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Measuring Equity Gaps in Enrollment and Graduation Trends in Illinois Computer Science Programs

Part 1: 4-Year Institutions

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External Review

To ensure that this report's contents are rigorous, accurate, and useful to educators and policymakers with varying levels of background knowledge, IWERC solicits feedback from experts. We thank the following reviewers of this report:

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Measuring Equity Gaps in Enrollment and Graduation Trends in Illinois Computer Science Programs

Part 1: 4-Year Institutions

Introduction

According to the US Bureau of Labor Statistics, the overall employment in computing-related occupations is projected to grow 15 percent from 2021 to 2031, much faster than the average for all occupations.[1] Moreover, computing-related fields make up almost half of all STEM jobs in Illinois and employment in computing-related fields is more remunerative compared to many other industries.[1,2] Despite increasing demand, inequitable participation in computing-related jobs among historically marginalized groups, such as women and Black/African American and Hispanic/Latino workers, persists.[3–5] Filling these positions while attracting and retaining a diverse workforce is equally important to avoid perpetuating existing disparities. Therefore, designing and delivering culturally relevant and responsive computer science (CS) and tech programs that meet the needs of a diverse student population is essential to broaden participation in CS programs, promote personal growth, and increase access to high-paying jobs.[6–9]

This report analyzes enrollment and completion trends for CS students at 4-year post-secondary institutions in Illinois. It measures gaps in equitable representation at the enrollment and completion time points for three historically marginalized groups: women, Black/African American students, and Hispanic/Latino students. We focus on these three groups because of their historical underrepresentation in CS despite closing enrollment gaps in post-secondary education.[6,10]

For the analyses, we used publicly available data from the Illinois Board of Higher Education (IBHE) on CS enrollment (Fall) and degrees conferred (Spring) at 4-year post-secondary institutions for the academic year (AY) 12-13 through AY 22-23.[a] A separate report on 2-year programs follows as Part 2 of this series. We start with a descriptive analysis showing enrollment and graduation trends by race/ethnicity, binary gender, institution, and program type. Using the Proportionality Index (PI), we measure the equity gap in CS programs across the state. Finally, we identify the top schools with equitable attainment for women, Black/African American, and Hispanic/Latino students.

This report is part of a research project that aims to improve equitable access and outcomes for historically marginalized groups in computer science in Illinois. The insights gathered from this analysis can greatly help institutions improve their future student services and shed light on improving the recruitment and retention of future students who may have historically marginalized identities. Additionally, it will serve as the baseline for evaluating the effectiveness of the ongoing change in the state's high school computer science education policy that affects post-secondary institutions. Starting in the 2023-2024 school year, all Illinois school districts serving grades 9-12 are required to offer students the opportunity to take at least one computer science course.[11] This may increase interest and participation in CS and possibly make more high school students interested in pursuing a college CS program. As a result, it is essential to examine the landscape of CS programs offered by Illinois universities.

[a] Enrollment data from AY 13-14 was not available and is not included in any analyses.

Methods

Data Source

The data used in our analyses are publicly available from IBHE's website.[12] This data includes school-level data for Fall Enrollment[b] and Spring Completion at 4-year colleges and universities in Illinois across AY 12-13 to AY 22-23. Data encompassed public, private for-profits, and private non-profit institutions. Student demographics include binary gender (male, female)[c] and race/ethnicity (Black/African American, Asian, Hispanic/Latino[d], White, American Indian and Alaska Native (AIAN), Native Hawaiian and other Pacific Islander (NHPI), International, and Two or more (2+) races)[e]. The data also contains detailed information on the names of programs and fields of study using CIP codes.[13] The data does not include information on graduation rates (i.e., percent of students who complete their degree within 150% of their program's anticipated length).

Defining Computer Science & Computer Science Programs

For this report, we use the following definition of computer science, which we have adopted from the Illinois Legislative Assembly's 2021 definition:

"**Computer science** studies computers and algorithms, including their principles, hardware, software designs, implementation, and societal impact. "Computer science" does not include the study of everyday uses of computers and computer applications, such as keyboarding or accessing the Internet." [11]

While the definition of what is (and is not) CS has been settled within the state legislature, there is still a lack of clarity on what courses or requirements constitute a CS program at the post-secondary level. After internal discussions and meetings with experts in CS and education policy in Illinois from across the state, we agreed on the post-secondary programs to include within "computer science." See the Supplemental Materials for a detailed list of CS programs and CIP codes included in this analysis and the criteria used to select them.

Descriptive Analysis

For our descriptive analysis, we use magnitude (i.e., number of students) and percentages (i.e., the proportion of students in a particular group) to show trends in enrollment and degrees conferred by sector (public, private for-profit, and private non-profit), binary gender, race/ethnicity, and the intersection of gender and race. These statistics will help set the landscape of CS in Illinois. However, we need to know more; contextualizing how broader university enrollment patterns shape enrollment and completion in CS is essential to identify the bottlenecks in the system. The overall trends might show improvements, but some subgroups still need higher achievement in one or more of these outcomes to achieve equitable representation. We use the Proportionality Index (PI) for historically minoritized groups to identify these bottlenecks and measure equity in CS enrollment.

[b] Fall enrollment counts include **every** student who is enrolled in a computer science program as defined by the CIP code our research team selected (see Appendix for more information on CIP codes). It is **not** a count of only new enrollees, but all CS students for that academic year.

[c] Our analysis is restricted to binary gender, as that is what was available in the data set.

[d] We use language throughout the paper to match that of the data source. For example, we use Hispanic/Latino instead of Hispanic/Latino/a/x because Hispanic/Latino is the label used by IBHE.

[e] See IBHE's website for more information on how they collect and label student identity data.

Measuring Equity: Proportionality Index (PI)

The PI method addresses the question, "If a subgroup of students represents 45% of the student body, does that subgroup also represent at least 45% of the students who achieve a specific educational outcome?"[14] Not only did we want to know if there was equitable attainment in CS programs, but also how that equitable attainment was related to the enrollment of historically marginalized groups in the institution and how it relates to their representation in Illinois. For a more comprehensive analysis of equity in CS programs, we calculated three different PIs for each institution: (1) the **Illinois-Institution Enrollment PI** compares enrollment in undergraduate programs relative to the Illinois state population[15]; (2) the **Institution-CS Enrollment PI** compares enrollment in CS programs relative to the enrollment in all undergraduate programs within an institution; and (3) the **CS Enrollment-Completion PI** compares degrees attained in CS programs to enrollment in CS programs within an institution. We included these three PIs to better understand representation at several levels within an institution (e.g., whole institution and departmental level). These three PIs also provide information on what aspects (recruitment or retention) institutions are excelling in or where improvement is needed. Table 1 below summarizes the PI equations and the research question they answer.

Table 1. Proportionality Indices, equations, and the questions they answer.

