	75.0	75.0
First-Generation Status (n=16,665)	$p < .001$	$p < .001$	$p < .001$	$p < .001$
Continuing Generation Students	18.5	18.1	45.2	71.2
First-Generation Students	2.3	4.8	30.5	61.8
Disability Status (n=15,954)	$p = .543$	$p = .783$	$p = .002$	$p = .180$
Students w/o Documented Disability	15.5	15.6	42.2	69.5
Students w/ Documented Disability	16.4	16.0	48.3	67.0
First-Interest in Computing (n=16,661)	$p = .013$	$p < .001$	$p < .001$	$p = .009$
Elementary School	17.0	18.0	47.0	70.6
Middle School	15.9	16.4	44.2	70.2
High School	15.1	14.4	40.7	69.4
Colleges	14.0	13.6	36.8	66.7

Note. Table includes only students reporting research connections. Note: Small sample size for BLIM Non-binary.

9 Discussion

Findings from the examination of demographic characteristics of CISE REU program applicants and how these vary over time indicate shifts by gender and race/ethnicity. We found that women and students from BLIM groups were over-represented among CISE REU applicants compared to current computing degree enrollments [18]. The proportion of women applicants was greater overall, ranging from 26%-35%, than that of the current proportion of women enrolled in undergraduate computing programs (22%)[18]. The proportion of White men significantly declined from 2010 to 2021, and while this may seem like a positive diversity indicator, this shift was due to significant increases in the proportion of Asian or Multiracial majority men and Asian or Multiracial women. A significant decline of BLIM students, and BLIM women, was observed overall, again likely due to the substantial increase in Asian applicants. However, it should be noted that the representation of BLIM students, even at its lowest point of 26% during the 12 year period, is higher than the proportion of BLIM students enrolled in undergraduate computing programs (18%)[18]. A decline for first-generation student applicants was observed, but an upward trend was observed among students reporting disabilities. Although these results represent applicants rather than participants, the trend of women and BLIM applicants being over-represented compared to their respective computing degree program enrollments suggest that CISE REU programs are attractive to students from historically marginalized groups and may be a positive indicator of the potential for diversification of the research pipeline.

Next, based upon existing literature [30, 32, 33, 38], the general hypothesis of this study was that engagement in the computing UR pathway is accessed by students who demonstrate early interest in computing and who have strong research network capital supporting their engagement. Our results show that interest in computing is shifting later, with significant increases in students who became interested in computing in high school or college. This is a promising finding that indicates research pathways are accessible to students who develop interest in computing at later educational stages. This shift is quite likely the result of a multifaceted and complex social context, like the advent of publicly available AI tools and the surrounding popularity, and the widespread efforts to broaden participation in computing overall. One example of this is the national upward trend in offering computer science education in high school curricula. In 2017, fewer than half of high schools offered CS courses; by 2021, 51% offered CS courses, with the trend continuing upward to 60% of high schools offering CS in 2025 [51]. However, students who develop an interest in computing earlier reported more research network capital than students who reported initial interest during high school or college. This finding demonstrates that early interest may confer cumulative advantage, as indicated in prior research [31, 47]. Offering multiple entry points into computing research can extend pathways and offset cumulative advantages. Expanding the range of introductory research programs can foster early engagement and persistence in undergraduate participation.

Research has shown that the primary influencers for undergraduate research engagement are professors [39] and family [41]. Though this study did not include a measure of faculty research connections, our study shows that peer groups and non-faculty university contacts, which we could conceive of as graduate students, post-docs, or academic staff, are also essential sources of support for undergraduate research engagement. With the majority of applicants reporting having only one or two research network connections, friends (69.5%) and non-faculty university contacts (42.6%) represented the majority of students' research network capital. Asian students had significantly higher numbers of family members in research compared to BLIM students, which according to (SCCT) [48], is likely a primary factor in the significant rise of Asian applicants. While BLIM and first-generation students reported having fewer research network connections, non-faculty university contacts were their primary sources of their research network capital. Given the importance of faculty mentors for motivating and retaining BLIM and women students in computing [22], it is promising to see that university staff and peers are vital resources within the computing research community.

Building extensive computing research communities on our campuses that extend beyond faculty to include peers and university staff, and offering multiple access points may sustain and grow the computing research ecosystem. An extensive computing research community could include offering a traditional summer research programs via external funding, providing course based research opportunities throughout the academic year for both early exposure and for capstone culmination, and making connections to campus wide research opportunities like internships and assistantships. The two primary reasons students indicate for not engaging in undergraduate research is lack of awareness and time commitment [25]. Several models demonstrate scalable approaches to entry-level research experiences [52], that engage women [53] and BLIM students in computing research [54] without the barrier of research being extra-curricular commitments. Additionally, integrating research into coursework may offset the faculty burden, institutional financial constraints, and student financial barriers to participation [14, 55, 56]. These strategies may expand pathways into computing research and may cultivate a more inclusive and sustainable computing research ecosystem.

