A Better Understanding of the Faculty Educating Computer Science Students in the United States

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Abstract

The motivation for this work is a better understanding of the faculty educating Computer Science students in the United States. Most previous work has largely concentrated on research faculty at PhD-granting institutions.

A broader look at faculty educating CS students is needed as CS PhD-granting "R1" institutions in the U.S. account for about half of the Bachelor's degrees awarded, but less than 15% of the institutions doing so. These percentages translate into over 800 non-CS-PhD-granting institutions awarding more than 50,000 Bachelor's degrees over two years of data. PhD-granting and research-focused institutions also account for a small percentage of institutions designated as serving populations of minority students.

Motivated by the need to not only examine a range of institution types, but also both "dual-track" (traditional tenure-track) and teaching-track faculty at these institutions, we take an approach where we gather public data about faculty at institutions offering Computer Science degrees. This approach allows us to select the institutions and faculty we study to ensure representation of a variety of types.

Over two years we have collected information about more than 16,000 Computer Science faculty from nearly 550 institutions awarding Computer Science degrees. These institutions are divided into nine distinct groups based on highest CS degree offered and Carnegie Classification of the institution. We use graduate CS ranking to further assist in distinguishing PhD-granting institutions. We also have three groups for institutions designated as minority serving for specific population groups.

Given this motivation and approach, we are able to determine answers to questions regarding different types of faculty at different types of institutions. Results from this analysis include: size and composition of dual- and teaching-track faculty, representation of teaching-track faculty (about a quarter) of full-time faculty across all institutions, ratios between degrees awarded and faculty, predicted gender distribution, rates for promotion in rank of dual- and teaching-track faculty, churn of faculty via additions and losses, and movement of faculty from one institution to another.

In addition to the results obtained thus far, we have established a baseline for future work including longitudinal analysis as well as following up with faculty of interest for demographic and background information to better understand the pathways taken by CS faculty at different types of institutions.

1 Introduction

The goal of this work is to gain a better understanding of the faculty educating Computer Science students in the United States. The demand for Computer Science has driven growth in the number of students pursuing degrees in Computer Science and related fields. While this growth has been tracked, there has been much less work on understanding the characteristics of the faculty educating these students.

The proposed work complements previous and ongoing work that examines aspects of faculty in Computer Science. The annual Taulbee Report [25] contains a wealth of information focused on the education of PhDs in Computer Science and closely related fields. It is based on survey responses from PhD-granting institutions. It also includes salary and demographic information for faculty as well as Bachelor's and Master's degree production at these institutions.

The National Academies of Sciences, Engineering, and Medicine has a study on pathways to doctoral degrees in computing [7]. This study is assessing trends in supply and demand towards advanced degrees.

Studies at the University of Colorado have examined issues within Computer Science around gender, productivity and prestige in faculty hiring networks [20] as well as subfield prestige and gender inequality at top research institutions [6]. These researchers have also examined faculty hiring at PhD-granting institutions more broadly than just Computer Science focusing on gender and retention [19, 11].

Our own work includes ten years studying the needs of Computer Science in terms of research areas and number of tenure-track faculty being sought by a range of universities and colleges, primarily in the U.S. [22]. In addition, we have periodically followed up the advertisement of these tenure-track faculty searches seeking to understand the relative success of institutions in hiring tenured/tenure-track faculty in the desired research areas. Results from such a follow-up study based on a survey of search and department chairs are available [21].

While previous work provides valuable perspective on Computer Science faculty in U.S. institutions, the focus has largely been on research aspects of faculty and students at CS PhD-granting institutions. In contrast, our work seeks to study characteristics of all faculty educating Computer Science students at U.S. institutions. The work not only seeks to examine faculty at a broader set of institutions, but also to consider teaching-focused faculty in addition to traditional tenured/tenure-track faculty.

In terms of teaching-focused faculty, the Taulbee report does provide counts and demographic information for these faculty at PhD-granting institutions [25]. The CRA Education Committee has reported on best practices for engaging teaching faculty [10] as well as for conducting teaching-track searches [3] in research computing departments. In contrast, our work seeks to examine characteristics of teaching-track faculty at not only these, but other types of institutions.

Other work has been done to better understand non-PhD-granting departments by seeking to replicate the Taulbee survey for these departments beginning with two studies [5, 12]. These were followed by ten years of ACM-sponsored "NDC" studies from 2013 [9] to 2022 [26] of non-doctoral-granting departments in computing [1]. However these NDC studies "struggled to get response rates from our departmental surveys that offer a reasonable degree of representativeness of our faculty data" and the survey portion of these studies has been discontinued [26].

Our own work is based on a similar premise that a better understanding of the different types of faculty at a broad range of institutions is important. From this perspective, we initially examine where Computer Science students are being educated in the United States. These results are reported in Section 2. In Section 3 we describe our approach to study different types of faculty at different types of institutions along with a set of research questions we seek to answer in doing so. Section 4 details the methodology we use to gather, extract and validate data for faculty at a range of institutions, which are characterized into groups. We then use these data to determine answers to the questions regarding different types of faculty and institutions in Section 5. In Section 6, we conclude with a summary of contributions and findings of our work as well as point to directions for future work.