Proportionality Index	Equation	Answers the question
Illinois-Institution Enrollment PI	For each subgroup... $\frac{Proportion\ of\ institution\ enrollment}{Proportion\ of\ Illinois\ population}$	Is a group equitably represented in the institution's enrollment compared to their representation in the state's population?
Institution-CS Enrollment PI	For each subgroup... $\frac{Proportion\ of\ CS\ enrollment}{Proportion\ of\ institution\ enrollment}$	Is a group equitably represented in their enrollment in CS compared to their representation in the institution's enrollment?
CS Enrollment-Completion PI	For each subgroup... $\frac{Proportion\ of\ CS\ degrees}{Proportion\ of\ CS\ enrollment}$	Is a group equitably represented in the degrees conferred for CS compared to their representation in the enrollment in CS?

Experts recommend using values equal to or less than 0.85 to identify instances of disproportionate impact.[14] We chose 0.85 instead as an intermediate level to highlight the institutions close to achieving a proportional impact but not quite there. See Table 2 for the PI scale.

Table 2. Proportionality index numeric scale, category, meaning of categorization, and an applied example.

PI value	Category	Meaning	Example
PI < 0.85	Disproportionate impact	The institution is **not** doing well for a particular subgroup of students.	*Example*: 20% of total student enrollment at the college identify as Hispanic/Latino, but only 3% of CS enrollment identify as Hispanic/Latino.
0.85 ≤ PI < 1	Somewhat proportionate impact	The institution is close to doing well for a particular subgroup of students but could be doing better.	*Example*: 10% of CS enrollment identify as Black/African American, and 8% of CS degree earners identify as Black/African American.
PI ≥ 1	Proportional impact	The institution is doing well for a particular subgroup of students.	*Example*: 25% of CS enrollment identify as female, and 25% of CS degree earners identify as female.

While the PI method effectively assesses equitable group representation, it is subject to error for small cell sizes. This is particularly problematic for small institutions and small programs. Moreover, because the three PIs decrease in population the more granular they become (i.e., institution enrollment has the largest N and CS degrees completed has the smallest N), PIs fluctuate more year to year. To address this, we calculated each of the PIs using the pooled enrollment or completion, respectively, for the five most recent years of data available (AY 18-19 through AY 22-23). This way, we maximize the cell size for each of the PIs and reduce the variability in year-to-year changes at the institutional level. However, if institutions wish to see their progression over time, we provide year-to-year PIs for each institution in the Supplemental Materials for each year data is available.

Lastly, we categorized each institution by their size using Carnegie's size classification[f] of Higher Education Institutions.[16] Institution size is an important factor affecting institutional structure, complexity, culture, finances, and other influential factors that impact the quality of service provided to various student subgroups.

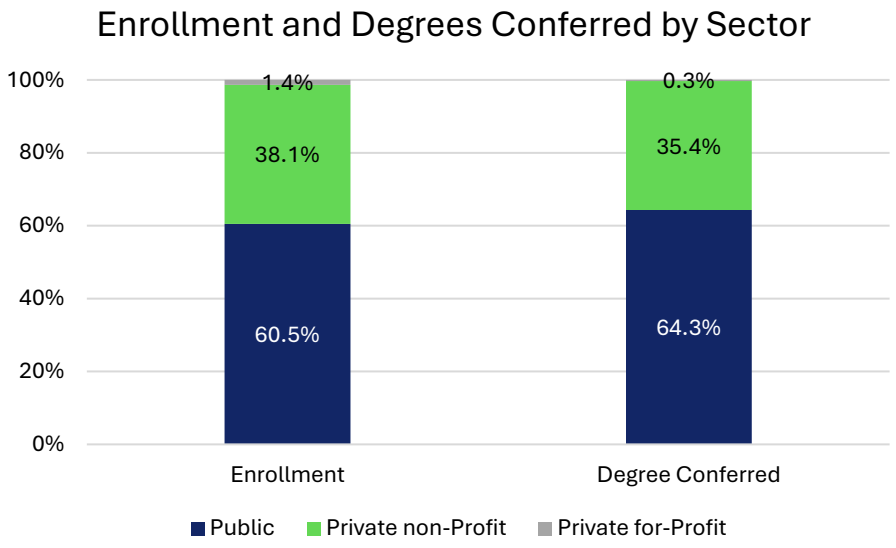
Findings: Descriptive Analysis

What does post-secondary CS education look like in Illinois, and how has it changed in the last decade?

Illinois counts 57 public and private (for-profit and non-profit) institutions that offer training for a bachelor's degree in CS. Public colleges and universities are the leading institutions, with 60.5% of the total enrollment between AY 12-13 and AY 22-23 (Figure 1). Private non-profit institutions followed with 38.1%, and private for-profit institutions made up only 1.4% of the total enrollment.

Public institutions account for 64.3% of CS degrees conferred, followed by private non-profit institutions (35.4%) and private for-profit institutions (0.3%). Because private for-profit institutions account for so few CS 4-year degrees, we omitted them from further analyses in this report.

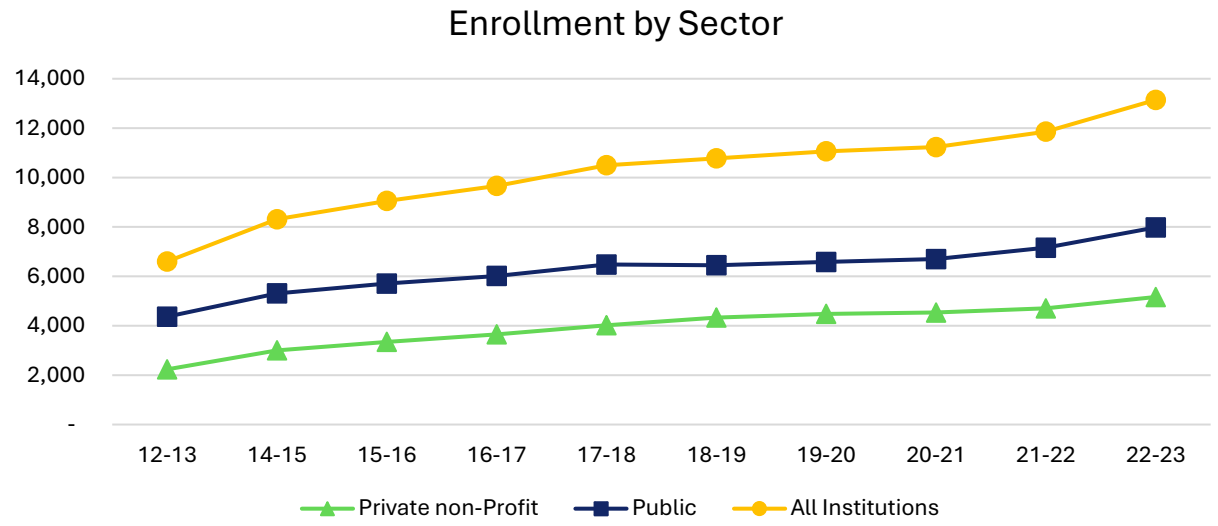
Figure 1. Average enrollment and degrees conferred in 4-year CS programs between AY 12-13 and AY 22-23.



[f] Large (Full-Time Enrollment of at least 10,000), Medium (FTE of 3,000–9,999), Small (FTE of 1,000–2,999), Very small (FTE less than 1,000).

