



Computing Enrollment and Retention:

Results from the 2021-22 Undergraduate Enrollment Cohort

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What happened with U.S. undergraduate enrollment and retention in the 2021-22 academic year, the first post-COVID enrollment cohort? Did retention recover from its decline in 2020-21? An ACM task force addresses these questions for bachelor's and associate's programs in its annual report. Five-year trends on enrollments, degree completions, and retention are provided. The report separately considers those bachelor's programs at non-doctoral granting institutions, providing retention data for these institutions for the first time while incorporating enrollment and completion data that formerly appeared in the ACM NDC Study.

INTRODUCTION

The ACM Education Board's Actionable Enrollment and Retention (ACER) Task Force gathers and reports national-level data about enrollment, degree completions, and retention of students in undergraduate computing degree programs in the United States. This project seeks to provide the computing community and other interested parties including academic leaders, government agencies, and the media, with useful comprehensive information against which local data can be compared and that can be used as a basis for further study. For the past several years, the task force has obtained, analyzed, and reported such data in various articles in *ACM Inroads* [5,9,11,12] and elsewhere [8]. The data in those articles is associated with enrollment cohorts between the 2016-17 and 2020-21 academic years. This article continues the effort by reporting comparable data associated with the 2021-22 enrollment cohort.

The National Student Clearinghouse (NSC) is the principal source of the task force's data [7]. The ACM Education Board and ACM's Committee for Computing Education in Community Colleges (CCECC) provided the funds required to obtain the NSC data.

The data covers the undergraduate computing disciplines in which ACM has published curricular guidelines [2,4] and ABET [1] accredits programs. At the bachelor's degree level, these disciplines include computer science (CS), computer engineering (CE), information systems (IS), information technology (IT), software engineering (SE), cybersecurity (CY) and data science (DS). Associate's degree disciplines of interest are CS, CY and IT. Within each degree level, the data provided by NSC for each discipline is reported using an intersectional approach with respect to gender and race/ethnicity. The data at each degree level is also disaggregated by various institutional characteristics. Bachelor's data is further disaggregated by class rank.

Prior to this year, ACM also published a separate report providing data on enrollments and degree completions at non-doctoral computing (NDC) programs. For the past four years, the data for this report also were obtained from the NSC. As was mentioned in the most recent such report [10], effective this year the NDC data is being incorporated into the ACER Task Force report. In addition to providing a single source that summarizes the NSC enrollment and degree completions data for all the institutional breakdowns, our report will include retention data for the NDC institutions for the first time. There no longer will be a separate NDC Study.

The next section details how we identified each discipline of interest and the various institutional disaggregations we employed. It also discusses how we define retention for the purposes of our study. Subsequent sections provide the respective results for enrollment, degree completions and retention for students from the 2021-22 enrollment cohort. We compare these results with those from prior years. In particular, we will identify changes to trends we have observed before and will examine whether prior results that were peculiar to the COVID period have continued or if they appear to have reverted to pre-COVID times. The main findings are summarized in the paper's final section.

PROFILE OF THE DATA

From the information provided by institutions, NSC can identify those students enrolled in bachelor's degree programs and those enrolled in associate's degree programs at that institution. An enrolled student's area of study is also provided by the institution, using Classification of Instructional Program (CIP) codes. Table 1 shows how the ACER task force maps CIP codes to the various computing disciplines, using the codes from the 2020 CIP update [6]. For each discipline of interest and each degree level, NSC assembled the data and provided reports to ACM showing the number of students enrolled during the 2020-21 academic year at the specific degree level in the specific discipline, the number of those enrolled students who completed that degree during the 2020-21 academic year, and the number of students from that enrollment cohort who were still in the program at the same institution during academic year 2022-23. Each of these sets of students is disaggregated using an intersectional approach by gender and race/ethnicity pairs. For bachelor's students, this disaggregation is done for each class rank (freshman, sophomore, junior, and senior). The number of students whose gender, race/ethnicity and/or class rank is not reported by the institution is also provided.

Table 1: Mapping of CIP Codes to Computing Disciplines

DISCIPLINE	CIP CODES
CE	14.0901, 14.0902
CS	11.0101, 11.0701
CY	11.1003, 43.0116, 43.0403, 43.0404
DS	30.7001, 30.7099, 30.7101, 30.7102, 30.7103
IS	11.0401, 11.0501, 11.0902, 52.1201, 52.1206, 52.1299
IT	11.0103, 11.0105, 11.0201, 11.0202, 11.0204, 11.0205, 11.0301, 11.0801, 11.0802, 11.0804, 11.0899, 11.0901, 11.1001, 11.1002, 11.1004, 11.1005
SE	14.0903

A student from a specific year's enrollment cohort is said to be retained by the program if the student either graduated from the program during the academic year in question, or the student was still in the program at the same institution in the subsequent academic year. This definition of retention has been used in the prior ACER reports.

In addition to receiving this data aggregated across all institutions, the data is disaggregated into institutional control categories of public, private nonprofit, and for-profit; whether the institution is minority-serving (MSI); and to which of three possible Carnegie classes [3] the institution belongs. For bachelor's programs, the Carnegie class disaggregations are Doctoral Very High Research (R1 institutions), Doctoral High Research (R2 institutions), and non-doctoral (abbreviated non-doc in this article). For associate's programs, the Carnegie class disaggregations are Associate's High Transfer, Bachelor's/Associate's Institutions (abbreviated Bach/Assoc), and Career Technical Education (CTE/Other). Table 2 illustrates the institutional profiles thus obtained for the 2021-22 enrollment cohort. For the non-doctoral institutions, we show the breakdown by institutional control and MSI for comparison with prior NDC reports.

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The number of institutions contributing to the data this year is considerably higher than those published in previous years, at each degree level and in each discipline. Most of the increase is due to the inclusion of additional non-doctoral institutions. In some disciplines, such as CY and DS that are relatively new, a large increase is not surprising as these disciplines are in a high growth period. We investigated the differences in the more established disciplines and learned that a little more than 1/3 of the increase seemed to be due to institutions with satellite campuses, where the campuses did not have separate entries previously but did have separate entries for the 2021-22 enrollments. The other part of the increase was based on new institutions that appeared to report 2021-22 data to NSC about computing program enrollments using the CIP codes that mapped to our disciplines but did not do so in 2020-21. NSC reported that overall, there was not any significant change in the number of institutions reporting data to them across all disciplines. But our computing program data appears to have been noticeably affected. We therefore caution against making comparisons with prior years on a per-institution basis. Our analysis of the data omits per institution comparisons that previously appeared in the NDC reports.

While we received data from NSC disaggregated into various institutional classes described above, except in some retention analyses, we confine our analysis of the bachelor's and associate's data to all institutions granting these respective degrees, and to

the subset of bachelor's granting institutions that are non-doctoral. This allowed us to provide basic enrollment, completion, and retention data from the 2021-22 enrollment cohort, including data consistent with previous NDC reports, and to use it to do intersectional analysis with respect to gender and race/ethnicity and to study trends while keeping the size of the report manageable. We recognize that analyses focusing on other institutional characteristics also will be of interest to certain readers.

ENROLLMENTS

Table 3 presents the percentage change in enrollment between the 2020-21 and 2021-22 academic years, broken out by discipline for all bachelor's and associate's degree granting institutions; bachelor's institutions also have a separate entry for the non-doctoral granting subset of institutions. Increases occurred at both degree levels in all disciplines except for CE bachelor's programs aggregated across all institutions, which saw a decline of 2.1%. The largest increases are in DS and CY programs, which is not surprising since these are relatively new areas that are experiencing rapid increases in the number of institutions offering bachelor's programs. Among the remaining disciplines, SE experienced the largest gains, followed by IT, CS, and IS for bachelor's programs; for associate's programs, CY was followed by CS and then IT.

Table 2: Number of Institutions by Discipline and Institution Type

BACHELOR'S		Overall	Public	Private not-for-profit	Private for-profit	MSI	R1	R2
CS	all institutions	1,164	469	660	25	232	139	117
	non-doc	908	296	587	25	185		
CE	all institutions	297	189	107	1	62	101	68
	non-doc	128	56	71	1	33	1	
IS	all institutions	499	263	214	22	91	66	68
	non-doc	365	156	187	22	66		
IT	all institutions	547	233	251	63	98	54	57
	non-doc	436	157	216	63	80		
SE	all institutions	90	40	46	4	11	13	12
	non-doc	65	24	37	4	6		
CY	all institutions	353	131	177	45	37	19	37
	non-doc	297	91	161	45	32		
DS	all institutions	155	54	96	5	15	16	19
	non-doc	120	29	86	5	11		
Bachelor's Totals	all institutions	3,105	1,379	1,551	165	546	408	378
	non-doc	2,319	809	1,345	165	413		

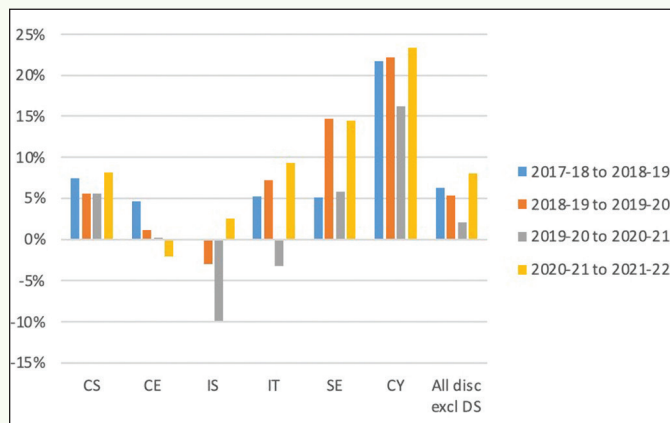
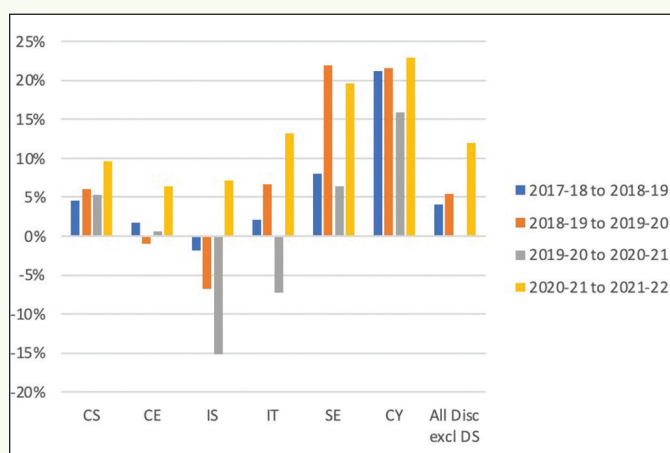
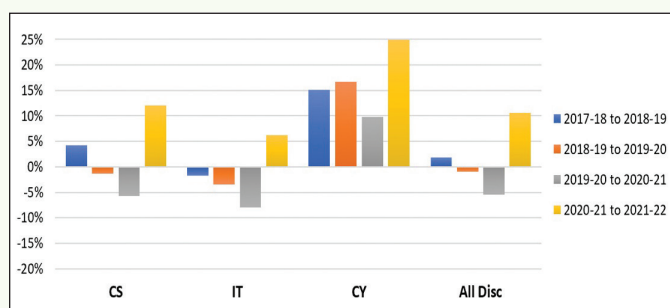
ASSOCIATE'S		Overall	Public	Private not-for-profit	Private for-profit	MSI	Associate High Transfer	Bach/Associate	Other
CS	all institutions	565	503	51	11	210	222	61	282
IT	all institutions	887	745	56	86	264	243	176	468
CY	all institutions	347	318	27	2	102	112	36	199
Associate's Totals	all institutions	1,799	1,566	134	99	576	577	273	949