2 Institutions Educating Computer Science Students

As part of initial work we sought to determine the institutions in the United States awarding Bachelor's, Master's and PhD degrees in Computer Science along with the number of degrees that each awards. We used data from the U.S. Department of Education College Scorecard [16]. The Scorecard provides both institution-level and field-of-study data in downloadable form. For our work, we used the field-of-study data, which shows the number of degrees awarded by each institution based on Classification of Instructional Programs (CIP) codes. We saved the institutions and counts of Bachelor's, Master's and PhD degrees for two CIP codes: "1101 Computer and Information Sciences; General" and "1107 Computer Science." We included both counts because we observed counts for one, the other or both CIP codes for institutions known to be offering Computer Science degrees. With our focus on Computer Science, we did not include counts for other potentially-related CIP codes. The degree counts are for two consecutive academic years (most recently 2020-21 and 2021-22) as reported by institutions to IPEDS [8]. The data also include whether the institution is public or a non-profit private (we did not include for-profit private nor primarily online institutions [23]) as well as the Basic Carnegie Classification (showing the 2021 classification [2]) of the institution.

Overall, we found 1,043 institutions awarding 129,520 Bachelor's degrees in Computer and Information Sciences, 418 institutions awarding 52,313 Master's degrees and 175 institutions awarding 3,880 PhD degrees. All degree counts are over the two years of data.

Figure 1 shows the breakdown based on the Carnegie Classification of each institution awarding at least one Bachelor's, Master's or PhD degree in Computer and Information Sciences over the two years. The results show close to 150 Very High Research, commonly referred to as R1, and roughly 120 High Research, or R2, institutions awarding degrees. Public institutions make up close to 75% of each of these types. Larger Master's institutions constitute the largest group of institutions while the two Baccalaureate types primarily consist of private institutions.

Figure 2 shows the percentage breakdown for institutions awarding graduate degrees in Computer and Information Sciences. Not surprisingly, the left portion of the figure shows R1 institutions account for 73% of institutions and 87% of PhD degrees awarded. The right portion of the figure shows R1 institutions account for 33% of institutions and 63% of MS degrees awarded.

Figure 3 shows the percentage breakdown of Bachelor's (BS or BA) degrees for institutions in the eight Carnegie Classifications. It shows that R1 institutions award about half of such degrees, but represent less than 15% of institutions doing so. R2 and Larger Master's institutions account for the next highest percentage of degrees awarded. Baccalaureate institutions account for close to a quarter of institutions, but only 6% of awarded degrees.

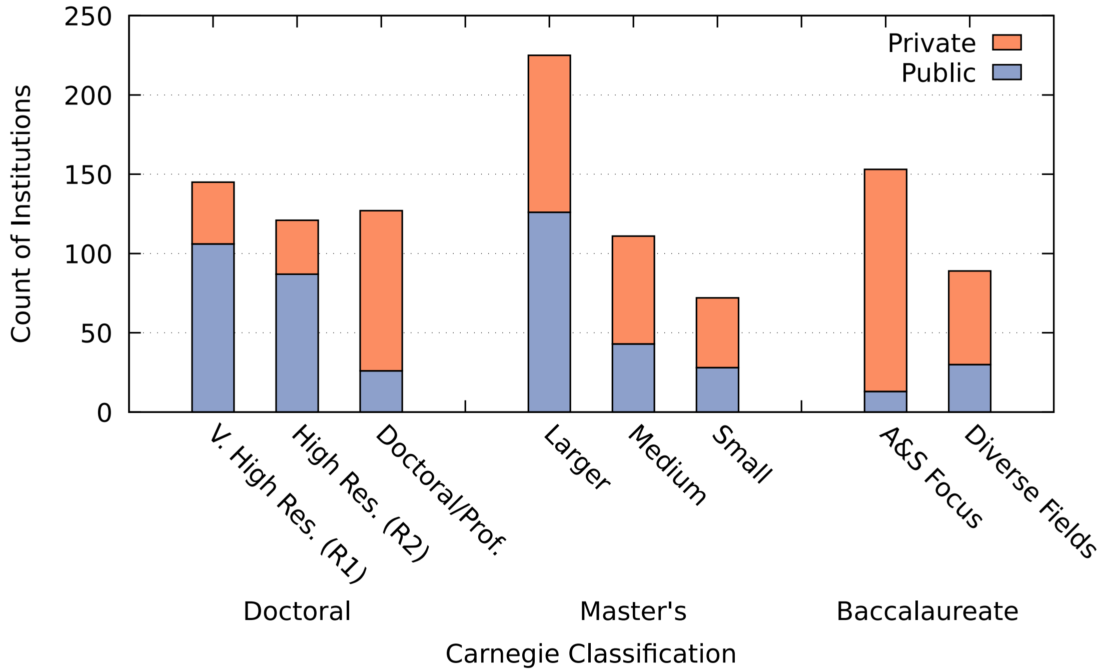

Figure 1: Count of Institutions Based on Carnegie Classification Awarding Degrees in Computer and Information Science