Overall, CS enrollment has steadily increased over the last ten years among all institutions (top/yellow line, Figure 2). The comparison by sector (i.e., institution type) shows a growth in enrollment in both the public and private non-profit sectors, with faster growth in the private non-profits, where the number of students enrolled more than doubled between AY 12-13 and AY 22-23 (131% percent increase vs. 83% percent increase).

Figure 2. Enrollment trends in 4-year CS programs by sector between AY 12-13 and AY 22-23.

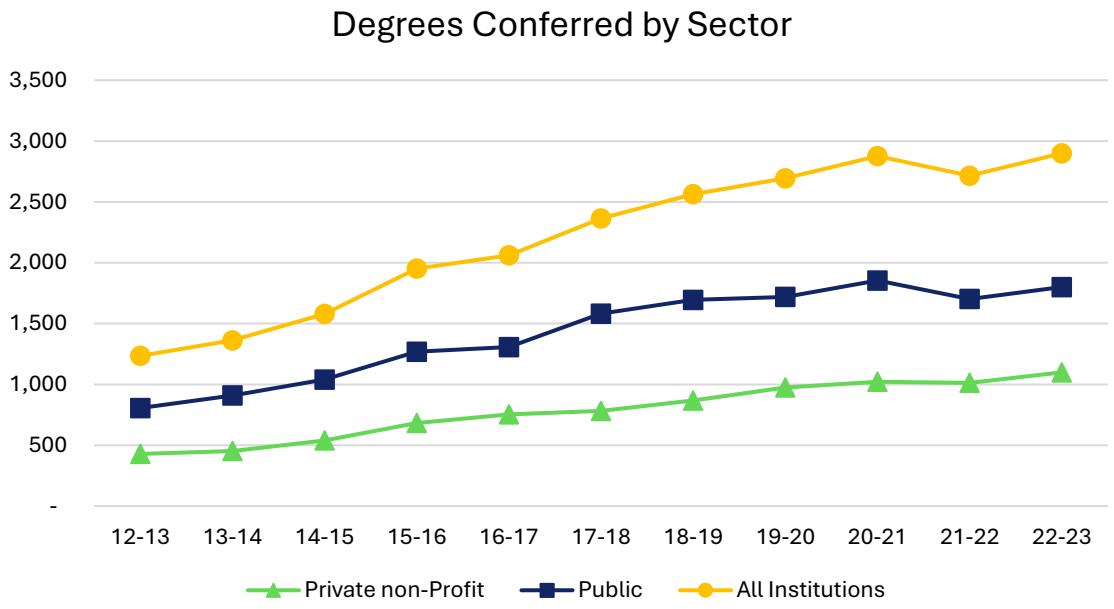


When comparing data from AY 15-16 to AY 20-21, post-secondary enrollment has declined both nationally and in Illinois (5% and 15%, respectively).[17] However, we observed an increase of 27% in Illinois CS post-secondary education enrollment over the same 5-year period, signaling a positive trend for the state.

The number of degrees conferred follows a similar trend as enrollment in both sectors (Figure 3). One interesting segment in the data shows a decrease in degrees earned in AY 21-22 that seems to have affected public institutions more. This might be one of the consequences of students' disengagement during the COVID-19 pandemic. In fact, in a national study from Fall 2020, 51% of college students expressed concern that COVID-19 would impact their ability to complete their degree.[18] However, we see a slight recovery in AY 22-23 for public institutions.

The number of degrees conferred followed the same trend as enrollment over the past decade, increasing at both private non-profit and public institutions (156% increase at private non-profit vs. 123% increase at public institutions). Overall, Illinois made more significant gains in CS degrees awarded compared to national statistics. Between academic years AY 14-15 and AY 19-20, the number of bachelor's degrees in CS awarded nationally has increased by 62.9%[19], while Illinois saw an increase of 70.4% over the same period.

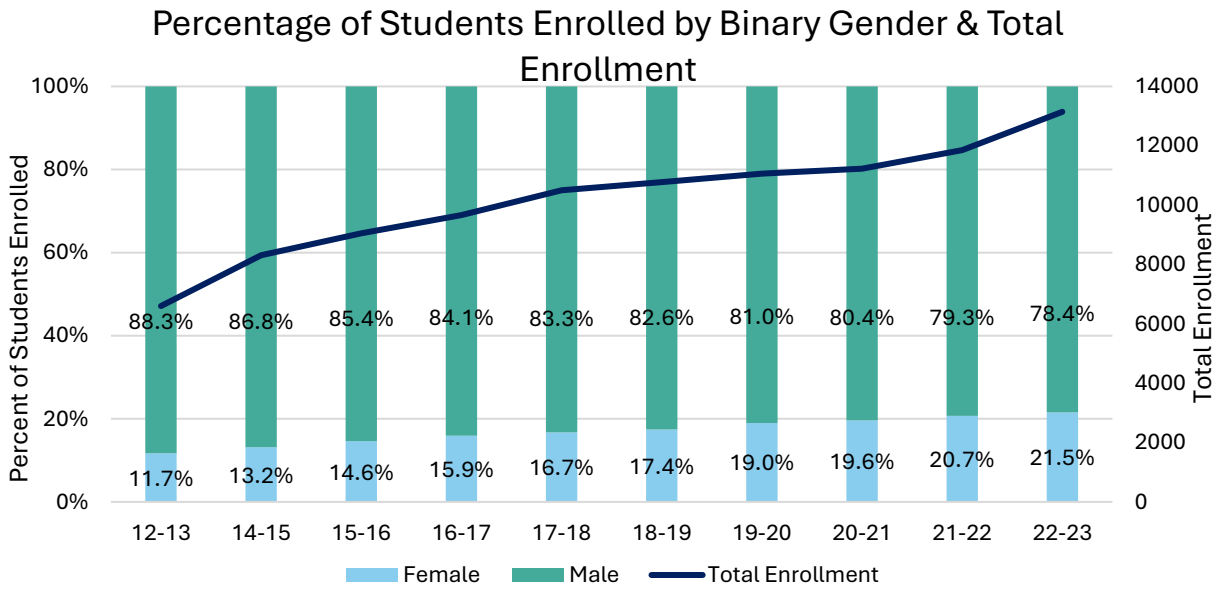
Figure 3. Degree conferred trends in 4-year CS programs by sector between AY 12-13 and AY 22-23.



Does representation in CS differ by binary gender or race?

As shown in Figure 4, most students pursuing CS degrees in Illinois are male, averaging 82.9% of total CS student enrollment over the last ten years. However, women's representation in CS is increasing up to 21.5% of the student body, as seen in recent years. On average, female student enrollment increased by 15.9% between AY 12-13 and AY 22-23 vs. a 6.7% increase for male students. Not only is total enrollment increasing over time, but the proportion of female enrollment is also increasing.