Table 3: One-Year Enrollment Change by Discipline

BACHELOR'S	2021-22 Enrollment		2020-21 Enrollment		% Change in Enrollment	
	All inst	Non-doc	All inst	Non-doc	All inst	Non-doc
CS	366,270	157,702	338,636	143,927	8.2%	9.6%
CE	54,029	12,136	55,160	11,408	-2.1%	6.4%
IS	81,921	43,691	79,887	40,789	2.5%	7.1%
IT	124,086	86,002	113,551	75,941	9.3%	13.2%
SE	13,758	6,115	12,017	5,113	14.5%	19.6%
CY	61,590	50,830	49,936	41,350	23.3%	22.9%
DS	6502	2,963	2453	1,323	165.1%	124.0%
Bachelor's Totals	708,156	359,439	651,640	319,851	8.7%	12.4%

ASSOCIATE'S	2021-22 Enrollment	2020-21 Enrollment	% Change in Enrollment
CS	115,530	103,149	12.0%
IT	126,102	118,724	6.2%
CY	33,625	26,926	24.9%
Associate's Totals	275,257	248,799	10.6%

Figures 1 and 2 show the year-over-year enrollment changes since 2017-18 in each bachelor's discipline except DS, respectively for all institutions and non-doctoral granting institutions. The figures do not include a disciplinary trend for DS since we only obtained enrollment information for the past two years. Figure 3 shows the corresponding year-over-year enrollment changes for each of the associate's disciplines. As can be seen in the figures, the magnitude of the 2021-22 enrollment increase is the highest over the last four years in most disciplines. When all bachelor's institutions are considered, it is highest in all disciplines except CE and SE. When looking only across non-doctoral granting institutions, it is highest in all disciplines except SE. It also is highest for all associate's disciplines, and in aggregate across all disciplines when considering either all bachelor's institutions, all associate's institutions, or all non-doctoral institutions. The larger number of institutions reporting data this year should be borne in mind in this context. This growth is encouraging in view of recent years' declines in IT and IS bachelor's enrollment (the latter for a 3-year period), multi-year declines in CS and IT associate's programs, and more modest growth in the other bachelor's and associate's disciplines. Many, though not all, of these declines came during the COVID period.

**Figure 1:** Bachelor's Enrollment Percentage Changes by Discipline: 2017-18 to 2021-22 (All Institutions)**Figure 2:** Bachelor's Enrollment Percentage Changes by Discipline: 2017-18 to 2021-22 (Non-Doctoral Granting Institutions)**Figure 3:** Associate's Enrollment Percentage Changes by Discipline: 2017-18 to 2021-22

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Table 4 shows the 2021-22 enrollments by gender for both bachelor's and associate's programs at all institutions, and for bachelor's programs at non-doctoral granting institutions. In both bachelor's groups, DS posted the highest percentages of females (34.6% and 36.2%) and CE the lowest (15.1% and 13.6%). In CS, there was a reported 21.5% females over all institution types and 20.7% for the non-doctoral institutions. Aggregated across all of the computing disciplines, there was a 0.9 percentage point increase in bachelor's students reporting as female between the 2020-21 and 2021-22 academic years (from 21.6% vs. 22.5%) when considering all bachelor's institutions. When aggregating only the non-doctoral granting institutions across all disciplines, there was a 1.3 percentage point increase in bachelor's students reported as female over the same period (from 21.0% to 22.3%).

Among the three associate's disciplines, IT had the largest representation of female students (24.8%), but unlike in the bachelor's programs, CY had a greater percentage of female associate's students than did CS. The percentage of CY associate's degree students who are female is higher than is the corresponding percentage for CY bachelor's students; in IT, the associate's degree percentage is lower, while in CS it is identical to the percentage across all bachelor's institutions though higher than the percentage across non-doctoral granting institutions.

The overall percentages of female students for 2021-22 are the highest reported in the five-year period since 2017-18, as shown in Figure 4. We grouped the disciplines in this figure so that all disciplines for which we have three institutional groupings (all bachelor's institutions, all associate's institutions, and non-doc bachelor's institutions) are together, and so that the two engineering bachelor's disciplines (CE and SE) are together. Data Science is included in this figure, and the bars for DS clearly show the larger representation of female students compared with the other disciplines. The inclusion of DS also influences the values in the 2020-21 and 2021-22 aggregations over all disciplines ("Total-Non-Doc" and "Total-AllBach"). Within each discipline, the five-year patterns are similar in the two bachelor's bar graph sets except that CE and IS are relatively flat during most of the period among non-doctoral institutions whereas they show increases among all institutions. The growth patterns within the associate's disciplines are similar to each other, and most similar to the CS bachelor's patterns.

Table 5 shows the breakdown of bachelor's and associate's enrollment by race/ethnicity and discipline for all institution types, and for non-doctoral bachelor's granting institutions. NSC does not report exact values in any category having fewer than 10 students out of concerns that this may reveal specific institutional information. Therefore, we were unable to determine some values in the table. These cells are reported as NA.

Table 4: Enrollments by Gender and Discipline

BACHELOR'S		Male		Female		Total Known Gender	Gender Unreported	Total
CS	all institutions	271,032	78.5%	74,266	21.5%	345,298	20,972	366,270
	non-doc	119,757	79.3%	31,188	20.7%	150,945	6,757	157,702
CE	all institutions	43,016	84.9%	7,638	15.1%	50,654	3,375	54,029
	non-doc	9,936	86.4%	1,560	13.6%	11,496	640	12,136
IS	all institutions	56,403	71.9%	22,016	28.1%	78,419	3,502	81,921
	non-doc	31,377	73.8%	11,142	26.2%	42,519	1,172	43,691
IT	all institutions	88,027	73.7%	31,386	26.3%	119,413	4,673	124,086
	non-doc	61,684	74.1%	21,565	25.9%	83,249	2,753	86,002
SE	all institutions	10,600	80.7%	2,541	19.3%	13,141	617	13,758
	non-doc	4,660	80.4%	1,139	19.6%	5,799	316	6,115
CY	all institutions	48,728	80.4%	11,902	19.6%	60,630	960	61,590
	non-doc	40,472	80.6%	9,741	19.4%	50,213	617	50,830
DS	all institutions	4,008	65.4%	2,117	34.6%	6,125	377	6,502
	non-doc	1,833	63.8%	1,042	36.2%	2,875	88	2,963
Bachelor's Totals	all institutions	521,814	77.5%	151,866	22.5%	673,680	34,476	708,156
	non-doc	269,719	77.7%	77,377	22.3%	347,096	12,343	359,439
ASSOCIATE'S		Male		Female		Total Known Gender	Gender Unreported	Total
CS	all institutions	86,313	78.5%	23,702	21.5%	110,015	5,515	115,530
IT	all institutions	90,855	75.2%	29,902	24.8%	120,757	5,345	126,102
CY	all institutions	24,961	76.5%	7,678	23.5%	32,639	986	33,625
Associate's Totals	all institutions	202,129	76.7%	61,282	23.3%	263,411	11,846	275,257

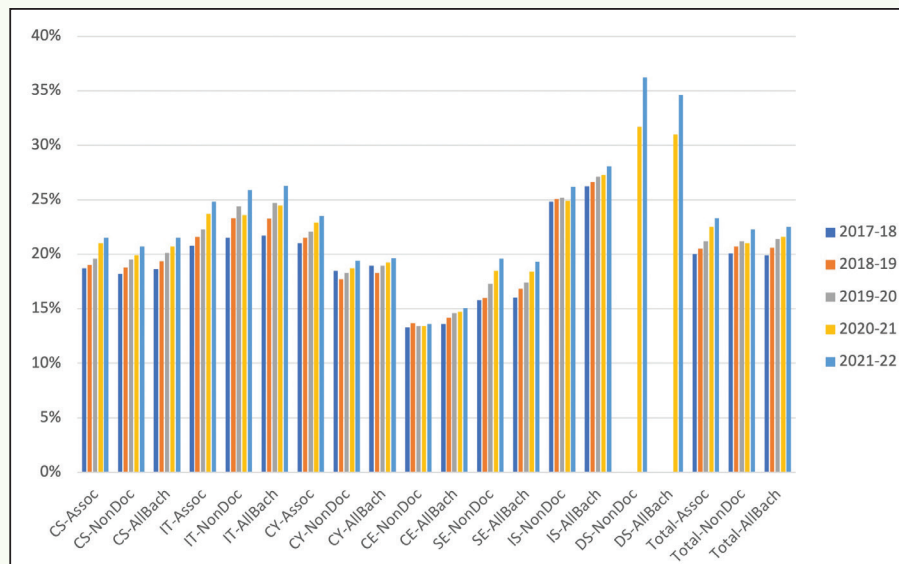


Figure 4: Female Enrollments by Discipline: 2017-18 through 2021-22

Note, however, this does not necessarily mean that the NA value represents fewer than 10 students. For example, bachelor's values for non-doctoral granting institutions are derived from the difference between the reported value for all bachelor's institutions and the total of the reported values for R1 and R2 institutions. Suppose the value for all institutions is 100, the value for R1 institutions is 30, and the value for R2 institutions is unknown but is less than 10. While we don't know the exact value for non-doctoral granting institutions, we know it is at least 61.

The presence of such NA values caused us to look for other ways to report data for race/ethnicity groups of interest. Except for DS non-doctoral institutions, we can compute enrollment percentages for students whose race/ethnicity was reported, who are not Asian, White or Non-resident. This includes Black, Hispanic, Native American, and Native Hawaiian/Pacific Islander students plus students of two or more races. Native American and Native Hawaiian/Pacific Islander students each typically comprise less than 1% of the total students whose race/ethnicity is known, while students of two or more races tend to have single-digit percentage of that enrollment. The aggregate set of students in these five race/ethnicity categories therefore includes populations that have been historically marginalized in technology,¹ a set that is of interest to those studying race/ethnicity trends. We will refer to this set as “historically marginalized populations in computing.” Figure 5 depicts the five-year trend for this set of students, for each discipline and aggregated over all disciplines, within each of the institution classes (all bachelor's, all associate's, and non-doctoral granting bachelor's), using the same ordering of disciplines as in Figure 4. The figure shows that there were no computations for DS in any

year for non-doctoral institutions, and that DS computations for all bachelor's institutions exist only for the last two years. Thus, the bachelor's aggregations over all disciplines (“Total-NonDoc” and “Total-AllBach”) include DS in years where it was possible to compute its percentages and exclude DS when that computation was not possible.