10 Conclusion

Shifting UR applicant trends found in this study have implications for computing education and the computing research pipeline. This study contributes a longitudinal, demographic-informed analysis of a national undergraduate computing research program to assess the health and stability of the U.S. computing research pipeline. By examining applicant characteristics, initial interest, and sources of research network capital over more than a decade, the analysis shows a persistent stagnation in pipeline diversity and highlights uneven access to social and institutional supports. These findings inform faculty, departments, and funding agencies about where and how alternative undergraduate research models can broaden participation, strengthen research networks, and expand national computing research capacity. By incorporating a variety of research models into the computing curriculum, we can create more entry points into introductory computing research, and engage students regardless of initial interest and prior exposure. Offering multiple access points can also build valuable research network capital in support of long-term engagement. Leveraging our rich community of faculty, staff, graduate students and peers, can amplify computing innovation capacity. A strong computing research ecosystem is essential to innovation and technological advancement. Undergraduate research programs not only build the research capacity of faculty and their institutions, but also develop our collective capacity for technical innovation.

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References

[1] T. Hacker, P. Smith, D. Brunson, L. Arafune, T. Cheatham, and E. Deelman, "Building the research innovation workforce: Challenges and recommendations from a virtual workshop to advance the research computing community," in *Practice and Experience in Advanced Research Computing 2022: Revolutionary: Computing, Connections, You*, 2022, pp. 1–7.

[2] S. E. Page, "Where diversity comes from and why it matters?" *European Journal of Social Psychology*, vol. 44, no. 4, pp. 267–279, 2014.

[3] J. Miller, "The power of diversity and inclusion: Driving innovation and success," Forbes Business Council Council Post, Aug. 2023, membership (fee-based). [Online]. Available: https://www.forbes.com/councils/forbesbusinesscouncil/2023/08/16/the-power-of-diversity-and-inclusion-driving-innovation-and-success/

[4] K. Palmer, "Details of trump's budget cuts alarm researchers," *Inside Higher Education*, Jun. 2025. [Online]. Available: https://www.insidehighered.com/news/government/science-research-policy/2025/06/03/new-details-trumps-budget-cuts-alarm-researchers

[5] A. Stephens, K. Brenner, and J. Gentile, "Undergraduate research experiences for stem students: Successes, challenges, and opportunities," 2017.

[6] J. Alonso, "Trump's cuts threaten key nsf undergraduate research program," *Inside Higher Education*, Mar. 2025. [Online]. Available: https://www.insidehighered.com/news/students/academics/2025/03/11/trumps-cuts-threaten-key-nsf-undergrad-research-program

[7] S. Chowdhury, A. Alzarrad, and S. Youn, "Evaluating the impact of a summer nsf reu program on undergraduate students' stem career aspirations and educational goals: A case study," in *Proceedings of the 2025 ASEE North Central Section (NCS) Annual Conference*, American Society for Engineering Education. Huntington, West Virginia: ASEE, Mar. 2025.

[8] P. R. Hernandez, A. Woodcock, M. Estrada, and P. W. Schultz, "Undergraduate research experiences broaden diversity in the scientific workforce," *BioScience*, vol. 68, no. 3, pp. 204–211, 2018.

[9] A. M. Karkowski and J. S. Fournier, "Undergraduate research as a catalyst for institutional change." *Council on Undergraduate Research Quarterly*, vol. 33, no. 1, 2012.

[10] H. Thiry and S. L. Laursen, "The role of student-advisor interactions in apprenticing undergraduate researchers into a scientific community of practice," *Journal of science education and technology*, vol. 20, pp. 771–784, 2011.

[11] D. Lopatto, "Survey of undergraduate research experiences (sure): First findings," *Cell biology education*, vol. 3, no. 4, pp. 270–277, 2004.

[12] A. S. Rorrer, J. Allen, and H. Zuo, "A national study of undergraduate research experiences in computing: Implications for culturally relevant pedagogy," in *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, 2018, pp. 604–609.

[13] S. H. Russell, M. P. Hancock, and J. McCullough, "Benefits of undergraduate research experiences," *Science*, vol. 316, no. 5824, pp. 548–549, 2007.

[14] Z. Ahmad and N. J. Al-Thani, "Undergraduate research experience models: A systematic review of the literature from 2011 to 2021," *International Journal of Educational Research*, vol. 114, p. 101996, 2022.