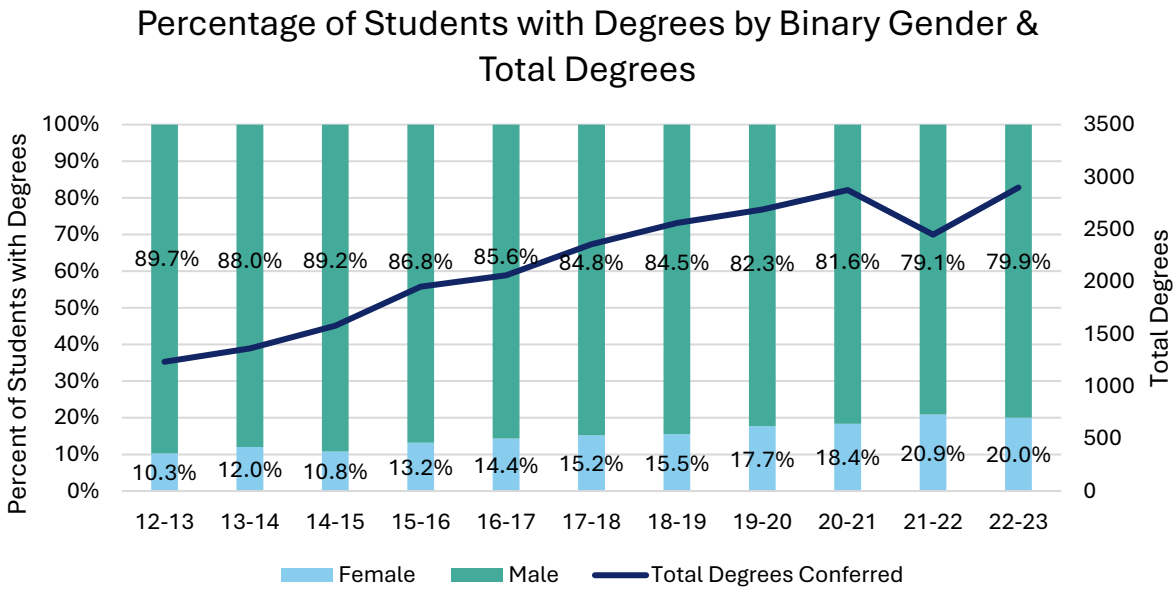
Figure 4. Percent of students enrolled in 4-year CS programs by binary gender (left axis, bar chart) and total enrollment (right axis, dark blue line) for AY 12-13 through AY 22-23.



Although men still receive a much higher proportion of CS degrees compared to women, similar to CS enrollment, representation of women among all CS degree recipients is on the rise (Figure 5). In

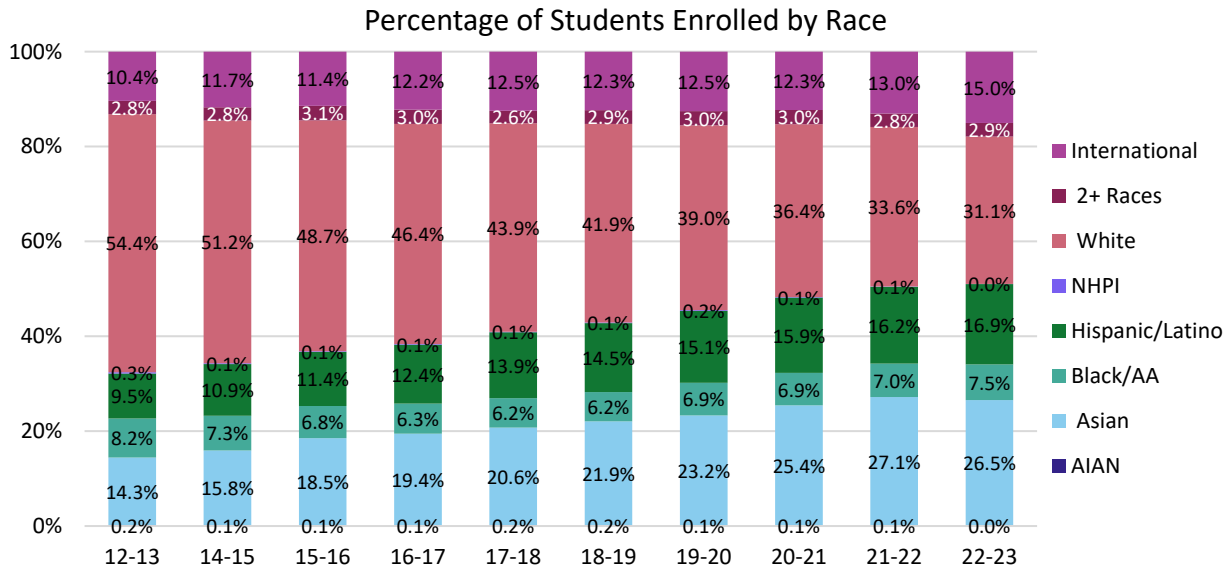
fact, between AY 12-13 and AY 22-23, the number of degrees awarded to women increased by an average of 17.2%, whereas the number of degrees awarded to men only increased by an average of 8.2%. Moreover, the total number of CS degrees awarded in Illinois declined in AY 21-22, while women represented a greater share of those degrees. Since then, total enrollment has increased, and women's representation has diluted.

Figure 5. Degrees conferred in 4-year CS programs by binary gender. Percent of students with CS degrees conferred by binary gender (left axis, bar chart) and total degrees conferred (right axis, dark blue line) for AY 12-13 through AY 22-23.



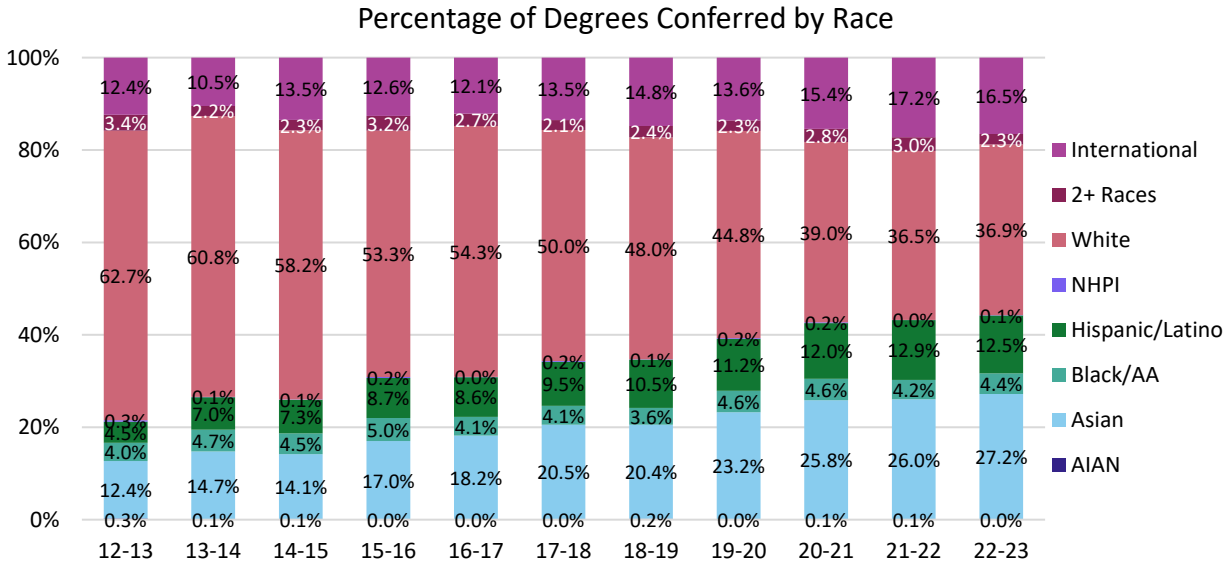
Enrollment in CS has also changed when disaggregated by students' racial identity (see Figure 6). Representation of Hispanic/Latino, Asian, and International students has increased overall in the last decade. During the period shown, enrollment of Asian students nearly doubled, Hispanic/Latino student enrollment grew from 9.5% to almost 17%, and International students increased from 10.4% to 15.0% of all enrollees. The enrollment of Black/African American students has decreased slightly over the last ten years and remains low overall compared to the state's Black/African American population.[15] Representation of students who identify as two or more races has remained constant. There has been little representation of Indigenous students (American Indian and Alaskan Native, Native Hawaiian and Pacific Islander) in CS enrollment. Lastly, proportional enrollment of White students has decreased more and more over the last ten years. In AY 12-13, White students represented 54.4% of all CS enrollees. In the most recent year, they now only represent 31.1% of all enrollees. This points to Illinois CS degree programs generally becoming more racially diverse.