When aggregated over all disciplines for all bachelor's institutions, the percentage of bachelor's students of known race/ethnicity who were from historically marginalized populations in computing was 33.2%, an increase of 1.8 percentage points over last year. Among non-doctoral granting institutions, the percentage of bachelor's students of known race/ethnicity who were from historically marginalized populations in computing was 40.7%, an increase of 2.1% over last year. In both classes of bachelor's institutions, there have been increases in each year of the five-year period. A similar situation occurs for associate's students, where the 2021-22 percentage of students from historically marginalized populations in computing is 46.7% vs. 44.4% in 2020-21, and there have been yearly increases in each of the three associate's disciplines.

While these results suggest improved racial/ethnic diversity in the computing programs during the past five years, the real story is more nuanced as would be expected from data for the first four years that was examined in a previous report [11]. The Hispanic/Latino share of enrollment across all institutions has indeed increased during the five-year period for all disciplines at both bachelor's (ranging from 1.9 percentage points in CE to 4.1 percentage points in CY) and associate's (ranging from 5.7 percentage points in CS to 6.2 percentage points in CY) degree levels. For Black/African American students, however, the increases are quite small by comparison, with only SE with a 3.3 percentage point increase showing a gain of more than one percentage point among the bachelor's disciplines. There also is a substantial difference between White and Asian percentage change. The rep-

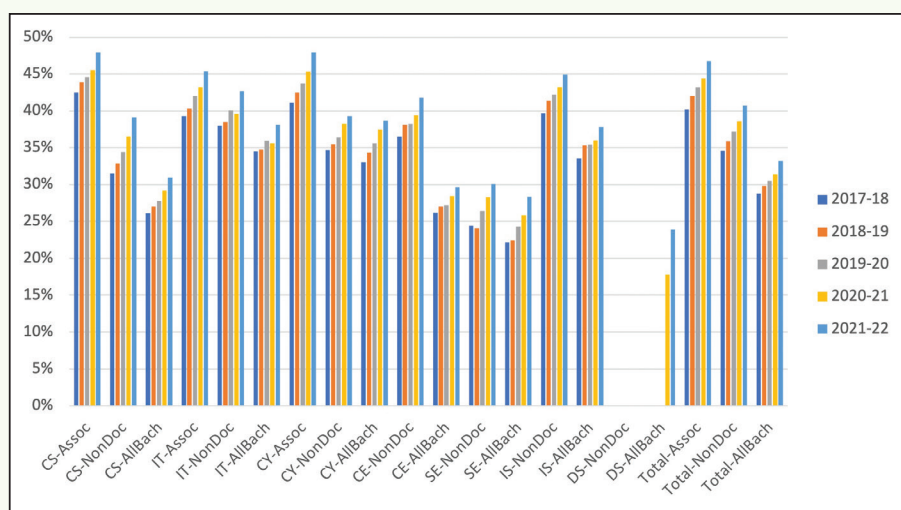
¹ We recognize that students of two or more races would not be historically marginalized if the races are White and Asian. We have no way to know from the data how many students are in that subcategory.

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Table 5: Enrollment by Race/Ethnicity and Discipline

Bachelor's		Amer Indian/ Alaska Native		Asian		Black/ African Amer		Hispanic/ Latino		Nat. Hawaiian/ Pacific Islands		Two or More Races		White		Non- Resident	Res./Race/ Eth. Known	Res./ Race/Eth. Unreported	Total
CS	all institutions	1,152	0.4%	57,279	20.6%	African Amer	10.4%	Latino	14.6%	Pacific Isl.	0.3%	14,604	5.3%	124,553	44.8%	10,031	277,854	88,416	366,270
	non-doc	675	0.6%	13,369	11.8%	15,090	13.3%	22,270	19.7%	398	0.4%	5,846	5.2%	52,628	46.5%	2,969	113,245	44,457	157,702
CE	all institutions	182	0.4%	9,479	22.0%	3,556	8.3%	6,960	16.2%	97	0.2%	1,972	4.6%	19,361	45.0%	1,460	43,067	10,962	54,029
	non-doc	66	0.7%	1,695	18.5%	671	7.3%	2,682	29.2%	37	0.4%	385	4.2%	3,430	37.3%	220	9,186	2,950	12,136
IS	all institutions	340	0.5%	9,034	14.4%	11,176	17.8%	8,053	12.8%	232	0.4%	3,951	6.3%	29,132	46.4%	930	62,848	19,073	81,921
	non-doc	212	0.7%	2,840	8.7%	7,040	21.7%	4,563	14.0%	173	0.5%	2,616	8.0%	14,776	45.5%	277	32,497	11,194	43,691
IT	all institutions	605	0.7%	11,137	13.3%	14,213	16.9%	13,034	15.5%	286	0.3%	3,840	4.6%	39,268	46.8%	1,565	83,948	40,138	124,086
	non-doc	470	0.9%	4,325	8.3%	10,178	19.6%	9,086	17.5%	229	0.4%	2,246	4.3%	24,507	47.1%	945	51,986	34,016	86,002
SE	all institutions	86	0.8%	1,558	14.0%	1,031	9.2%	1,568	14.1%	51	0.5%	428	3.8%	6,227	55.8%	211	11,160	2,598	13,758
	non-doc	NA		573	12.3%	549	11.8%	667	14.3%	NA		164	3.5%	2,540	54.5%	87	4,664	1,451	6,115
CY	all institutions	234	0.6%	2,194	5.9%	6,114	16.3%	5,768	15.4%	155	0.4%	2,209	5.9%	20,168	53.9%	591	37,433	24,157	61,590
	non-doc	208	0.7%	1,426	5.0%	4,872	17.2%	4,229	15.0%	137	0.5%	1,668	5.9%	15,248	53.9%	496	28,284	22,546	50,830
DS	all institutions	28	0.5%	666	12.4%	440	8.2%	462	8.6%	5	0.1%	352	6.5%	3,048	56.7%	375	5,376	1,126	6,502
	non-doc	NA		181	7.3%	289	11.6%	255	10.2%	NA		154	6.2%	1,535	61.6%	59	2,492	471	2,963
Bachelor's Totals	all institutions	2,627	0.5%	91,347	17.5%	65,440	12.5%	76,448	14.7%	1,548	0.3%	27,356	5.2%	241,757	46.3%	15,163	521,686	186,470	708,156
	non-doc	NA		24,409	10.1%	38,689	16.0%	43,752	18.1%	NA		13,079	5.4%	114,664	47.3%	5,053	242,354	117,085	359,439

Bachelor's		Amer Indian/ Alaska Native		Asian		Black/ African Amer		Hispanic/ Latino		Nat. Hawaiian/ Pacific Islands		Two or More Races		White		Non- Resident	Res./Race/ Eth. Known	Res./ Race/Eth. Unreported	Total
CS	all institutions	624	0.7%	13,832	15.2%	11,264	12.4%	26,050	28.6%	309	0.3%	5,435	6.0%	32,398	35.6%	1,196	91,108	24,422	115,530
IT	all institutions	844	0.8%	10,024	9.7%	17,777	17.2%	22,776	22.0%	413	0.4%	5,051	4.9%	45,121	43.7%	1,319	103,325	22,777	126,102
CY	all institutions	179	0.6%	2,049	7.2%	6,183	21.7%	5,545	19.4%	98	0.3%	1,656	5.8%	12,517	43.9%	283	28,510	5,115	33,625
Associate's Total	all institutions	1,647	0.7%	25,905	11.6%	35,224	15.8%	54,371	24.4%	820	0.4%	12,142	5.4%	90,036	40.4%	2,798	222,943	52,314	275,257

**Figure 5:** Enrollment from Historically Marginalized Populations in Computing by Discipline: 2017-18 through 2021-22

representation of White students among students whose race/ethnicity was reported declined in every discipline, with bachelor's declines ranging from 4.8 percentage points in CE and SE to 7.8 percentage points in CS. In contrast, the Asian share of bachelor's enrollment increased between 1.3 and 2.2 percentage points in four of the six disciplines while declining by less than one percentage point in SE and CY. Non-resident changes are small, with no bachelor's discipline changing in absolute value by more than one percentage point. The Non-resident share of enrollment has been less than 5% each year in all bachelor's disciplines.

In addition to the trend noted above for Hispanic/Latino students in associate's programs, there was a considerable decrease in the percentage of White students enrolled in associate's programs (5.6 percentage points in CS and CY and 6.3 percentage points in IT). All other race/ethnicity enrollment changes at the associate's level fluctuated less than 1 percentage point except for Asian CY students whose percentage decreased 1.2 percentage points.

Figures 6 and 7 depict the cross tabulation of gender and race/ethnicity in 2021-22 for a subset of racial/ethnic categories in bachelor's programs. Figure 8 does likewise for associate's programs. For all disciplines in each of the three institution classes, the representation of female students is higher among Black/African American, Asian and Non-resident students than it is overall for all race/ethnicities in that discipline; conversely, the representation of female students is lower among White students than it is among all race/ethnicities. The repre-

sentation of female students among Hispanic/Latino students does not have a consistent relationship across all disciplines with the representation of female students when aggregated over all race/ethnicities.

Bachelor's enrollment also was tabulated by class rank. Class rank is divided into four categories: freshman, sophomore, junior, and senior. These ranks roughly divide the amount of completion of the total program credits required for the program into quartiles, with freshman generally meaning the student has earned fewer than one fourth of the total degree credits, while senior generally means the student has earned more than three fourths of the total degree credits. Table 6 shows each bachelor's discipline's distribution with respect to class rank among those students for whom class rank was reported, among all bachelor's institutions in the discipline as well as only the non-doctoral institutions. The table also contains the change in each value from that observed in 2020-21. Of note is that freshman comprised a higher share in 2021-22 than in 2020-21 for each discipline, with respect to all bachelor's institutions as well as non-doctoral institutions. Despite the gains at the freshman rank, seniors continue to comprise the highest share in all disciplines. This is likely reflective of the classification as senior of any student who has earned more than 3/4 of the total degree credits, no matter how long the student takes to complete the remainder of the program. It is important also to note that there is a very large fraction of students for whom class rank was not reported.