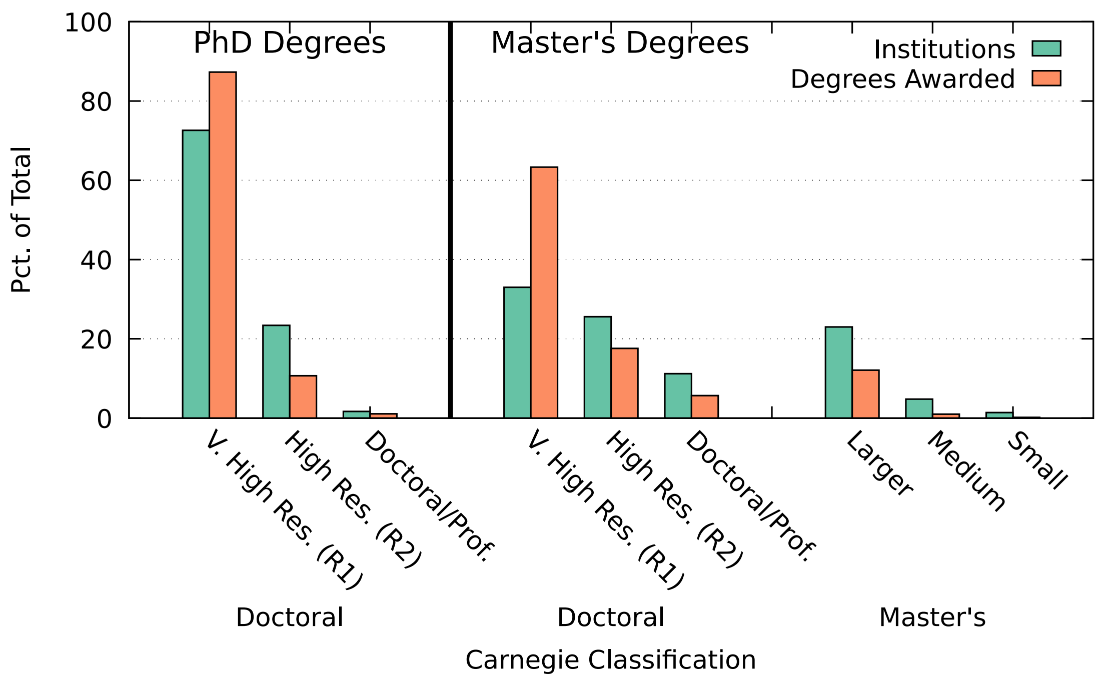

Figure 2: Distribution of PhD and Master's Institutions and Degrees Awarded in Computer and Information Science Based on Carnegie Classification

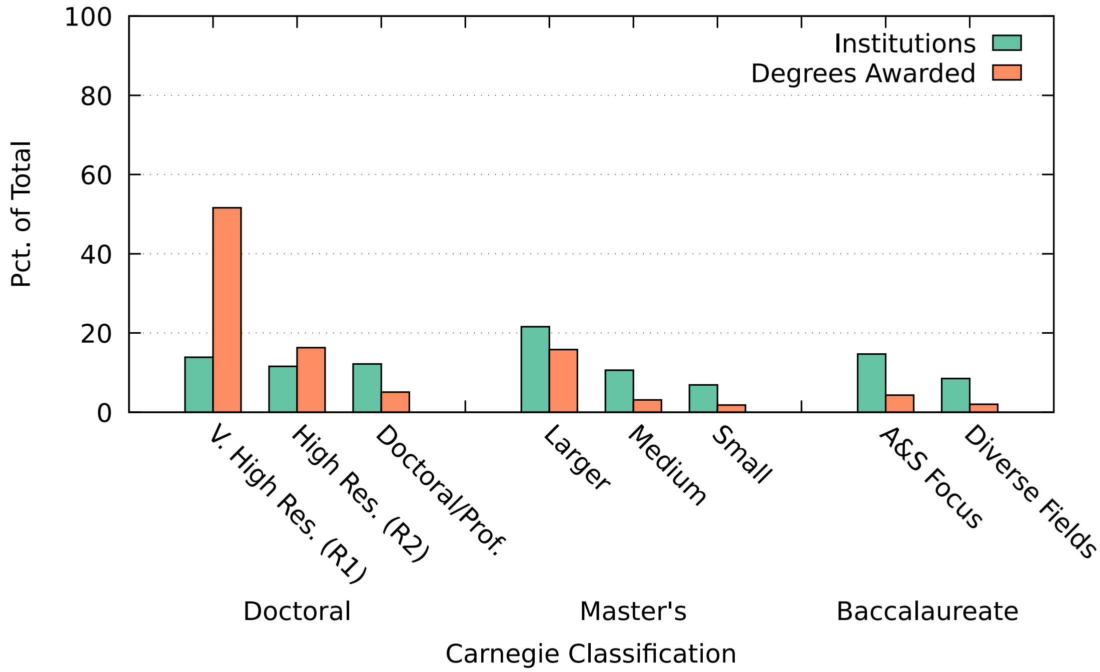

Figure 3: Distribution of Bachelor's Institutions and Degrees Awarded in Computer and Information Science Based on Carnegie Classification

As another basis for comparison, we use a list of institutions awarding CS PhD degrees based on prior work that determined the highest degree awarded by institutions seeking tenure-track faculty in CS [22]. This CS PhD group is based on the observation that not all Carnegie Doctoral institutions award CS PhDs (not even all R1 institutions). Figure 4 shows the percentage of Computer and Information Science degrees awarded and institutions by institutions awarding CS PhD degrees. As expected both percentages are nearly 100% for PhD degrees (it is less because Information Science degrees are also being counted) while institutions awarding Computer Science PhD degrees account for 46% of the institutions and 76% of the MS degrees awarded. The last grouping in the figure shows that institutions offering CS PhDs award 60% of Bachelor's degrees, but account for less than 20% of the institutions.

These collective results show that while R1 and CS PhD institutions are producing the majority of both graduate and undergraduate degrees, these institutions represent only a minority of the institutions involved in the education of Computer Science students, even at the MS level. For example, these percentages translate into over 800 non-CS-PhD-granting institutions awarding more than 50,000 Bachelor's degrees in the two years of data.

In addition to making use of an institution's Carnegie Classification, we obtained a list of those designated as Minority Serving Institutions [15] for certain populations of students. As part of work described in Section 3 we discovered close to 140 of these institutions award degrees in Computer Science, yet only 23% of these institutions award PhD degrees and 16% are R1 institutions. These results serve as further motivation to study a broader set of faculty and institutions educating CS students beyond simply the research-focused faculty at PhD-granting institutions.