Figure 6. Percent of students enrolled in 4-year CS programs by racial group for AY 12-13 through AY 22-23.



The overall trends we observed for enrollment by race are mirrored in degrees conferred during AY 13-23 (see Figure 7). However, if we compare data points within the same academic year, many student groups (particularly students of color) are not graduating proportionately to their enrollment representation. For example, in AY 22-23, Fall enrollment representation of Hispanic/Latino students was at 16.9%, but at Spring degrees conferred, only 12.5% of all graduates identified as Hispanic/Latino. Black/African American students experienced a similar trend: 7.5% of Fall 2022 enrollment identified as Black/African American, but only 4.4% of Spring 2023 graduates identified as Black/African American. These student groups historically marginalized in CS are still not equitably represented in enrollment or degrees conferred.

Figure 7. Percent of degrees conferred in 4-year CS programs by racial group for AY 12-13 through AY 22-23.

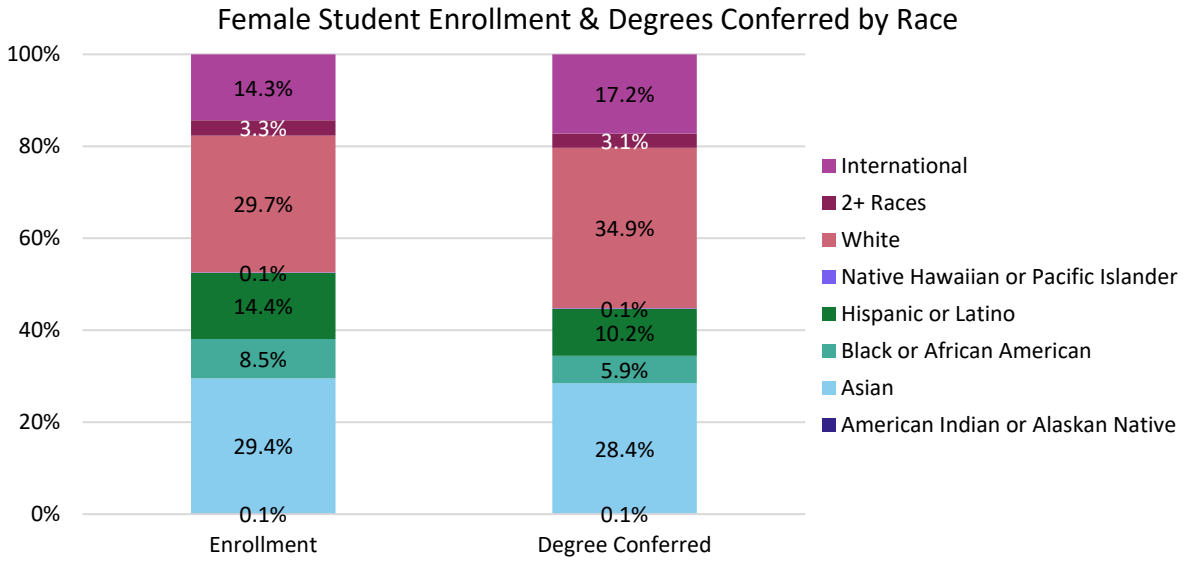


Does representation in CS differ by the intersection of binary gender and race?

While we know women represent 20% (or less) of the CS student body, the women who are represented are relatively more racially diverse compared to their male counterparts. CS enrollment for women is nearly equal between White and Asian women, collectively representing about 60% of all women in CS programs. Hispanic/Latina and International female students share similar enrollment representation at 14% each. The remaining 12% of women in CS include Black/African American women, women of two or more races, and Indigenous women (see Figure 8).

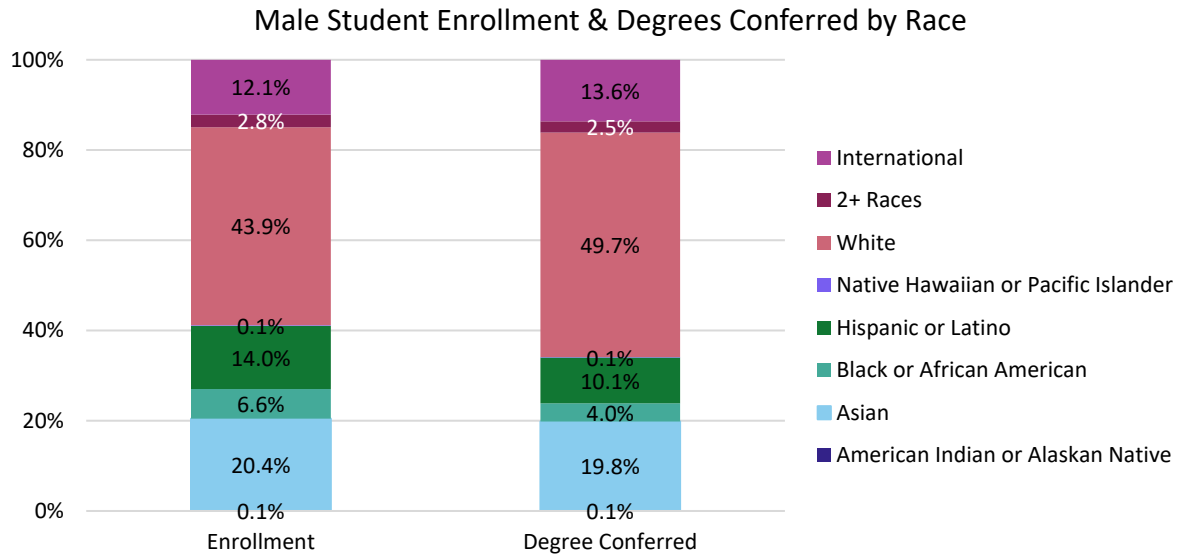
White and International women represent disproportionately more degrees conferred compared to their enrollment. Women of two or more races and Native Hawaiian or Pacific Islander women received a proportional rate of degrees. However, Hispanic/Latina, Black/African American, Asian, and American Indian or Alaskan Native women were disproportionately underrepresented in degrees conferred compared to their enrollment.