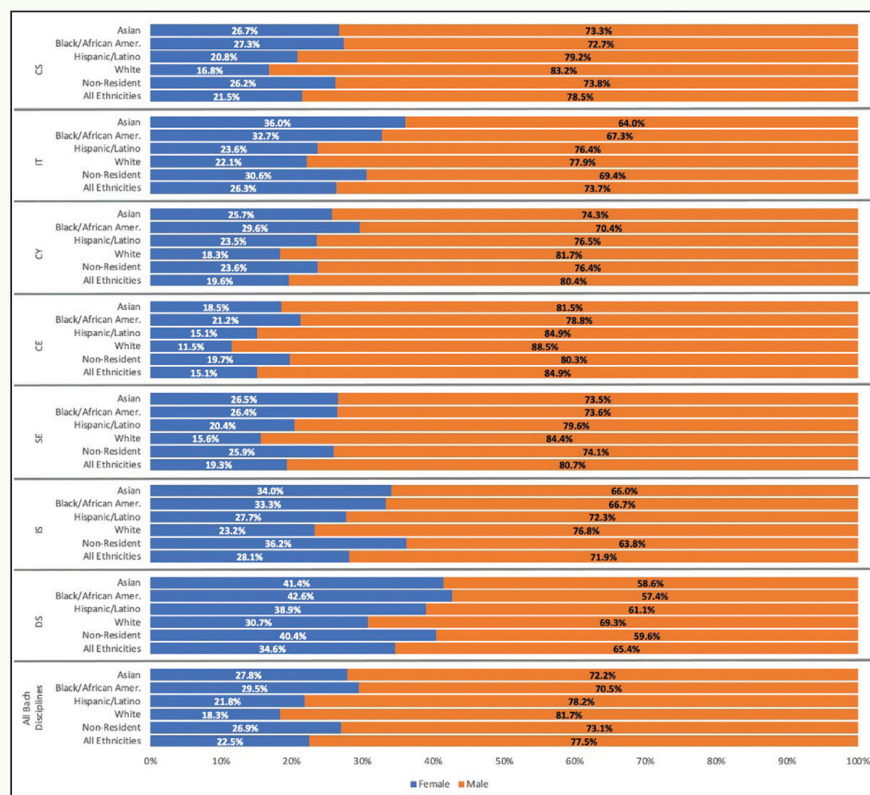


Figure 6: Bachelor's Enrollment by Discipline for Selected Gender x Race/Ethnicity Categories: All Institutions

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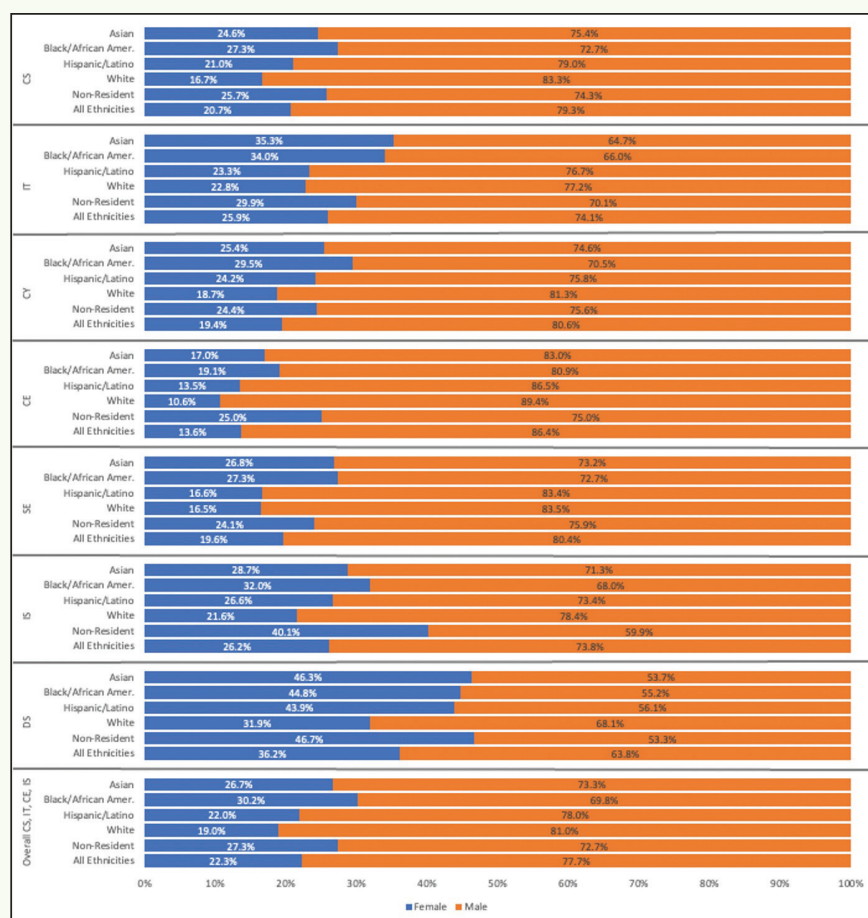


Figure 7: Bachelor's Enrollment by Discipline for Selected Gender x Race/Ethnicity Categories: Non-Doctoral Institutions

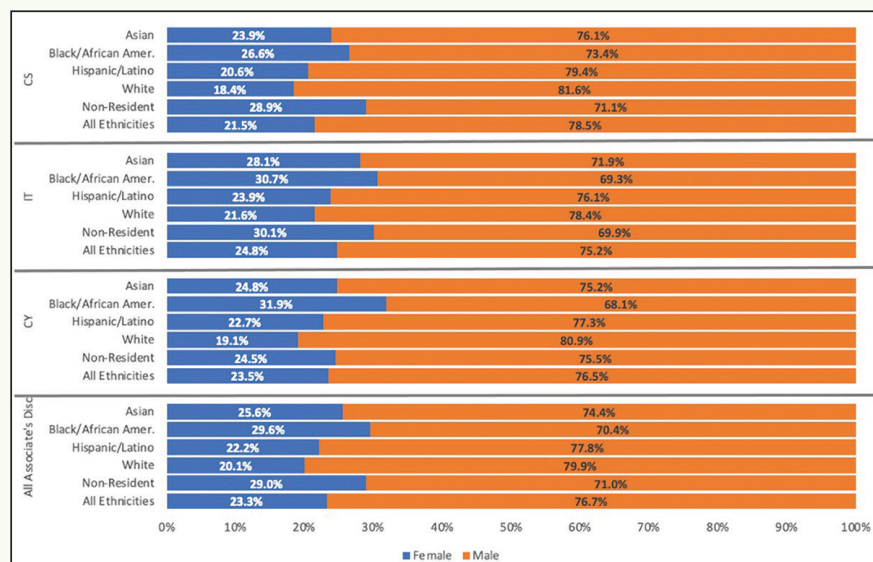


Figure 8: Associate's Enrollment by Discipline for Selected Gender x Race/Ethnicity Categories

We have noted this in previous reports. Across all disciplines, this fraction is slightly more than 1/4 for all bachelor's institutions, and slightly over 1/3 for non-doctoral institutions. In each case, these fractions are a bit higher than in 2020-21. We therefore caution against placing too much reliance in the exact percentages in the table, although if institutions do or do not report class rank consistently from year to year, the year over year changes should be representative of those institutions.

DEGREE COMPLETIONS

Table 7 presents the percentage change in bachelor's and associate's degree completions broken out by discipline for all institution types and the bachelor's completions for non-doctoral granting institutions. Completions in 2020-21 for DS are not available in the non-doctoral granting institutions. After a slight dip in bachelor's degree production and a major dip in associate's degree production between 2019-20 and 2020-21, completions over all institution types rebounded between 2020-21 and 2021-22 with an 11.7% increase in bachelor's (10.9% without DS) and a 24.7% increase in associate's degrees. Non-doctoral institutions exclusive of DS saw an increase in degree production of 12.9% between 2020-21 and 2021-22.

Figures 9-11 illustrate the trends in year-over-year degree production by discipline as well as the trends across all disciplines. For bachelor's programs, the all-discipline analyses exclude DS. Figure 9 shows that the decline in degree production across all bachelor's institutions in 2020-21 was the result of a large decline in IS production, a small decline in IT production, and very small increases in all other disciplines except SE, which is the smallest of the bachelor's disciplines. It also shows

that the 2021-22 rate increase across all disciplines is more like that seen in the two years prior to 2019-20. Among non-doctoral institutions, Figure 10 shows that there were declines in bachelor's production in four of the six disciplines in 2020-21, and there was an overall decrease of 3.8% across all disciplines. The 2021-22 increase of 12.9% is nearly double that seen in the two years prior to the 2020-21 decline. Among associate's programs (Figure 11), CS and IT showed declines for both 2019-20 and 2020-21, resulting in declines in aggregate across the three associate's disciplines during these years after a modest 3.7% increase for 2018-19. The large overall increase in 2021-22 permeated across all three associate's disciplines, with that in CS being the largest. Our analysis of degree completions serves as an indicator that the impact of COVID on computing programs has diminished and perhaps had been felt more acutely at institutions that are not doctoral-granting.

Table 8 reports 2021-22 degree-completion data broken out by gender and discipline. The percentage of degrees awarded to graduates whose gender was reported as female was 22.6% for all bachelor's institution types, 21.2% for non-doctoral granting institutions, and 23.0% for associate's institutions. Each represents an increase over 2020-21, when the respective values were 21.6%, 20.6% and 21.4%. As was seen in bachelor's enrollment data, the highest percentage of females for all institution types and for non-doctoral granting institutions occurred in DS, followed by IS and IT. CE has the lowest percentage among the bachelor's disciplines for both all institution types and non-doctoral granting institutions, as it does with respect to enrollment. Among the associate's degree disciplines, IT has the highest percentage of female graduates, followed by CY and CS; this is the same ordering as is seen in the 2021-22 associate's enrollments.

Table 6: Bachelor's Enrollment Distribution by Class Rank*

BACHELOR'S		Freshman		Sophomore		Junior		Senior	
			Change		Change		Change		Change
CS	all inst	20.6%	1.6%	19.7%	-0.4%	25.2%	-0.7%	34.5%	-0.5%
	non-doc	26.4%	2.2%	19.7%	-0.2%	22.9%	-1.0%	31.0%	-1.0%
CE	all inst	19.9%	1.9%	18.9%	-1.6%	23.1%	-1.0%	38.1%	0.6%
	non-doc	26.7%	2.9%	18.8%	-1.2%	19.3%	-0.9%	35.2%	-0.8%
IS	all inst	12.0%	2.1%	16.4%	-0.2%	30.9%	-0.2%	40.6%	-1.8%
	non-doc	14.6%	2.9%	16.6%	-0.2%	31.6%	-0.5%	37.2%	-2.2%
IT	all inst	22.3%	1.3%	17.9%	-0.3%	24.5%	-0.8%	35.3%	-0.2%
	non-doc	28.6%	1.0%	18.6%	-0.3%	21.5%	-0.6%	31.2%	-0.2%
SE	all inst	19.9%	2.5%	17.6%	-0.8%	23.7%	-1.0%	38.8%	-0.8%
	non-doc	26.9%	4.3%	18.5%	-1.3%	21.4%	-1.3%	33.2%	-1.7%
CY	all inst	21.8%	1.1%	22.0%	-0.7%	25.2%	-0.3%	31.0%	0.0%
	non-doc	23.2%	0.8%	22.2%	-1.3%	24.3%	0.1%	30.3%	0.5%
DS	all inst	17.1%	5.1%	20.6%	1.5%	30.3%	0.8%	32.1%	-7.4%
	non-doc	22.1%	4.7%	21.1%	-0.3%	27.4%	1.8%	29.4%	-6.2%
All Disc	all inst	19.8%	1.7%	19.1%	-0.4%	25.6%	-0.7%	35.5%	-0.6%
	non-doc	24.9%	2.1%	19.3%	-0.3%	23.8%	-0.8%	32.0%	-1.0%