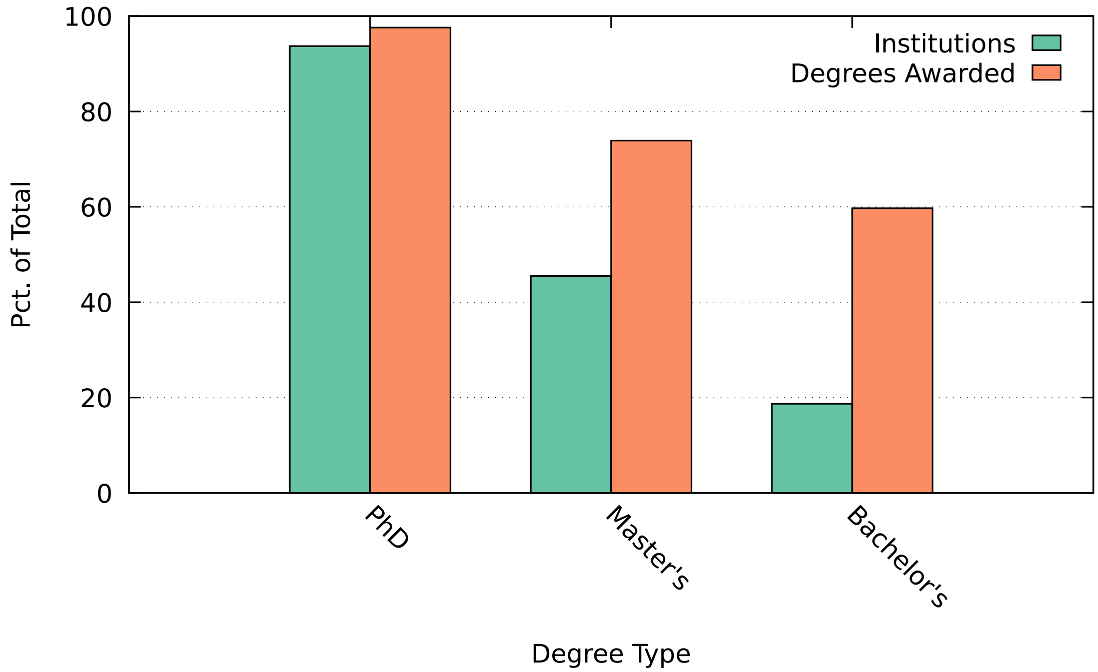

Figure 4: Distribution of PhD, Master's and Bachelor's Institutions/Degrees Awarded in Computer and Information Science by Institutions Awarding CS PhD Degrees

3 Approach

The results on where Computer Science students are being educated demonstrates it is important to consider faculty at all types of institutions and not just the research-focused faculty at PhD-granting institutions. Traditional tenured/tenure-track faculty at most institutions have been joined by teaching-focused faculty in educating students.

In studying different types of faculty at different institutions we adopt standardized terminology for doing so. For traditional tenured/tenure-track positions we use the term "dual-track," indicating both teaching and research responsibilities. The reason for this distinction is that not only have many institutions increased the security of employment for teaching-track faculty, but institutions have also put mechanisms in place for teaching-track faculty to earn tenure. For example, the University of California system has the equivalent of tenurable teaching-track positions [14]. The University of British Columbia and our own institution have tenurable Professor of Teaching positions [13, 24]. Equating "tenured/tenure-track" faculty with those focused on both teaching and research is not entirely accurate. Thus in our work we intentionally describe positions as either "dual-track" or "teaching-track" (or as "research-track") without delineating whether these positions are tenure-track or not.

Our interest in studying the different types of faculty educating Computer Science students at the different types of institutions leads to a number of research questions we seek to answer in our work. These questions are enumerated below.

1. **How does the size and composition (across ranks) of dual-track faculty compare at different types of institutions?** Are there differences in the composition of faculty across

ranks at CS PhD-granting institutions versus other institutions?

2. **How does the size and composition (across ranks) of teaching-track faculty compare at different types of institutions?** Are size and composition trends for teaching-track faculty comparable to those for dual-track faculty at different types of institutions?

3. **What is the contribution of teaching-track faculty to educating students?** Are ratios between dual-track and teaching-track faculty comparable at different institution types? Are they comparable between institutions of similar type?

4. **What is the ratio between students receiving degrees in Computer Science and the faculty educating them?** Do these ratios vary based on degree and institution type?

5. **Are there differences in demographics between faculty at different types of institutions?** Name-based tools exist to predict gender with good accuracy. How does this predicted gender compare across different types of faculty and institutions?

6. **Do we see differences in the rate in which faculty are promoted in rank across faculty tracks and institution types?** Both dual and teaching tracks have multiple ranks, how much movement do we see between ranks in each track?

7. **Do we see differences in the number of faculty added and lost across faculty and institution types from one year to the next?** What is the total amount of churn for different faculty and institution types? What is the net change in the number of faculty of each type?

8. **How much movement of faculty do we see between institutions of different types?** Can we identify faculty that leave one institution for another another and what can we learn from these transitions?

4 Methodology

If the focus of our work was only on faculty at PhD-granting institutions then many, but not all, of these questions could be answered with reported Taulbee data, which includes data from many PhD-granting institutions. While we do make use of these reported data to validate and provide historical context, they do not allow us to study faculty at the majority of institutions educating Computer Science students. The NDC survey studies attempted to address this issue, but did not receive a representative number of responses [26], although we also reference these results as appropriate for historical context.