Figure 8. Female student enrollment and degrees conferred in 4-year CS programs by race between AY 12-13 and AY 22-23.



The male student body in CS is slightly less racially diverse compared to women. As seen in Figure 9, about 65% of male enrollees are either White or Asian – this raises to almost 70% for degrees conferred. Men identifying as two or more races and Indigenous men represent a small proportion of enrollees but remain steady in their degrees conferred representation. Black/African American and Hispanic/Latino male students are less represented in degrees conferred compared to their enrollment and see the largest decrease over time compared to other groups in the male student body.

Figure 9. Male student enrollment and degrees conferred in 4-year CS programs by race between AY 12-13 and AY 22-23.



When examining any differences between the female and male student body, we do see some stark differences. White students represent more of the male student body than their female peers. Black/African American students represent less of the male student body (6.6% enrollees and 4.0% degrees conferred) than the female student body (8.5% and 5.9%, respectively). This is also true for many other historically marginalized groups in CS.

Findings: Measuring Equity in Illinois CS Programs

Table 3 summarizes the three types of PIs of all 4-year post-secondary institutions in the state offering CS programs for AY 18-19 to AY 22-23 (5-year pooled) for each subgroup. PIs are coded as either a gradient of green or solid blue. The impact for a subpopulation is *somewhat proportionate* ($0.85 \leq PI < 1$) when a cell is shaded light green or *proportionate* if a cell is darker green ($PI \geq 1$). The impact is *disproportionate* if a cell is shaded blue ($PI < 0.85$). In short, any shade of green implies an institution is approaching or at proportionate impact for a particular student group, while blue indicates disproportionate impact, and the institution could be doing more to recruit and retain a particular student group.

Suppose an institution has a dark green color on all the indicators. In this case, not only does its enrollment rate match the percentage of the subpopulation in Illinois, but the enrollment rate school-wide matches the enrollment rate in CS, and bachelor's degrees conferred in CS match the CS enrollment rate. The enrollment and completion data suggests that the institution appears to be recruiting and retaining students well for that subgroup of students. Similar tables completed for each year in the data set are available in the Supplemental Materials.

It is important to note that because the PI calculations are based on individual institution populations, they are not meant to be used as comparisons across institutions, particularly of different size classifications.

Table 3. Pooled 5-year PIs for Illinois 4-year institutions with CS programs between AY 18-19 and AY 22-23.

Institution	Size	Illinois-Institution Enrollment PI			Institution-CS Enrollment PI			CS Enrollment-Completion PI		
		AfAm	Hisp	Female	AfAm	Hisp	Female	AfAm	Hisp	Female
Public										
Illinois State University	Large	0.67	0.66	1.11	1.18	0.93	0.19	0.40	0.51	0.83
Northern Illinois University	Large	1.28	1.15	1.02	0.54	0.80	0.33	0.41	0.81	0.80
Southern Illinois University Edwardsville	Large	0.93	0.29	1.10	0.47	1.07	0.25	0.91	0.76	1.03
University of Illinois Chicago	Large	0.52	1.91	1.04	0.64	0.57	0.36	0.81	0.78	0.90
University of Illinois Urbana/Champaign	Large	0.42	0.73	0.91	0.25	0.34	0.50	0.83	0.67	0.85
Eastern Illinois University	Medium	1.43	0.50	1.20	1.28	0.68	0.29	0.98	0.72	1.00
Governors State University	Medium	2.68	0.93	1.25	0.76	0.90	0.30	0.62	0.77	0.83
Northeastern Illinois University	Medium	0.75	2.40	1.14	0.68	0.77	0.30	0.72	0.90	1.04
Southern Illinois University Carbondale	Medium	1.05	0.52	0.95	0.84	1.16	0.30	0.66	0.96	0.87
Western Illinois University	Medium	1.44	0.69	1.07	1.15	0.56	0.26	0.40	0.82	0.56
Chicago State University	Small	4.95	0.54	1.38	0.97	1.05	0.36	0.90	0.97	0.79
University of Illinois Springfield	Small	0.96	0.58	1.02	0.68	1.12	0.33	0.77	0.81	0.92
Private Non-Profit										
DePaul University	Large	0.53	1.14	1.06	0.80	0.96	0.35	0.55	0.70	0.88
Loyola University of Chicago	Large	0.36	0.94	1.34	1.31	0.99	0.41	0.74	0.78	1.03
Northwestern University	Large	0.42	0.72	1.03	0.83	0.77	0.44	0.99	1.02	0.92
University of Chicago	Large	0.40	0.81	0.95	0.64	0.75	0.63	0.86	0.87	1.01
Aurora University	Medium	0.43	1.97	1.30	0.71	1.21	0.25	0.73	0.76	0.98
Bradley University	Medium	0.51	0.65	1.00	1.14	0.79	0.27	0.38	0.74	0.97
Columbia College Chicago	Medium	1.01	1.19	1.17	0.82	1.33	0.38	0.00	0.71	0.62
Concordia University Chicago	Medium	0.84	1.85	1.12	1.17	1.48	0.20	0.53	0.77	2.03
Elmhurst University	Medium	0.37	1.41	1.22	1.22	0.96	0.30	0.50	0.80	1.23
Illinois Institute of Technology	Medium	0.33	0.96	0.64	0.85	0.87	0.57	0.40	0.72	1.10
Lewis University	Medium	0.40	1.24	1.00	0.79	0.89	0.31	0.64	0.72	1.04
National Louis University	Medium	1.36	2.88	1.46	0.83	1.08	0.29	0.49	0.91	1.07
Roosevelt University	Medium	1.16	1.58	1.26	1.14	1.16	0.36	0.82	0.89	1.06
St. Xavier University	Medium	0.79	2.43	1.25	1.39	1.09	0.33	0.62	0.92	1.21
Augustana College	Small	0.35	0.64	1.10	0.15	0.77	0.33	0.00	0.63	1.16
Benedictine University	Small	0.60	0.96	1.02	1.08	0.86	0.29	0.40	0.51	1.27
Dominican University	Small	0.35	3.35	1.36	1.08	0.98	0.34	0.27	0.95	0.93
Illinois College	Small	0.65	0.44	1.04	0.97	1.49	0.41	0.74	0.86	0.81
Illinois Wesleyan University	Small	0.46	0.55	1.01	1.00	1.14	0.26	0.90	0.89	1.24
Judson University	Small	0.81	1.57	1.06	1.61	1.66	0.18	0.00	0.00	0.00
Knox College	Small	0.51	0.75	1.12	0.69	0.56	0.46	0.87	1.02	0.87
Lake Forest College	Small	0.29	0.93	1.15	0.69	0.86	0.31	0.60	1.20	0.77
McKendree University	Small	0.89	0.34	1.00	0.75	1.33	0.12	0.64	0.38	0.00
Millikin University	Small	0.97	0.28	1.12	0.52	0.36	0.52	0.00	0.00	2.11
North Central College	Small	0.33	0.85	1.04	1.22	0.90	0.38	0.57	0.85	1.15
Olivet Nazarene University	Small	0.57	0.61	1.14	0.69	0.81	0.23	0.00	0.67	0.92
Quincy University	Small	0.80	0.26	0.97	2.24	0.61	0.30	0.22	2.02	2.02
Rockford University	Small	0.81	0.96	1.09	0.89	0.53	0.38	0.58	1.15	0.94
Trinity International University	Small	1.30	0.66	0.80	1.78	1.49	0.05	0.65	1.23	0.00
University of St. Francis	Small	0.64	1.36	1.33	0.93	0.98	0.17	0.00	0.45	1.46
Wheaton College	Small	0.17	0.38	1.09	1.23	1.40	0.51	0.58	0.92	0.90
Blackburn College	Very small	0.65	0.31	1.12	0.70	0.00	0.27	0.00	NA	1.11
East-West University	Very small	3.59	1.39	1.01	0.51	0.68	0.49	0.29	0.83	0.89
Monmouth College	Very small	0.62	0.64	0.99	0.89	1.13	0.28	0.69	0.85	0.39
Principia College	Very small	0.16	0.28	0.90	1.73	0.00	0.36	1.76	NA	0.88
St. Augustine College	Very small	0.29	4.84	1.58	1.42	0.83	0.43	1.21	1.01	0.53
Trinity Christian College	Very small	0.72	0.88	1.29	1.43	0.81	0.25	1.10	0.86	1.34