* as a percentage of students for whom class rank was reported

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Table 7: One-Year Degree Completion Change by Discipline

BACHELOR'S	2021-22 Degree Completions		2020-21 Degree Completions		% Change in Degree Completions	
	All inst	Non-doc	All inst	Non-doc	All inst	Non-doc
CS	55,614	18,627	50,564	17,425	10.0%	6.9%
CE	8,578	1,464	8,660	1,394	-0.9%	5.0%
IS	15,148	6,281	14,099	6,092	7.4%	3.1%
IT	16,339	9,218	14,108	7,644	15.8%	20.6%
SE	1,853	769	1,600	671	15.8%	14.6%
CY	5,685	4,380	4,037	2,871	40.8%	52.6%
DS	879	381	105	NA	737.1%	NA
Bachelor's Totals	104,096	41,120	93,173	36,097	11.7%	12.9%

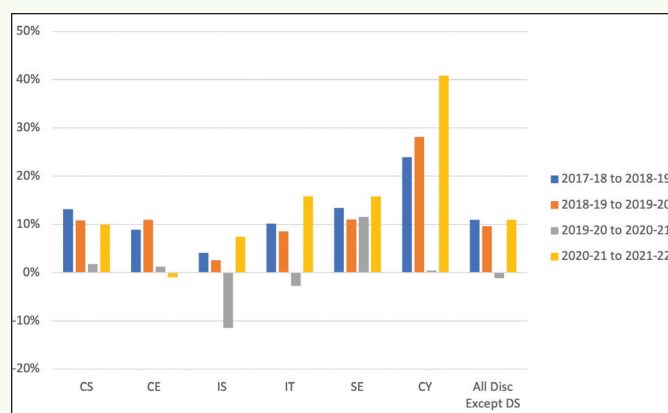
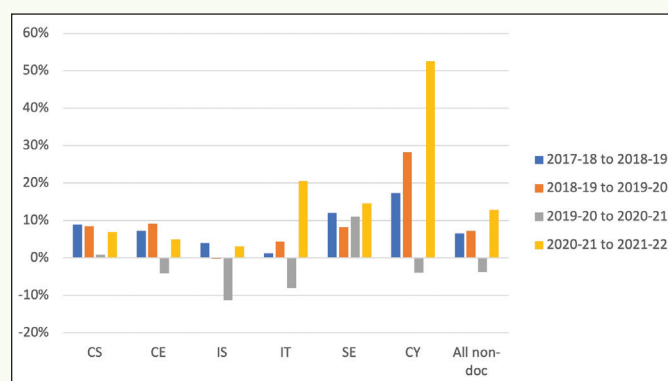
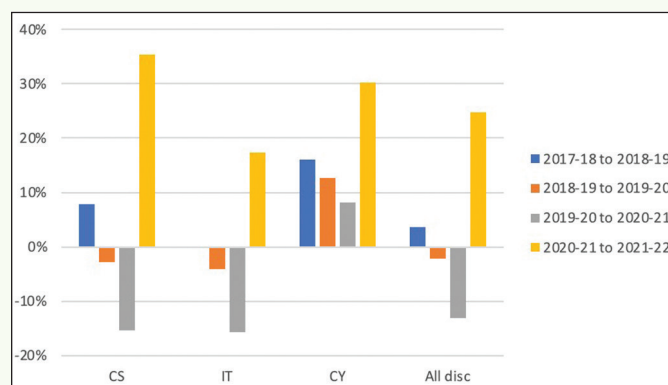
*non-doc bachelor's total percentage change excludes DS

ASSOCIATE'S	2021-22 Degree Completions		2020-21 Degree Completions		% Change in Degree Completions	
	All inst	Non-doc	All inst	Non-doc	All inst	Non-doc
CS	7,640		5,642		35.4%	
IT	11,618		9,906		17.3%	
CY	3,022		2,321		30.2%	
Associate's Totals	22,280		17,869		24.7%	

The percentage of female graduates compared with 2020-21 declined in CY for both categories of bachelor's institutions as well as for associate's institutions. Among non-doctoral granting institutions, SE also saw a decline in 2021-22 compared with 2020-21. All other bachelor's and associate's disciplines saw an increase in the percentage of female graduates.

Figure 12 presents the five-year trends in the percentage of degrees granted to women among those graduates whose gender was reported. The format of this figure is the same as that of Figure 4 for enrollments except that DS is excluded. Except in CY, the percentage of degrees earned by women was highest in 2021-22 over the 5-year period, though there were ups and downs from year to year.

Degree completions broken out by race/ethnicity and discipline are shown in Table 9. As was the case for enrollments, some cell values could not be determined from the information reported by NSC; they are noted as NA. As we did for enrollments, we focus on completion trends among students whose race/ethnicity is known and who are from historically marginalized populations in computing. Five-year trends for degree completions by discipline for such students are shown in Figure 13. Data Science is not included in this figure due to the lack of trend data for that discipline in both bachelor's institution groupings. In addition, we are unable to produce trends for non-doctoral institutions in SE and CY. Thus, the trends over all disciplines in Figure 13 include all three disciplines for associate's institutions, four bachelor's disciplines (CS, CE, IS, and IT) for non-doctoral institutions, and six disciplines for all bachelor's institutions.

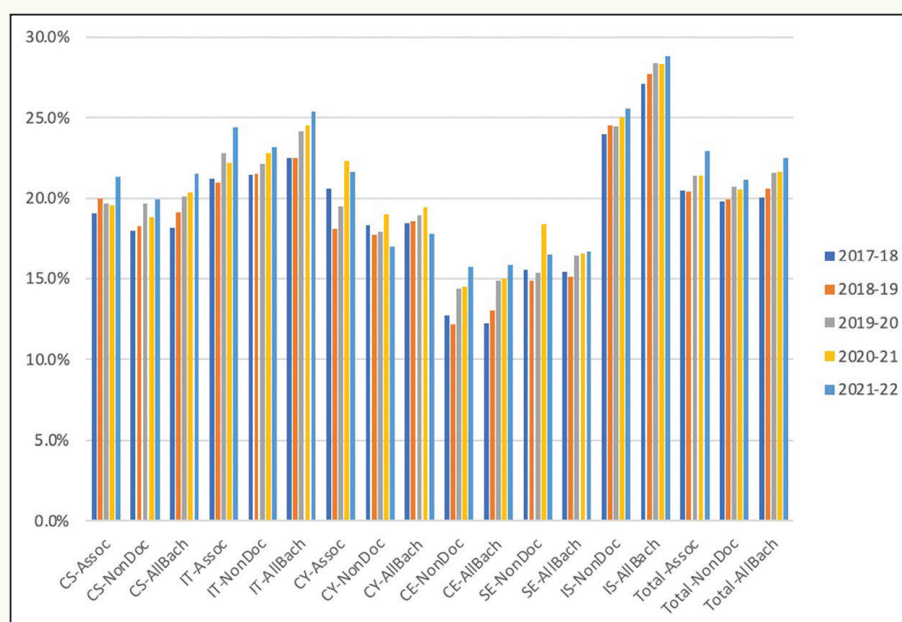
**Figure 9:** Bachelor's Degree Percentage Changes: 2017-18 through 2021-22 (All Institutions)**Figure 10:** Bachelor's Degree Percentage Changes: 2017-18 through 2021-22 (Non-doctoral Institutions)**Figure 11:** Associate's Degree Percentage Changes: 2017-18 through 2021-22

In those disciplines for which we can report the five-year trends, the percentage of graduates who are from historically marginalized populations in computing generally has been increasing during this period. The 2021-22 values are highest among the five years in all disciplines except CE, where they are second highest. Among the three associate's disciplines, CS had the highest percentage (38.9%) of 2021-22 graduates who were from historically marginalized populations in computing while IT had the lowest (35.6%). At the bachelor's level, IT had the

Table 8: 2021-22 Degree Production by Gender and Discipline

BACHELOR'S		Male		Female		Total known gender	Gender Unreported	Total
CS	all institutions	40,916	78.4%	11,244	21.6%	52,160	3,454	55,614
	non-doc	14,236	80.1%	3,541	19.9%	17,777	850	18,627
CE	all institutions	6,746	84.2%	1,268	15.8%	8,014	564	8,578
	non-doc	1,165	84.3%	217	15.7%	1,382	82	1,464
IS	all institutions	10,317	71.2%	4,176	28.8%	14,493	655	15,148
	non-doc	4,548	74.4%	1,563	25.6%	6,111	170	6,281
IT	all institutions	11,717	74.6%	3,989	25.4%	15,706	633	16,339
	non-doc	6,834	76.8%	2,065	23.2%	8,899	319	9,218
SE	all institutions	1,477	83.3%	296	16.7%	1,773	80	1,853
	non-doc	597	83.5%	118	16.5%	715	54	769
CY	all institutions	4,597	82.2%	998	17.8%	5,595	90	5,685
	non-doc	3,594	83.0%	737	17.0%	4,331	49	4,380
DS	all institutions	544	65.5%	286	34.5%	830	49	879
	non-doc	221	60.2%	146	39.8%	367	14	381
Bachelor's Totals	all institutions	76,314	77.4%	22,257	22.6%	98,571	5,525	104,096
	non-doc	31,195	78.8%	8,387	21.2%	39,582	1,538	41,120

ASSOCIATE'S		Male		Female		Total known gender	Gender Unreported	Total
CS	all institutions	5,806	78.7%	1,575	21.3%	7,381	259	7,640
IT	all institutions	8,477	75.6%	2,734	24.4%	11,211	407	11,618
CY	all institutions	2,318	78.4%	640	21.6%	2,958	64	3,022
Associate's Totals	all institutions	16,601	77.0%	4,949	23.0%	21,550	730	22,280

**Figure 12:** Female Completions by Discipline: 2017-18 through 2021-22

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highest percentage (30.4%) and SE the lowest (20.5%) among the six disciplines when all bachelor's institutions are considered, while IS was highest among the four non-doctoral disciplines at 37.1% and CS was lowest at 29.1%.

As we did with enrollments, we investigated the cross tabulation of gender and race/ethnicity within degree completions for a subset of racial/ethnic categories and disciplines. Figures 14–16 illustrate the results. Each figure shows, within each selected discipline, the respective breakdowns by gender of 2021-22 graduates who are Asian, Black/African American, Hispanic/Latino, White, and Non-resident as well as the breakdown by gender of all graduates in that discipline whose race/ethnicity was reported. Figure 14 reports these breakdowns across all bachelor's institutions for seven disciplines, Figure 15 does likewise for non-doctoral bachelor's institutions in four disciplines (CS, IT, CE and IS), and Figure 16 shows the breakdowns for associate's institutions for the CS, IT and CY disciplines. The Non-resident breakdown for CY associate's programs could not be computed, so that row, and the corresponding Non-resident row across all associate's disciplines, are blank in Figure 16.