Instead of requesting department leaders to complete a survey, the approach we take is to gather public data from a department's Web pages identifying the faculty in the department along with their titles. Generally departments offering Computer Science degrees, unless particularly small, do publicize the set of faculty in the department.

Our approach has a number of advantages for answering questions about faculty educating Computer Science students:

1. it can be applied to any institution publishing a faculty roster allowing the selection of institutions representing a variety of types,

2. it does not require use of a survey with potentially uneven or changing participation,
3. it can be repeated for longitudinal comparison on the same set of institutions,
4. it allows for comparison of individual faculty to identify updates such as additions, losses and change in rank within an institution,
5. it allows the possibility of identifying faculty switching between institutions, and
6. it allows for the potential of identifying specific faculty of interest for a follow-up investigation to augment the baseline information.

Despite the many advantages, our approach does assume institutions keep public faculty information up-to-date and with it we cannot gather sensitive information, such as salary information, or information that is not provided by all departments, such as faculty background. In addition, survey responses have built-in human validation of the reported results while automatically gathered data and extracted information from sources, which have a myriad of formats, may result in errors. Validation on the correctness and completeness of our gathered data is addressed as an important part of our methodology.

4.1 Institutions for Study

Initial work for this study began in the 2022-23 academic year when we gathered faculty data in March'23 from a variety of institutions in anticipation of additional data gathering and analysis during the 2023-24 academic year.

We not only wanted to include PhD-granting, but also a variety of other institutions. Thus our initial gathering included candidate institutions in the R1, R2 and Doctoral/Professional Carnegie Classifications. We augmented this list with top regional institutions and national liberal arts colleges based on U.S. News rankings [18]. We added candidate institutions that are designated as minority serving [15].

Faculty information was gathered for each candidate institution if 1) it has a department offering a Computer Science degree, which may include other degrees; and 2) it has a Web page(s) identifying the faculty in the department along with their titles. A number of institutions with Master's and Baccalaureate Carnegie Classifications are not included in the dataset because they did not meet both of the requirements. In departments offering multiple degrees, such as EECS, CSE and Math/CS, we did not distinguish the discipline of the faculty member in extracting the contents of a page.

The URL(s) for the page(s) containing faculty information were identified for each institution. Most (roughly 80%) of these faculty pages could be retrieved automatically, but some (roughly 15%) require browser assistance and the remaining 5% require manual augmentation for correct data extraction. The text on the pages are then parsed to identify faculty name, title, rank, track, status and email address. More details on data extraction and validation are provided in Section 4.4.

4.2 Faculty Characterization

In total, our initial work collected information on over 14,000 Computer Science faculty from roughly 450 institutions. In this section, we describe how faculty are characterized in our dataset.

Each identified faculty member for a department at an institution is assigned a track, title, rank and status. The set of assigned values for each attribute (if known) are summarized as follows with additional explanation below.

- Track: Dual, Teaching, Research
- Title: Professor, Instructor
- Rank: Assistant, Associate, Full, Senior
- Status: Regular, Adjunct, Affiliate, Emeritus, Visiting

Our use of faculty tracks, titles and rank for dual-track faculty are standardized across institutions to Assistant/Associate/Full Professor. A relatively small number of faculty have additional designations such as "Distinguished" or a "Chair" position (separate from department leadership), but we do not encode these as additional ranks in our dataset. We also collect ranks for research-track faculty, but do not include post-docs in our dataset.

In contrast, we observe teaching-track positions at different institutions are assigned a much broader set of titles. In our own dataset, we standardize all teaching titles and ranks to either Assistant/Associate/Full Teaching Professor or [Senior] Instructor. A title of Lecturer is encoded as Instructor. Although a few institutions employ the rank of Assistant/Associate/Full for Instructors (which we record as such), Instructors either have no rank or have the promoted rank of "Senior", which is also recorded for "Advanced" or "Principal" Instructor positions. Instructor levels such as "I", "II" or "III" are not encoded because we do not observe many occurrences and there is no standard for how such levels are used across institutions.

Teaching Professor (or Professor of Teaching) positions are recorded with one of the three standard ranks. Aside from these titles, institutions employ a myriad of alternate labels to distinguish teaching-track professors from dual-track professors. These include variations of "Practice," "Clinical," "Instruction," "Residential," "General," "Special" and "Collegiate." Each of these labels is assigned as a teaching-track Professor position in our dataset at appropriate rank.

A faculty status of "Regular" is assigned to long-term, full-time faculty in a department and our analysis is entirely focused on this set of faculty at each institution. Other status types of "Adjunct" (or "Part-Time"), "Affiliate", "Emeritus" and "Visiting" are recorded when identified by departments, but were not a focus in data gathering with less certainty on completeness. Faculty with dual or joint appointments in more than one department are included as "Regular" faculty in our data extraction unless it is labeled as an "affiliate" or "courtesy" secondary appointment.

Two other pieces of information about each faculty member were recorded when available. The first are administrative titles such as "Chair," "Head," "Dean" and "Provost," which are translated to a Full Professor position if a faculty title is not provided. The second are email addresses, which are currently not used in our analysis but stored for potential future use.

4.3 Set of Institutions and Characterization

In looking to analyze our collected data for Computer Science programs at different types of institutions we wanted to create groups of institutions with similar characteristics and group size. We also wanted to create distinctions among the nearly 200 PhD-granting institutions. In contrast, the only distinction for most results in the Taulbee survey is between public and private PhD-granting institutions. Based on these considerations we grouped our set of institutions with gathered faculty information using three factors:

1. The highest degree (PhD, Master's (shown as MS), Bachelor's (shown as BS/BA)) offered by the institution in Computer Science. We used data from our previous work on faculty hiring [22] and supplemented it as needed.