[15] Center for Evaluating the Research Pipeline, "National science foundation computer and information science and engineering research experiences survey 2023 annual report," Computing Research Association, Washington, D.C., Tech. Rep., 2025.

[16] National Science Foundation, "Cise research experiences for undergraduates (reu) sites: Program guidelines for solicitation nsf 23-601," 2023, accessed: 2026-01-20. [Online]. Available: https://www.nsf.gov/funding/opportunities/cise-reu-sites-cise-research-experiences-undergraduates-sites

[17] C. R. Association, “Taulbee survey report: Computing degree and enrollment trends, 2010–2011,” Computing Research Association, Tech. Rep., 2012.

[18] CRA, “2021 taulbee survey: Undergraduate and graduate enrollment and degree trends,” Computing Research Association, Tech. Rep., 2022. [Online]. Available: https://cra.org/resources/taulbee-survey/

[19] Zippia, “25+ telling diversity in high tech statistics,” https://www.zippia.com/advice/diversity-in-high-tech-statistics/, 2023, race ethnic diversity in U.S. tech sector: white 62%, Black 7%, Latinx 8%, Asian 20%.

[20] P. Felten and L. M. Lambert, *Relationship-rich education: How human connections drive success in college*. Jhu Press, 2020.

[21] D. Lopatto, “Undergraduate research experiences support science career decisions and active learning,” *CBE—Life Sciences Education*, vol. 6, no. 4, pp. 297–306, 2007.

[22] J. G. Stout, N. B. Tamer, and C. J. Alvarado, “Formal research experiences for first year students: A key to greater diversity in computing?” in *Proceedings of the 49th ACM technical symposium on computer science education*, 2018, pp. 693–698.

[23] A. Lillywhite and G. Wolbring, “Undergraduate disabled students as knowledge producers including researchers: A missed topic in academic literature,” *Education Sciences*, vol. 9, no. 4, p. 259, 2019.

[24] National Survey of Student Engagement, “Engagement insights: Survey findings on the quality of undergraduate education,” Indiana University Center for Postsecondary Research, Bloomington, IN, Tech. Rep., 2019, national Survey of Student Engagement Annual Report 2019.

[25] E. A. Boyd and K. B. Lazar, “Undergraduate research science capital: Measuring capacity to engage in research,” *PLOS ONE*, vol. 19, no. 10, p. e0310053, 2024. [Online]. Available: https://doi.org/10.1371/journal.pone.0310053

[26] H. Haeger, A. BrckaLorenz, and K. Webber, “Participation in undergraduate research at minority-serving institutions,” *Perspectives on Undergraduate Research and Mentoring*, vol. 4, no. 1, 2015.

[27] J. Zilvinskis and A. C. McCormick, “Do working students buy into hips? working for pay and participation in high-impact practices,” *Journal of College Student Development*, vol. 60, no. 5, pp. 543–545, 2019.

[28] J. Kinzie and A. BrckaLorenz, “Expectations for and quality experiences in undergraduate research over time: Perspectives of students and faculty,” *Journal of the Scholarship of Teaching and Learning*, vol. 21, no. 1, 2021.

[29] K. L. Webber, T. F. Nelson Laird, and A. M. BrckaLorenz, “Student and faculty member engagement in undergraduate research,” *Research in Higher Education*, vol. 54, no. 2, pp. 227–249, 2013.

[30] M. Saffar Perez and C. M. Lewis, “Predictors of k-12 cs teacher isolation and course offerings,” in *Proceedings of the 2024 on RESPECT Annual Conference*, 2024, pp. 35–42.

[31] J. Tillmann and C. Wegner, “” when i started, i wasn’t really interested in such things”: Catching and holding an interest in computer science and technology.” *International Journal of Research in Education and Science*, vol. 10, no. 3, pp. 524–542, 2024.

[32] J. Margolis, A. Fisher, and F. Miller, “The anatomy of interest: Women in undergraduate computer science,” *Women’s Studies Quarterly*, vol. 28, no. 1/2, pp. 104–127, 2000.

[33] Purdue University, “Gems program report: Stem in schools,” Purdue University, Tech. Rep., 2019.

[34] A. Master, A. N. Meltzoff, and S. Cheryan, “Gender stereotypes about interests start early and cause gender disparities in computer science and engineering,” *Proceedings of the National Academy of Sciences*, vol. 118, no. 48, p. e2100030118, 2021.

[35] J. Wang and S. Hejazi Moghadam, “Diversity barriers in k-12 computer science education: Structural and social,” in *Proceedings of the 2017 ACM SIGCSE technical symposium on computer science education*, 2017, pp. 615–620.