The overall breakdowns by gender generally follow the patterns observed for enrollment. Women comprise a higher percentage of Asian and Black/African American graduates than overall graduates and comprise a lower percentage of White graduates than overall graduates. Except in DS, women also comprise a higher percentage of Non-resident graduates than overall graduates. When considering all bachelor's institutions, women comprise more than 40% of the Asian and Hispanic/Latino DS graduates whose gender was reported. Among non-doctoral bachelor's institutions, women comprise just over 40% of the IT Asian graduates whose gender was reported. Women also comprise over 1/3 of the Black/African American associate's graduates in CY whose gender was reported.

RETENTION

Table 10 shows, for each degree level and each discipline of interest at that degree level, the percentages of students from the 2021-22 enrollment cohort who were retained in the program. The data in the table shows the retention figures for students enrolled at various types of institutions. As was

Table 9: Degree Production in 2021-22 by Race/Ethnicity and Discipline

Bachelor's		Amer Indian/ Alaska Native		Asian		Black/ African Amer		Hispanic/ Latino		Nat. Hawaiian/ Pacific Islands		Two or More Races		White		Non- Resident	Res./Race/ Eth. Known	Res./ Race/Eth. Unreported	Total
CS	all institutions	1,152	0.4%	57,279	20.6%	African Amer	10.4%	Latino	14.6%	Pacific Isl.	0.3%	14,604	5.3%	124,553	44.8%	10,031	277,854	88,416	366,270
	non-doc	675	0.6%	13,369	11.8%	15,090	13.3%	22,270	19.7%	398	0.4%	5,846	5.2%	52,628	46.5%	2,969	113,245	44,457	157,702
CE	all institutions	182	0.4%	9,479	22.0%	3,556	8.3%	6,960	16.2%	97	0.2%	1,972	4.6%	19,361	45.0%	1,460	43,067	10,962	54,029
	non-doc	66	0.7%	1,695	18.5%	671	7.3%	2,682	29.2%	37	0.4%	385	4.2%	3,430	37.3%	220	9,186	2,950	12,136
IS	all institutions	340	0.5%	9,034	14.4%	11,176	17.8%	8,053	12.8%	232	0.4%	3,951	6.3%	29,132	46.4%	930	62,848	19,073	81,921
	non-doc	212	0.7%	2,840	8.7%	7,040	21.7%	4,563	14.0%	173	0.5%	2,616	8.0%	14,776	45.5%	277	32,497	11,194	43,691
IT	all institutions	605	0.7%	11,137	13.3%	14,213	16.9%	13,034	15.5%	286	0.3%	3,840	4.6%	39,268	46.8%	1,565	83,948	40,138	124,086
	non-doc	470	0.9%	4,325	8.3%	10,178	19.6%	9,086	17.5%	229	0.4%	2,246	4.3%	24,507	47.1%	945	51,986	34,016	86,002
SE	all institutions	86	0.8%	1,558	14.0%	1,031	9.2%	1,568	14.1%	51	0.5%	428	3.8%	6,227	55.8%	211	11,160	2,598	13,758
	non-doc	NA		573	12.3%	549	11.8%	667	14.3%	NA		164	3.5%	2,540	54.5%	87	4,664	1,451	6,115
CY	all institutions	234	0.6%	2,194	5.9%	6,114	16.3%	5,768	15.4%	155	0.4%	2,209	5.9%	20,168	53.9%	591	37,433	24,157	61,590
	non-doc	208	0.7%	1,426	5.0%	4,872	17.2%	4,229	15.0%	137	0.5%	1,668	5.9%	15,248	53.9%	496	28,284	22,546	50,830
DS	all institutions	28	0.5%	666	12.4%	440	8.2%	462	8.6%	5	0.1%	352	6.5%	3,048	56.7%	375	5,376	1,126	6,502
	non-doc	NA		181	7.3%	289	11.6%	255	10.2%	NA		154	6.2%	1,535	61.6%	59	2,492	471	2,963
Bachelor's Totals	all institutions	2,627	0.5%	91,347	17.5%	65,440	12.5%	76,448	14.7%	1,548	0.3%	27,356	5.2%	241,757	46.3%	15,163	521,686	186,470	708,156
	non-doc	NA		24,409	10.1%	38,689	16.0%	43,752	18.1%	NA		13,079	5.4%	114,664	47.3%	5,053	242,354	117,085	359,439

Bachelor's		Amer Indian/ Alaska Native		Asian		Black/ African Amer		Hispanic/ Latino		Nat. Hawaiian/ Pacific Islands		Two or More Races		White		Non- Resident	Res./Race/ Eth. Known	Res./ Race/Eth. Unreported	Total
CS	all institutions	624	0.7%	13,832	15.2%	11,264	12.4%	26,050	28.6%	309	0.3%	5,435	6.0%	32,398	35.6%	1,196	91,108	24,422	115,530
IT	all institutions	844	0.8%	10,024	9.7%	17,777	17.2%	22,776	22.0%	413	0.4%	5,051	4.9%	45,121	43.7%	1,319	103,325	22,777	126,102
CY	all institutions	179	0.6%	2,049	7.2%	6,183	21.7%	5,545	19.4%	98	0.3%	1,656	5.8%	12,517	43.9%	283	28,510	5,115	33,625
Associate's Total	all institutions	1,647	0.7%	25,905	11.6%	35,224	15.8%	54,371	24.4%	820	0.4%	12,142	5.4%	90,036	40.4%	2,798	222,943	52,314	275,257

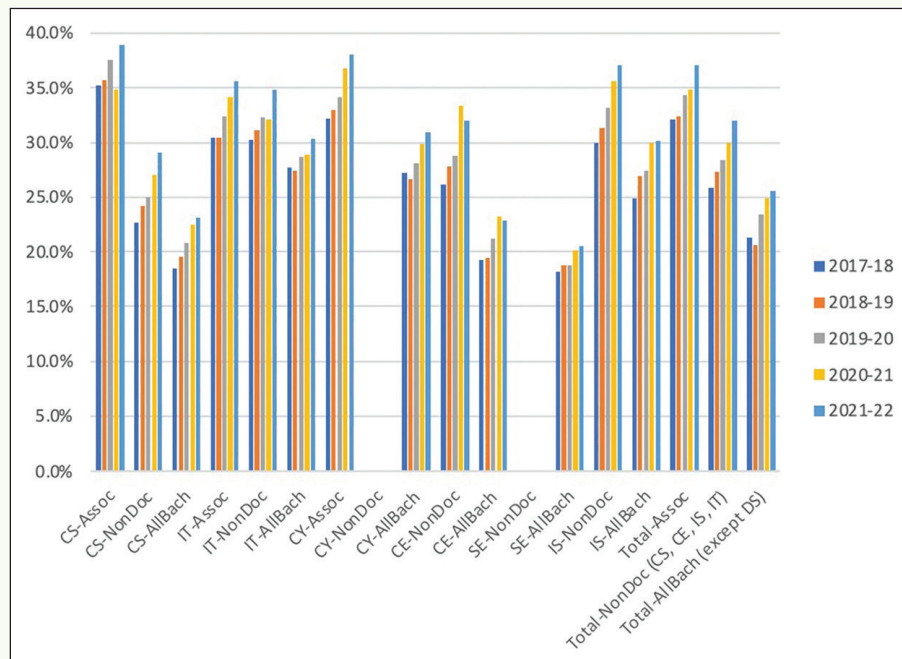


Figure 13: Completions for Historically Marginalized Populations in Computing by Discipline: 2017-18 through 2021-22

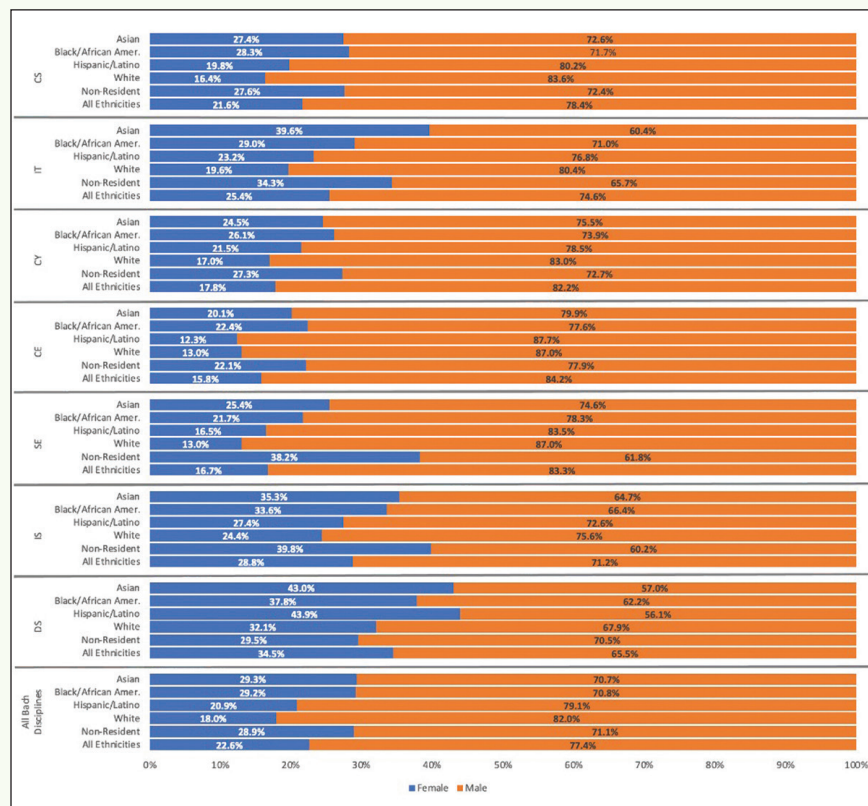


Figure 14: Bachelor's Degree Completions by Discipline for Selected Gender x Race/Ethnicity Categories: All Institutions