2. The Carnegie Classification for the institution (Doctoral, Master's, Baccalaureate). Note that just because an institution is classified as Doctoral does not mean that it offers a CS PhD or even a CS MS degree. In fact we found many institutions where Computer Science is offered at a lower degree level than the institution's Carnegie Classification or not at all.

3. The U.S. News Computer Science Graduate Ranking [17]. This ranking is based on peer assessment and like any ranking is open for debate on its ordering, but we do use it because it is well known and we only use it broadly to distinguish the top-50 and top-100 CS graduate programs.

Based on those three factors we classify each CS-degree-granting institution in our dataset into one of nine distinct groups. As an example of the institutions in each group, we indicate the public and private institution with most degree production based on highest CS degree offered using data described in Section 2. The complete set of institutions for each group are shown in Appendix A.

1. PhD-Top50-R1: CS PhD-granting, R1 institution ranked in the Top 50 (including ties) of graduate Computer Science programs (Georgia Tech and Carnegie Mellon U.);

2. PhD-Next50-R1: CS PhD-granting, R1 institution ranked in the Top 100 (including ties) of graduate Computer Science programs, but not ranked in the Top 50 (U. Buffalo and George Washington U.);

3. PhD-One-Top: CS PhD-granting and either classified as an R1 institution or ranked in the Top 100 (including ties) of graduate Computer Science programs, but not both (U. North Texas and Illinois Tech);

4. PhD-No-Top: CS PhD-granting institution neither classified as an R1 institution nor ranked in the Top 100 (including ties) of graduate Computer Science programs (Oakland U. and Nova Southeastern U.);

5. MS-Doctoral: CS MS-granting institution classified as a Doctoral institution (R1, R2 or Doctoral/Professional) (California State Fullerton and Pace U.);

6. MS-Masters: CS MS-granting institution classified as a Master's institution (Larger, Medium or Small) (Towson U. and New York Institute of Technology);

7. BS/BA-Doctoral: CS BS/BA-granting institution is classified as a Doctoral institution (R1, R2 or Doctoral/Professional) (Rutgers U.-Newark and Regis U. Denver);

8. BS/BA-Masters: CS BS/BA-granting institution classified as a Master's institution (Larger, Medium or Small) (Middle Georgia State and Marist College); and

9. BS/BA-Bacc: CS BS/BA-granting institution classified as a Baccalaureate institution (A&S Focus or Diverse Fields) (United States Military Academy and Carleton College).

In addition to these nine groups where each institution is in one and only one group, we also created three groups based on the three largest minority-serving institution designations, which are indicated below along with the public and private institution awarding the largest number of Bachelor's degrees.

1. AANAPISI: Asian American and Native American Pacific Islander-Serving Institutions (U. Washington and New York Institute Technology);

2. HBCU/PBI: Historically Black College & Universities or Primarily Black Institutions (Georgia State and Clark Atlanta U.); and

3. HSI: Hispanic Serving Institutions (U. California Irvine and Nova Southeastern U.).

With these groups in place we repeated our data collection in the middle of the 2023-24 academic year (January'24) for institutions in our initial set the previous year. We also added institutions in groups that were not as well represented, primarily from Master's institutions. We particularly tried to add previously-not-included institutions awarding relatively more degrees among Master's institutions in Figure 3.

The end result is that our dataset for the 2023-24 academic year contains over 16,000 faculty from nearly 550 institutions. This dataset contains all PhD-granting institutions and a good representation of BS/BA- and MS-granting institutions that provide public rosters of their CS faculty. The breakdown of these institutions among the 9+3 groups with separation of public and private institutions is shown in Figure 5.

The figure shows that each of the 9+3 groups is of a comparable size with between 40 and 80 institutions in each group. There tend to be more public than private institutions, except for Baccalaureate institutions, which is similar to Figure 1.

4.4 Extraction and Validation of Faculty Data

The typical Web page providing faculty information contains at a minimum each faculty member's name followed by their title and rank. We convert the Web page content to text and then use heuristics on the possible form of a valid name (what form it may and may not take) as well as that of a valid title. When a valid faculty title is found then it is associated with the last valid name that was extracted. In addition, other information about a faculty member such as photo, office location, email address, phone number, administrative position, earned degrees, biography and research/teaching interests may be available on the page contents. We do store the administrative position (head/chair, dean, provost) and email address of faculty if available (it may not or it may be intentionally obscured), but do not try to store other information in our dataset. Roughly 95% of pages can be automatically extracted as they follow the typical organization with the remaining pages needing suitable modification before data extraction.

While the typical Web page of department faculty follows the format of name followed by rank and title, the way that this format is expressed in a Web page has no standardization. As such it is important to understand the correctness and completeness of the resulting dataset. We have