Note: AfAm = Black/African American; Hisp = Hispanic/Latino; NA = Data not available. Illinois Population: Female (50.6%), Black/African American (14.7%), Hispanic/Latino (18.3%).

Below we highlight several institutions where students from historically marginalized identities in CS are equitably represented at some level in their institution or CS program in both the public and private sector.

Public Institutions

Among the twelve public colleges and universities offering CS programs in the state, none has a CS Enrollment-Completion PI greater than 1 (dark green) for Black/African American and/or Hispanic/Latino students, though five are nearing equitable[g] attainment. Women are equitably represented in CS enrollment and degrees conferred (CS Enrollment-Completion PI) at three institutions and are nearing proportional impact at four others.

- **Small size:** The **University of Illinois Springfield (UIS)** attracts equitable or nearly equitable populations of Black/African American students and women to their institution more broadly with respect to these groups' representation within the state (Illinois-Institution Enrollment PIs = 0.96 and 1.02, respectively). However, neither of these groups are equitably represented in CS compared to the larger student body (Institution-CS Enrollment PI < .085), though Hispanic/Latino students are very well represented in the CS program (Institution-CS Enrollment PI = 1.12). Female students are nearing equitable representation in CS degrees conferred (CS Enrollment-Completion PI = 0.92), though Black/African American and Hispanic/Latino students are still far from this goal. **Chicago State University** has an Institution-CS Enrollment PI value of 1.05 for Hispanic/Latino students, and Black/African American students are nearing equitable enrollment in CS compared to the rest of the undergraduate student body (PI = 0.97). Both groups are also approaching equitable attainment in CS degrees (CS Enrollment-Completion PIs nearing 1). **Chicago State University** also enrolls Black/African American and female students at a much higher rate than their representation in the state more broadly (Illinois-Institution Enrollment PIs = 4.95 and 1.38, respectively).
- **Medium size: Eastern Illinois University (EIU)** also enrolls Black/African American and female students at a much higher rate compared to their representation in the state (Illinois-Institution Enrollment PIs = 1.43 and 1.20, respectively). **EIU** also enrolls Black/African American students in CS at a higher rate compared to the rest of the undergraduate student body (Institution-CS Enrollment PI = 1.28). For CS degrees completed, female students are at equitable representation compared to their CS enrollment (CS Enrollment-Completion PI = 1.00). **Northeastern Illinois University (NEIU)** and **Southern Illinois University Carbondale (SIUC)** are both approaching equitable CS completion for Hispanic/Latino students (0.85 ≤ CS Enrollment-Completion PI < 1) and **NEIU** is at equitable representation for female students (CS Enrollment-Completion PI = 1.04).
- **Large size: Southern Illinois University Edwardsville (SIUE)** not only enrolls Black/African American and female students nearing or at equitable rates compared to their state representation (Illinois-Institution Enrollment PIs = 0.93 and 1.10, respectively), but both groups are at or nearing equitable completion in CS compared to their CS enrollment (CS Enrollment-Completion PI = 0.91 and 1.03, respectively). However, neither of these groups are represented as well in the CS program as they are in the student body (Institution-CS Enrollment PIs < 0.85), revealing space for improvement. **Illinois State University (ISU)** enrolls Black/African American students in CS programs at equitable rates compared to their representation in the student body (Institution-CS Enrollment PI = 1.18) and Hispanic/Latino students are nearing equitable representation (Institution-CS Enrollment PI = 0.93).

[g] Throughout, we use "equitable" and "proportionate" interchangeably.

However, no group is graduating with CS degrees at equitable rates compared to their CS enrollment (CS Enrollment-Completion PI < 0.85).

Despite these positive trends towards equitable representation for historically marginalized groups in CS, no public institution has reached equitable representation across all three subgroups. Moreover, no public institution enrolls female students in CS at equitable rates compared to the overall student body.

Private non-Profit Institutions

Several private non-profit institutions show equitable representation in CS completion for female students, and many for Hispanic/Latino students. Private non-profit institutions also show more promise of equitable representation or nearing equitable representation for CS enrollment compared to the aggregated student body.

- **Small and Very small sizes:** Despite less than equitable representation of Black/African American and Hispanic/Latino students in the institution more broadly, **Trinity Christian College** enrolls Black/African American students in CS above equitable proportions compared to the wider student body (Institution-CS Enrollment PI = 1.43) and graduates Black/African American, Hispanic/Latino, and female CS students at or near equitable rates compared to their CS enrollment (CS Enrollment-Completion PI = 1.10, 0.86, and 1.34, respectively). **Knox College** and **Illinois Wesleyan University** are approaching or at equitable CS degree attainment for Black/African American, Hispanic/Latino, and female students.
- **Medium size: Roosevelt University** not only enrolls Black/African American, Hispanic/Latino, and female students above equitable representation compared to the state population, but they also enroll Black/African American and Hispanic/Latino into CS at above equitable rates compared to the student body, and Hispanic/Latino and female students are all at or approaching equitable representation in CS degrees awarded compared to CS enrollment. **National Louis University** and **St. Xavier University** have also been doing well at recruiting students from historically marginalized backgrounds into their institutions and their CS programs. Both institutions are at or nearing equitable CS degree attainment for both Hispanic/Latino and female students.
- **Large size: Northwestern University** graduates Hispanic/Latino CS students at equitable rates compared to their CS enrollment (CS Enrollment-Completion PI = 1.02) and are nearing equitable CS degree attainment for Black/African American students and women (CS Enrollment-Completion PI = 0.99 and 0.92, respectively). The **University of Chicago** graduates female CS students equitably with respect to their CS enrollment (CS Enrollment-Completion PI = 1.01), and are approaching equitable representation among Black/African American and Hispanic/Latino CS degree recipients (CS Enrollment-Completion PI = 0.86 and 0.87, respectively).