[36] R. Chaffee and P. Gupta, “Accessing the elite figured world of science,” *Cultural studies of science education*, vol. 13, no. 3, pp. 797–805, 2018.

[37] P. Bourdieu, “Economic capital, cultural capital, social capital,” *Soziale-Welt, Supplement*, vol. 2, no. 13, pp. 183–198, 1983.

[38] L. Archer, E. Dawson, J. DeWitt, A. Seakins, and B. Wong, ““science capital”: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital in science education,” *Journal of Research in Science Teaching*, vol. 52, no. 7, pp. 922–948, 2015.

[39] J. J. Thompson and D. Jensen-Ryan, “Becoming a “science person”: Faculty recognition and the development of cultural capital in the context of undergraduate biology research,” *CBE—Life Sciences Education*, vol. 17, no. 4, p. ar62, 2018.

[40] J. I. Venegas-Muggli, C. Barrientos, and F. Álvarez, “The impact of peer-mentoring on the academic success of underrepresented college students,” *Journal of College Student Retention: Research, Theory & Practice*, vol. 25, no. 3, pp. 554–571, 2023.

[41] R. W. Lent, S. D. Brown, G. Hackett *et al.*, “Social cognitive career theory,” *Career choice and development*, vol. 4, no. 1, pp. 255–311, 2002.

[42] B. O. Banwo, L. Navarrete-Burks, S. McGee, and R. McGee-Tekula, “Building bridges in stem education: Minoritized secondary school student computer science pathways and experiences,” *Education Sciences*, vol. 14, no. 8, p. 831, 2024.

[43] R. Sauve and L. Schneider-Bentley, “Disaggregating data from peer-led, small group discussion workshops for engineering and computer science undergraduates: Examining’belonging’and’mentorship’outcomes for underrepresented student populations,” 2024.

[44] Y. Rankin, M. Agharazidermani, and J. Thomas, “The role of familial influences in african american women’s persistence in computing,” in *2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, vol. 1. IEEE, 2020, pp. 1–8.

[45] J. Clarke-Midura, F. J. Poole, K. Pantic, C. Sun, and V. Allan, “How mother and father support affect youths’ interest in computer science,” in *Proceedings of the 2018 ACM Conference on International Computing Education Research*, 2018, pp. 215–222.

[46] K. J. Lehman, A. M. Wofford, M. Sendowski, K. N. Newhouse, and L. J. Sax, “Better late than never: Exploring students’ pathways to computing in later stages of college,” in *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 2020, pp. 1075–1081.

[47] J. DeWitt, S. Godec, E. Watson, L. Archer, and J. Moote, “Who participates in informal science learning experiences? analysis of data from six surveys of a cohort in england from age 10–22 years,” *International Journal of Science Education, Part B*, pp. 1–18, 2025.

[48] R. W. Lent, S. D. Brown, and G. Hackett, “Toward a unifying social cognitive theory of career and academic interest, choice, and performance,” *Journal of vocational behavior*, vol. 45, no. 1, pp. 79–122, 1994.

[49] A. S. Rorrer, “An evaluation capacity building toolkit for principal investigators of undergraduate research experiences: A demonstration of transforming theory into practice,” *Evaluation and program planning*, vol. 55, pp. 103–111, 2016.

[50] Y. A. Rankin and J. O. Thomas, “The intersectional experiences of black women in computing,” in *Proceedings of the 51st ACM technical symposium on computer science education*, 2020, pp. 199–205.

[51] Code.org, “2025 state of ai + cs education,” Code.org, Tech. Rep., 2025, retrieved from Code.org Advocacy Coalition website. [Online]. Available: https://advocacy.code.org

[52] C. Alvarado, J. Hummel, D. Mirza, R. Revelo, and L. Yan, “Scaling and adapting a program for early undergraduate research in computing,” in *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education-Volume 1*, 2022, pp. 50–56.

[53] S. Menzel and C. Frieze, “Experiencing research through ourcs: Opportunities for undergraduate research in computer science,” in *2018 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*. IEEE, 2018, pp. 1–4.

[54] B. Jelen, J. Dunbar, S. Monsey, O. K. Richards, and K. A. Siek, “Utilizing the affinity research group model in a summer research experience for undergraduates program,” in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 2019, pp. 990–996.

[55] G. Bangera and S. E. Brownell, “Course-based undergraduate research experiences can make scientific research more inclusive,” *CBE—Life Sciences Education*, vol. 13, no. 4, pp. 602–606, 2014.

[56] S. Pierszalowski, J. Bouwma-Gearhart, and L. Marlow, “A systematic review of barriers to accessing undergraduate research for stem students: problematizing under-researched factors for students of color,” *Social Sciences*, vol. 10, no. 9, p. 328, 2021.