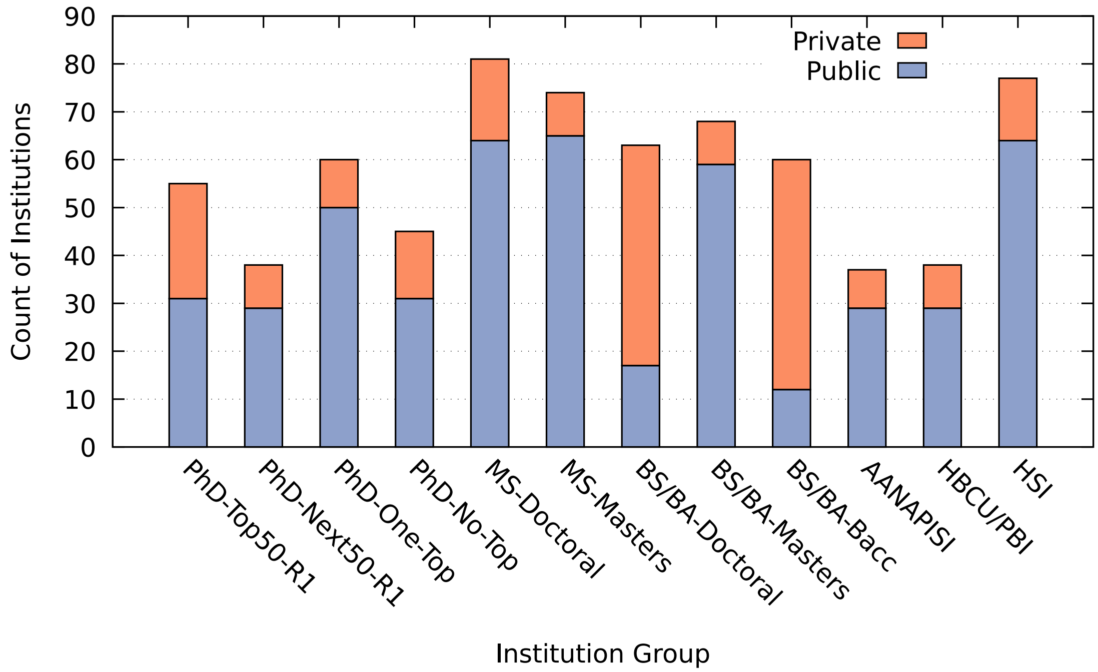

Figure 5: Count of Institutions By Group with Gathered Computer Science Faculty Information

taken a number of steps in our initial data gathering last academic year and our data gathering this academic year to both determine the completeness and correctness of our dataset as well as correct inaccuracies that are found. These steps include:

1. We determine the number of faculty extracted for each track for each institution. In the initial gathering unusually small numbers indicated institutions where the automated data retrieval did not capture all faculty. Comparisons of faculty counts between the two years helped to identify missing faculty such as institutions that include teaching-track faculty on a separate Web page or not including all pages in the initial collection for rosters that span multiple pages. As would be expected, the URL containing the roster of faculty also changed between years for a small number of institutions. We also identified large drops in faculty counts when faculty with joint or collaborative appointments are moved to a separate page.

2. We convert names to a standard format and remove additions such as “Dr” and “, PhD.” to aid in comparison. We use a stoplist of words to reduce the likelihood of false positives in name identification and flag names for manual inspection that contain known English words.

3. We randomly selected 30 institutions from this year’s data gathering and manually compared the extracted faculty with the actual faculty roster for the Computer Science Department of each institution. Institutions were selected from each of the institution groups described in Section 4.3. We extracted roughly 500 faculty from these 30 institutions. Manual comparison found that six faculty were missed by our extraction process and another four faculty were identified with the wrong title or name. We also identified five instances where the title for a faculty member on the Web page was wrong or missing. Ignoring these issues in

content, the total of ten inaccuracies for our extraction process resulted in a 2% error rate for this random set.

4. As part of our analysis, we sought to identify faculty promoted from one rank to a higher rank within a track. During this analysis we found 1-2% of faculty where the previous and current rank/title did not correspond indicating data extraction and analysis errors.

In all, the small rate of errors (which were corrected when encountered) allows us to be confident in comparing results for different institutional groups, but also demonstrates that the extracted data need to be validated if results are reported for specific faculty or institutions.

5 Results

We use our gathered and curated dataset to answer the questions posed in Section 3 for our defined set of institution groups. For each group, we generally show results for the combined set of public and private institutions, but do note when there are distinctions between public and private within an institution group.

5.1 Dual-Track Faculty Size and Composition

Our first research question seeks to understand the size and composition of dual-track faculty for each of the institution groups. For this analysis we use faculty rosters for the 2023-24 academic year. The average size for institutions within each group are shown in Figure 6.