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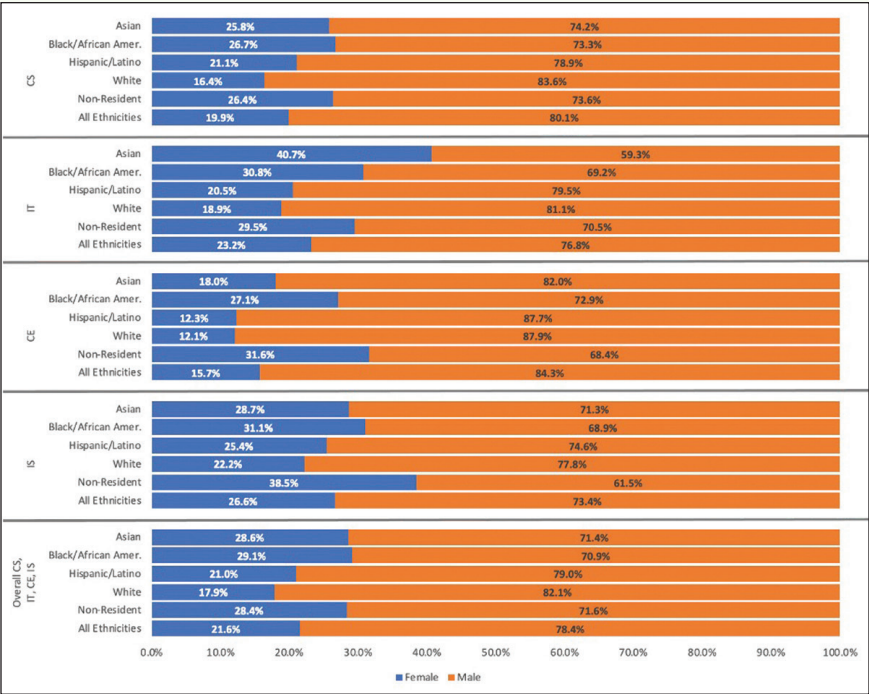


Figure 15: Bachelor's Degree Completions by Discipline for Selected Gender x Race/Ethnicity Categories: Non-Doctoral Institutions

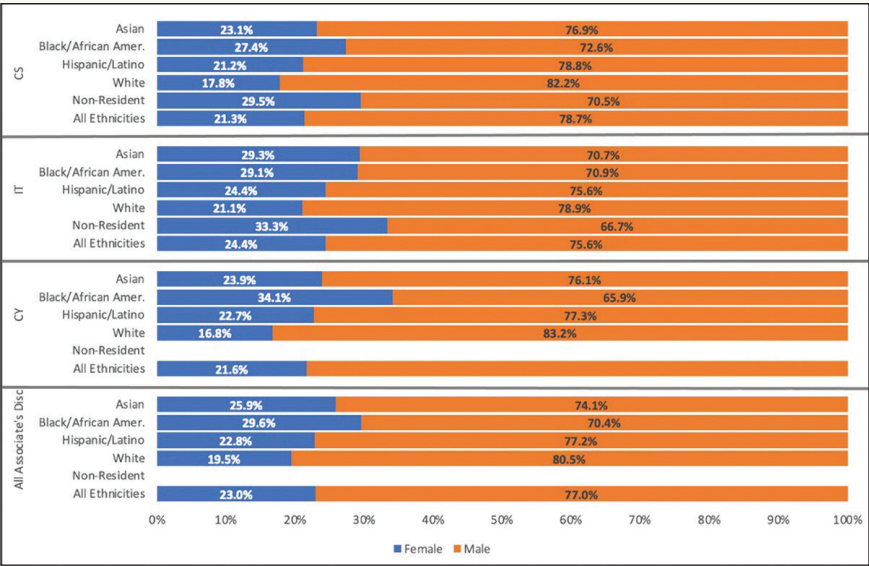


Figure 16: Associate's Degrees by Gender x Race/ethnicity for selected Race/ethnicity Categories

mentioned earlier in the report, this means that the student either graduated from the program in 2021-22 or was still in the program in 2022-23.

At public and private non-profit institutions, bachelor's retention was highest in CE, SE and DS and was lowest in CS and CY. Non-doctoral institutions and non-MSI institutions also showed the highest bachelor's retention in CE, SE and DS, while MSI institutions had the highest bachelor's retention in CE, SE and IS. Retention of bachelor's students at for-profit institutions was uniformly the lowest among the various insti-

tution types studied. Retention of associate's students was uniformly lower than its counterpart bachelor's retention for each institution type and discipline.

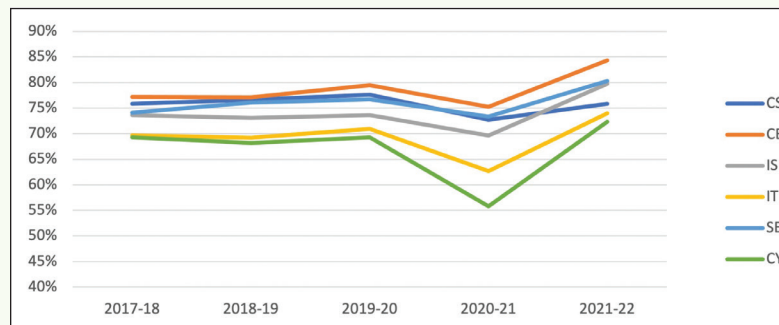
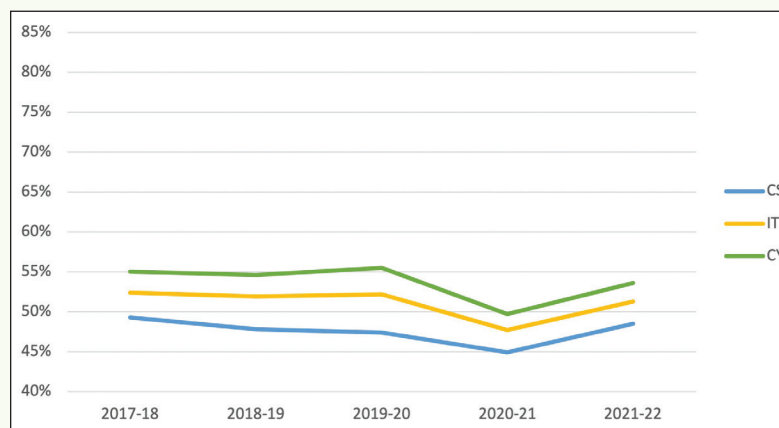
Figures 17 and 18 plot the retention trends for bachelor's and associate's students, respectively, at all institutions during the past five years. The 2021-22 data points in these figures are those from the "all institutions" column of Table 10.

Note that overall retention increased from 2020-21 to 2021-22 in every discipline at each degree level. This follows a year in which retention decreased in every discipline at each degree level, which

Table 10: Retained 2021-22 Students by Institution Type and Discipline (percentage of total enrollment)

BACHELOR'S	All Institutions	Public	Private not-for-profit	Private for-profit	MSI	Non-MSI	R1	R2	Non-doc
CS	75.8%	77.8%	72.6%	54.6%	78.3%	75.0%	83.9%	75.0%	68.2%
CE	84.3%	84.7%	82.8%	31.3%	82.5%	85.1%	87.2%	81.6%	79.9%
IS	79.7%	80.8%	77.8%	67.6%	83.4%	78.3%	89.4%	81.9%	73.2%
IT	74.0%	80.1%	73.6%	63.1%	75.9%	73.7%	86.0%	80.5%	69.5%
SE	80.3%	82.2%	85.1%	63.7%	80.0%	80.5%	80.7%	84.2%	78.5%
CY	72.3%	77.0%	72.2%	61.7%	79.8%	71.5%	83.4%	81.5%	70.3%
DS	84.5%	84.3%	87.5%	56.7%	76.2%	85.8%	86.1%	90.1%	81.4%

ASSOCIATE'S	All Institutions	Public	Private not-for-profit	Private for-profit	MSI	Non-MSI	High Transfer	Bach/Assoc	CTE/Other
CS	48.5%	48.6%	47.5%	45.9%	48.3%	48.7%	48.8%	47.5%	48.3%
IT	51.3%	50.9%	57.0%	54.6%	49.7%	52.2%	49.8%	52.3%	52.0%
CY	53.6%	53.4%	56.2%	56.4%	51.4%	54.9%	53.8%	56.9%	52.2%

**Figure 17:** Overall Bachelor's Student Retention by Discipline – All Institutions**Figure 18:** Overall Associate's Student Retention by Discipline – All Institutions

likely was a byproduct of the 2020-21 educational changes brought about by COVID. It is heartening to see retention recover, in many of the bachelor's disciplines, recovery was to a level greater than pre-COVID. It will be interesting to see if this is a one-year phenomenon or if this recovery is sustained in future years.

This is the first year that we are reporting retention for bachelor's students at non-doctoral institutions, although the annual data provided to us by NSC allowed its computation in previ-

ous years. It is of interest to see the five-year trend of bachelor's student retention at these institutions, and to compare this with the trends across all institutions. Figure 19 shows the trend at non-doctoral institutions, by discipline.

The patterns in Figures 17 and 19 are very similar for each discipline. The differences generally lie in the actual retention rates, which are lower for non-doctoral institutions except for the early years in SE.

Computing Enrollment and Retention: Results from the 2021-22 Undergraduate Enrollment Cohort

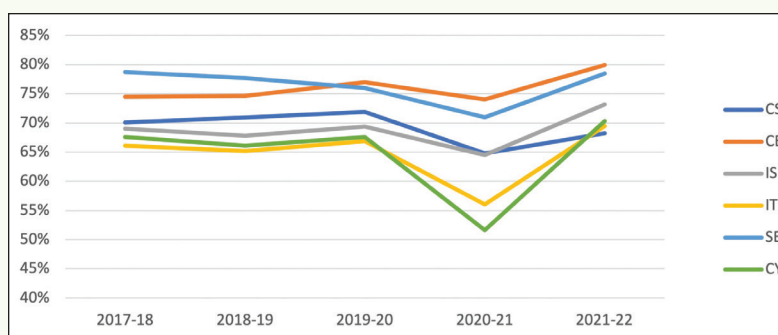


Figure 19: Overall Bachelor's Student Retention by Discipline - Non-Doctoral Institutions

In addition to overall retention, we were interested in differences in retention between male and female students within each discipline. Figures 20 and 21 plot these differences, respectively for bachelor's and associate's programs, for each discipline during the past five years.