Similar to public institutions, no private non-profit institution in the state enrolls women in their CS programs at equitable rates compared to the overall student body, indicating a wide-spread disparity in CS post-secondary programs. Representation for Black/African American and Hispanic/Latino

students varies by institution, but private non-profit institutions seem to be enrolling these students and graduating them at equitable rates compared to their institutions' population, more so than public institutions.

Across institution sectors and sizes, not one CS program enrolls women at a proportional rate to their enrollment in the institution's respective undergraduate student body. Only a handful of institutions graduate more than one historically marginalized group *at or above* proportional rates to their CS enrollment, though several more are approaching equitable representation. However, while Black/African American, Hispanic/Latino, and female students are not enrolling in CS programs at equitable rates compared to the student body more widely, those enrolled in CS programs are successfully matriculating to a degree conferred.

Highly Ranked Institutions

Rankings for post-secondary programs are widely used to inform future students on their college decision-making and institutions use these rankings to tout their accomplishments and recruit students into their programs that are marked as exemplary.[20] But what does it mean to be an exemplary program if the program does not represent all students?

Table 4 is a condensed version of the PI table above (Table 3) but includes the rankings of Illinois' top CS programs according to CSRankings and US News & World Report.[21,22] All four institutions are highly regarded by these metrics with all of them being placed in the top 60 best programs nationally and one program in the top 5. However, moving to the right of the table, no institution has equitable representation of Black/African American, Hispanic/Latino, nor female students relative to their enrollment at the institution more broadly. This suggests these institutions are not recruiting students from historically marginalized backgrounds as well as they could be. Despite this, the story improves somewhat for students that do enroll in CS programs at these institutions. Across all four institutions, female students are approaching or at equitable representation in those that successfully matriculate through the CS program. The University of Chicago is approaching equitable representation for Black/African American and Hispanic/Latino students graduating with CS degrees. Northwestern University graduates Hispanic/Latino students at equitable rates and is very close to doing the same for Black/African American students compared to their enrollment in CS. The University of Illinois Urbana/Champaign and the University of Illinois Chicago have room for improvement when it comes to graduating students from historically marginalized groups.

Table 4. Illinois institutions with high-ranking programs and their respective pooled 5-year Institution-CS Enrollment and CS Enrollment-Completion PIs.

Institution	CS Rankings	US News	Institution-CS Enrollment PI			CS Enrollment-Completion PI		
			AfAm	Hisp	Female	AfAm	Hisp	Female
University of Illinois Urbana/Champaign	#2	#5	0.25	0.34	0.50	0.83	0.67	0.85
University of Chicago	#23	#24	0.64	0.75	0.63	0.86	0.87	1.01
Northwestern University	#31	#31	0.83	0.77	0.44	0.99	1.02	0.92
University of Illinois Chicago	#45	#60	0.64	0.57	0.36	0.81	0.78	0.90

Note: AfAm = Black/African American; Hisp = Hispanic/Latino.

It is important to note that these rankings are determined from either peer assessments given only to deans and senior faculty members of CS departments or by weighing CS departments by their presence in "prestigious publication venues."[23,24] Moreover, the CS faculty in post-secondary programs who would be eligible to contribute to these rankings via peer assessments do not

represent historically marginalized identities in CS, considering CS faculty are less than a quarter female or non-binary and Black/African American and Hispanic/Latino faculty represent less than 6% of all CS faculty, combined.[25] These rankings that are heavily relied upon by future students and institutions alike are not given by students nor incorporate any measure of student experience, including quality of teaching. This calls into question the metrics used to deem a CS program "exemplary." Exemplary for whom?

Student voice and experience are important aspects that are missing from these rankings. While the PIs calculated in this report do not elaborate on student experiences, they do lend themselves to the overall landscape of a CS program of who is represented and who is not. Research regarding student experiences at Illinois post-secondary CS programs is needed to better understand what programs are doing well for their students and what can be improved upon to better retain and educate students. See IWERC's report *Towards an "uplifting environment": Understanding supports and barriers for students in Illinois computer science college programs* for student perspectives on such issues.[26]

Limitations

Proportionality indices are just one way of measuring equity gaps in quantitative data and have limitations. The main limitation is that, for institutions with small counts (N) in the denominator of each PI (Illinois population proportion, subgroup overall enrollment, and CS enrollment), the PI value can vary widely from year to year in response to enrollments and degrees conferred for a small number of students. We tried to combat this limitation by implementing pooled PI calculations, but the limitation remains for particularly small institutions or programs.

Second, we know this analysis is limited to two time-points: enrollment and degrees conferred. A lot happens in a student's life between these two points, and the data in this study do not provide insights into the inner workings of the CS programs or student experiences. We can see an extremely disproportionate impact on CS enrollment or completion. However, we do not know if that program has taken actionable steps to improve equitable access to CS for all students. We can see equitable enrollment or attainment of a CS degree for a subgroup, but we do not know if that program had other barriers for students. Another report addresses the experiences of CS undergraduate students in a large sample of Illinois colleges and universities.[26]

See the Supplemental Materials for further information on the PI methodological details and critiques.

Conclusion

Computer Science programs in Illinois are experiencing an increase in enrollment. This is a positive finding since so much focus has been placed on broadening participation in the state with efforts like establishing K-12 CS standards[27], state funding for CS program expansion including teacher development[28], funding for undergraduates who major in tech-related fields[29], and our Governor being one of 50 signatories on the *Compact To Expand K-12 Computer Science Education*[30]. Although progress is evident across all races and binary genders, Black/African American, Hispanic/Latino, and female students still face challenges in graduating at proportional rates to their enrollment. Moreover, gaps in equitable attainment of these groups varied from institution to institution across the state.

Improving outcomes is a shared responsibility. Stakeholders need to make a joint, concerted effort to close gaps. To do this, researchers can further study the effects of (a) high school preparation such as content preparation and access to advanced courses and counseling[31,32], (b) wrap-around services at post-secondary institutions, especially for students from historically marginalized backgrounds[33], and (c) state policies that impact CS students and workers (such as iGROW[29] and the CS Equity Grant Program[28]). Institutions can use findings from this analysis as a jumping off point for how they can improve their CS programs. This may include, but not be limited to, distributing program evaluations and responding to student feedback, creating or improving wrap-around services or mentoring programs to improve retention[34], providing professional development for instructional staff on culturally relevant and responsive CS pedagogy[8,35,36], and hiring diverse faculty[37]. Institutions must collaborate, establish relevant policies, and follow through in the implementation process. Lastly, students should feel empowered to voice their experiences to help improve their institution's CS program, and those programs should listen.

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