In these graphs, downward sloping lines indicate that the year-over-year change in retention more positively affect-

ed female students than it did male students. For bachelor's students, this was true in 2021-22 in every discipline except CY, while for associate's students, female student retention was more positively affected than was male student retention only in CS. Retention lines near the zero percent y-value indicate that there was little difference in retention percentage between male and female students. Points below the zero in-

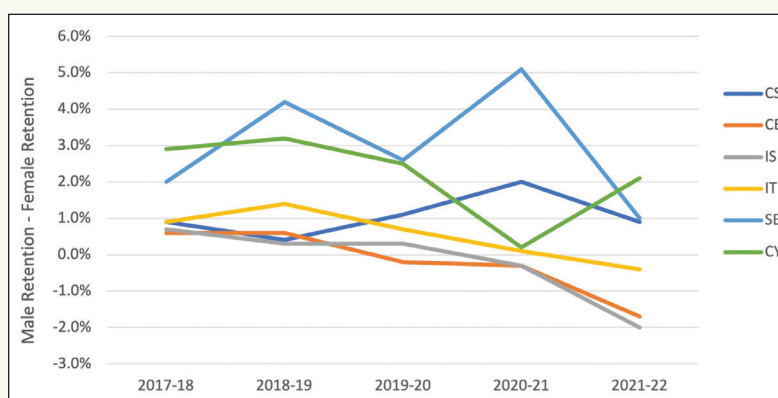


Figure 20: Difference Between Male and Female Retention by Year and Discipline - Bachelor's Programs

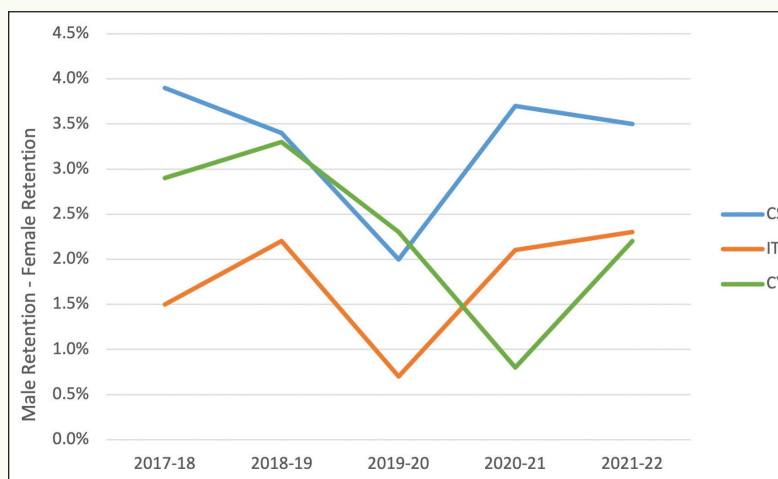


Figure 21: Difference Between Male and Female Retention by Year and Discipline - Associate's Programs

dicate that female retention was higher than male retention, while points above the zero indicate that male retention was higher than female retention. In 2021-22, bachelor's students in IT exhibited the smallest difference (0.4%) between male and female retention, and since it favored female retention, the data point is at -0.4%. In addition to IT, CS and SE also had differences of 1% or less between male and female bachelor's student retention (both favoring male students). Retention of female students in CE and IS bachelor's programs also was higher than that of male students. Associate's retention favored male students for each of the three disciplines by margins of more than 2%.

Table 11 shows the retention percentages for students of selected race/ethnicity categories, for each discipline. There was insufficient data from which to compute some of the retention percentages for the data science area; these are noted as "NA" in the table.

Asian and Non-resident students have the highest retention values among these race/ethnicities, and Black/African American students have the lowest, for all bachelor's disciplines. This

continues a pattern observed during the previous four years [11]. For associate's disciplines, non-resident Alien students rank either first or second in retention, and Black students again have the lowest retention rates. All values in Table 11 are higher than their corresponding values for 2020-21 [11] except for Non-resident associate's students in IT and CY.

We also investigated differences between retention of male and female students within the selected race/ethnicity categories shown in Table 11. For these analyses, we performed two-tailed z-tests for statistical significance. Table 12 has the results of these tests. A test that is not significant is denoted by "NS." If the test could not be performed because of lack of sufficient data, the entry is "NA." Otherwise, the cell contains which gender had significantly higher retention, and at which level of significance (1% or 5%).

For the first time, we saw significant differences among White bachelor's students favoring retention of female students. These were present in CE and IS. Differences among Asian bachelor's students favoring female student retention had been present in prior years, but not consistently, and never before in CE [11]. Retention differences among associate's students are like those seen in prior years, though there have been year-to-year differences.

We also were able to investigate retention changes by class rank for bachelor's students. In a prior report [11] we observed that, between 2019-20 and 2020-21, retention declined in each discipline at each class rank that we were able to compare. We were interested in learning if each class rank's retention value improved, and the extent to which it offset the 2020-21 cohort's decline. Table 13 shows the retention for the 2021-22 cohort by class rank, the change in retention percentage from that observed in 2020-21, and the cumulative retention percentage change over the two-year period from 2019-20 to 2021-22. All class ranks for which comparisons could be made with 2020-21 showed one-year improvement. Except for CS, in all cases for which such two-year computations were possible, overall retention improvement in 2021-22 exceeded the corresponding retention decline in 2020-21, resulting in positive change over the two-year period.

Table 11: Retention Percentages by Discipline for Selected Race/Ethnicity Categories (all institutions)

BACHELOR'S	Asian	Black	Hispanic	Nonresident Alien	White
CS	84.4%	65.5%	72.3%	81.9%	75.9%
CE	88.0%	75.9%	81.2%	85.8%	85.3%
IS	86.9%	72.0%	79.6%	87.5%	81.3%
IT	86.0%	68.6%	74.6%	78.8%	76.9%
SE	84.5%	69.4%	78.8%	81.0%	80.1%
CY	78.4%	67.5%	73.9%	82.4%	75.4%
DS	84.5%	NA	NA	NA	83.5%

BACHELOR'S	Asian	Black	Hispanic	Nonresident Alien	White
CS	47.7%	45.8%	48.6%	53.9%	49.1%
IT	51.7%	46.6%	49.9%	53.6%	53.5%
CY	58.1%	49.8%	52.6%	56.5%	54.9%

Table 12: Retention Difference by Gender within Selected Race/Ethnicity Categories, 2021-22

	BACHELOR'S						Associate's		
	CS	CE	IS	IT	SE	CY	CS	IT	CY
Asian	NS	F(5%)	F(1%)	F(1%)	NS	NS	M(1%)	NS	NS
Black/ Afric Amer	NS	NS	NS	M(1%)	M(5%)	M(5%)	M(1%)	M(1%)	NS
Hispanic/ Latino	M(1%)	NS	NS	NS	NS	M(5%)	M(1%)	M(5%)	NS
White	M(1%)	F(1%)	F(1%)	M(5%)	NS	M(1%)	M(1%)	M(1%)	M(1%)
Non-resident	NS	NS	NS	NS	NS	NS	NS	NS	NA
All Races/ ethnicities	M(1%)	NS	NS	NS	M(1%)	NS	M(1%)	M(1%)	NS

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Table 13: Bachelor's Retention by Class Rank and Discipline

		FR	SO	JR	SR
CS	2021-22	60.8%	74.1%	80.4%	83.2%
	1-yr change	4.1	3.1	3.2	4.2
	2-yr change	-3.3	-0.8	-1.4	-1.4
CE	2021-22	74.1%	83.0%	87.2%	89.7%
	1-yr change	NA	NA	9.0	5.1
	2-yr change	NA	NA	4.5	2.1
IS	2021-22	68.4%	80.0%	82.4%	84.0%
	1-yr change	11.2	14.4	11.0	9.2
	2-yr change	9.2	9.8	6.0	3.6
IT	2021-22	60.2%	77.0%	80.7%	81.6%
	1-yr change	11.2	13.2	10.3	8.0
	2-yr change	3.1	5.2	4.0	1.7
SE	2021-22	69.5%	80.5%	82.3%	85.7%
	1-yr change	NA	NA	6.0	4.5
	2-yr change	NA	NA	2.5	1.9
CY	2021-22	64.4%	72.6%	78.1%	77.8%
	1-yr change	15.4	15.1	13.4	6.7
	2-yr change	6.8	6.2	4.6	0.9

SUMMARY AND CONCLUDING REMARKS

The 2021-22 enrollment cohort demonstrated the continued strong interest in computing among students. Bachelor's enrollment increased in all disciplines except CE. Even IS, which had shown a decline for the previous two years, increased in 2021-22, and IT, which declined slightly in 2020-21, rebounded in 2021-22. CS, by far the largest of the bachelor's disciplines, had a larger increase in 2021-22 than it had in any of the prior four years. All three of the associate's disciplines that we tracked also exhibited increased enrollment. In CS, this followed two years of decline, and enrollment rose to a level greater than that existing prior to the COVID pandemic. In IT, which had a longer period of prior declining enrollment, the increase recovered much of the 2020-21 decline.

It is interesting to speculate whether the observed changes in IT enrollments have been influenced by the growing presence of CY as a discipline. Many IT programs have security components and/or tracks. In some cases, these can form the basis for new CY programs, which in turn can siphon students from IT to CY programs. Those IT programs that did not have a security track in prior years may recently have introduced one, particularly if there was no other CY program available at their institution. Such a change could attract new students to an existing IT program. Further research to determine the effect of CY on IT enrollment could prove enlightening.

The increased enrollment was accompanied by improvements in gender and racial/ethnic diversity in computing programs. Representation of women in 2021-22 was at its highest level of the past five years in both bachelor's and associate's pro-

grams; in most disciplines, there has been some increase each year during this period. Although we had limited data about the DS discipline, it already was clear that the representation of women in this discipline is higher than that in the other computing disciplines. With respect to race/ethnicity, the percentage of students for whom race/ethnicity was reported and who were from historically marginalized populations in computing also rose each year during the five-year period for both bachelor's and associate's programs. Hispanic/Latino enrollment had much larger percentage growth than did Black/African American enrollment. Although the percentage who were White or Asian declined each year, the declining percentages were among White students; the Asian percentage of bachelor's enrollment actually grew during the five years. At the intersection of gender and race/ethnicity, we observed that the representation of women within the major race/ethnicity categories is lowest among White students, also in all disciplines at both degree levels. In CS bachelor's programs, for example, though the overall representation of women is over 21 percent, the representation of women among White students is under 17 percent. In contrast, the representation of women among Black/African American and Asian CS students is in the 26-27 percent range; for other disciplines, the representation of women among Black/African American and Asian students is over 30 percent and for DS it is over 40 percent.

Degree production also increased in 2021-22 across the different institution types, degree types and disciplines, except for a slight decline in CE bachelor's degrees across all institutions. Similar to enrollment, degree production also was increasingly diverse in most cases, with CY being the main exception with respect to gender diversity and CE being the exception with respect to race/ethnicity diversity.

In addition to the increased enrollment and degree production, we observed improved retention for the 2021-22 cohort following a drop in retention in 2020-21. The improvement more than countered the 2020-21 decline that may have been a byproduct of the educational disruptions necessitated by the COVID pandemic.

Another change observed during the COVID period was a decline in the percentage of non-retained students who could be tracked by NSC as continuing their education in the following year, whether at the same institution or at a different institution [11]. The declines were present in each of the two disciplines (CS and IT, the two largest disciplines) that we studied, though they were more noticeable in CS. They also were present at both the bachelor's and associate's level, though more pronounced at the bachelor's level. We were interested in seeing whether this decline also rebounded for the 2021-22 cohort. We found that the 2021-22 cohort was tracked at about the same level as was present in the COVID period for both disciplines and at each degree level. Table 14 shows the percentages of non-retained students from each cohort who were tracked for each discipline at each degree level.

The NSC data continues to provide the computing community with a rich source of knowledge about undergraduate ed-

education trends in the United States. We hope that our report can inform both targeted and systemic approaches to creating a more diverse population of computing students. We also hope that other countries are able and interested in having comparable data made available to the community. ♦

Table 14: Percentage of Non-retained Students Tracked

		2017-18	2018-19	2019-20	2020-21	2021-22
Bachelor's	CS	54.3%	56.6%	51.4%	48.5%	48.8%
	IT		33.3%	29.5%	29.7%	27.9%
Associate's	CS	43.3%	43.6%	41.7%	40.6%	41.7%
	IT		31.6%	28.9%	30.0%	29.5%

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