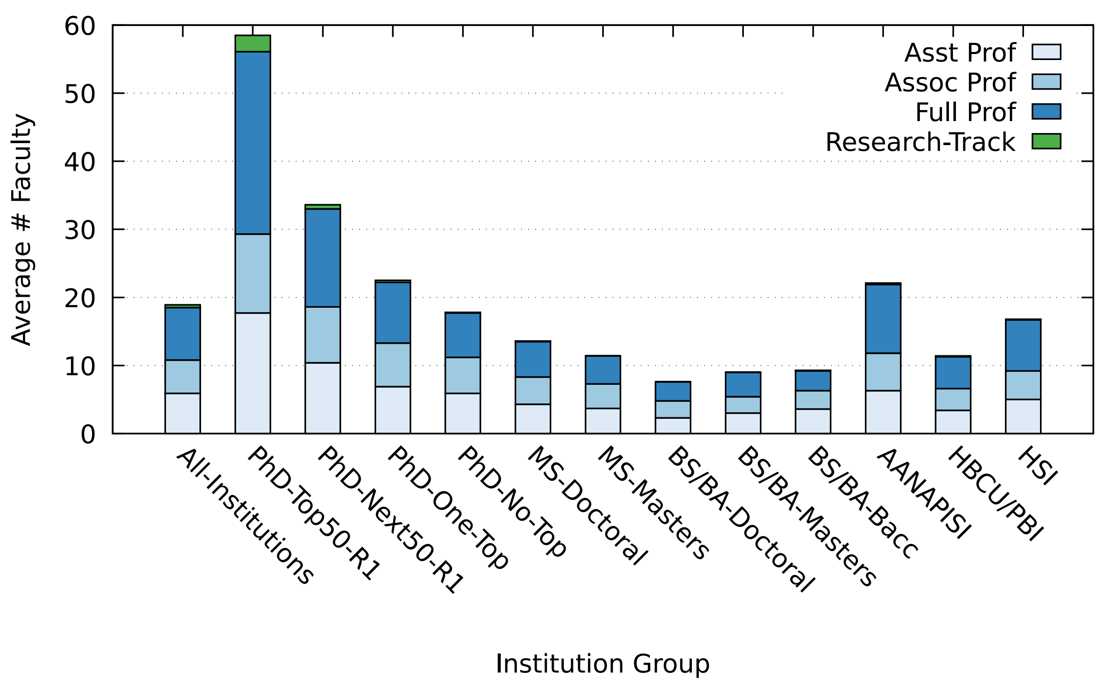

Figure 6: Average Sizes of Dual-Track Faculty for Institutions in Each Group

The results are not surprising in that PhD-granting departments are the largest, particularly the top-ranked ones, with MS-granting institutions smaller and BS/BA-granting institutions the smallest on average. Not shown in the figure is that faculty size at public institutions within most groups tend to be larger. Overall the average size of dual-track faculty is 16% larger at public relative to private institutions.

Figure 6 breaks down the average number of faculty in each rank for each institution group. Overall, Full Professors account for 42%, Associate Professors for 26% and Assistant Professors for 32% of all dual-track faculty.

Figure 6 also includes the average number of research-track faculty for institutions in each group. While not a focus of our work, we did note such faculty in our data extraction and include the results here for completeness. Not surprisingly, these faculty are most visible for the PhD-Top50-R1 group where they are 4-5% of the size of dual-track faculty. This percentage is similar as reported by in the most recent Taulbee survey results for PhD institutions [25].

Another way to examine the composition of dual-track faculty is to do so for each institution within each group. The results of this analysis are shown in Figure 7. These results characterize the percentage of institutions within each group as having a majority of their dual-track faculty at the Full Professor rank and as having a majority of their dual-track faculty at the Assistant Professor rank. Other institutions have their "median" dual-track faculty rank at the Associate Professor level.

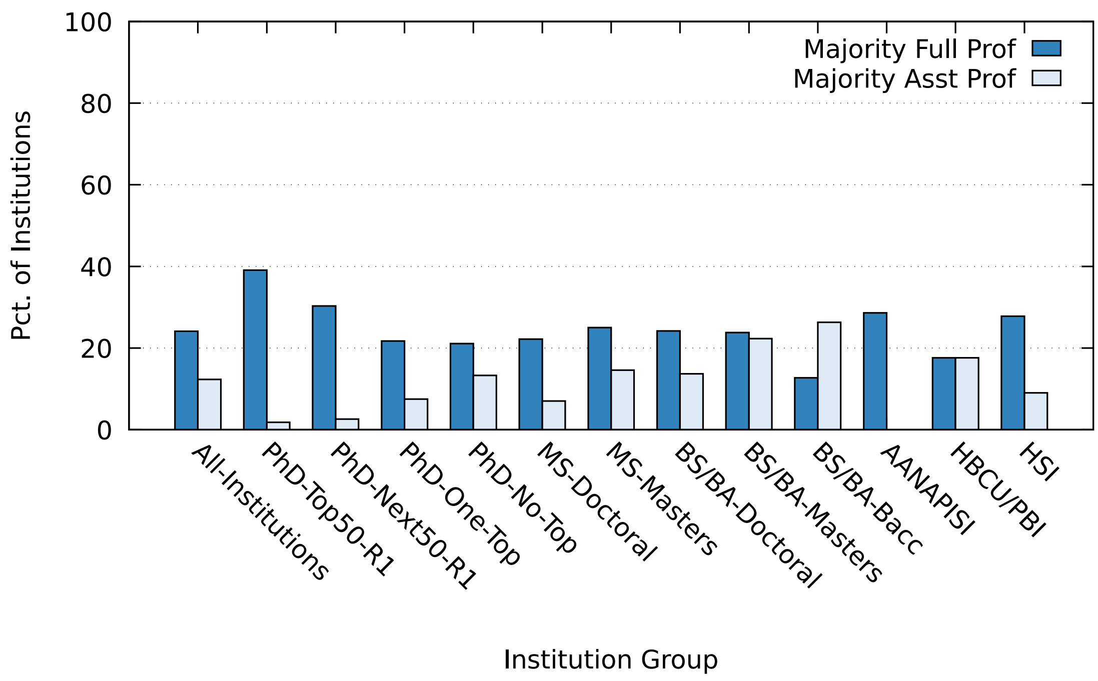

Figure 7: Rank Characterization of Dual-Track Faculty at Institutions of Each Group

The results show that 23% of all institutions have a majority of their faculty at the Full Professor level while 12% have the majority at the Assistant Professor level. These differences are even more pronounced for the top-ranked PhD institutions with 39% and 30% of institutions in these two groups having a majority of Full Professors among dual-track faculty with few having a majority of

Assistant Professors. These results indicate a relatively "senior" mix of dual-track faculty at these institutions. Only BS/BA-granting Baccalaureate and HBCU/PBI groups have a higher percentage of institutions with a majority of dual-track faculty at the Assistant Professor level indicating a relatively "junior" faculty mix.

5.2 Teaching-Track Faculty Size and Composition

We next examine the size and composition of full-time teaching-track faculty for each of the institution groups again for the 2023-24 academic year. The average sizes for institutions within each group are shown in Figure 8.

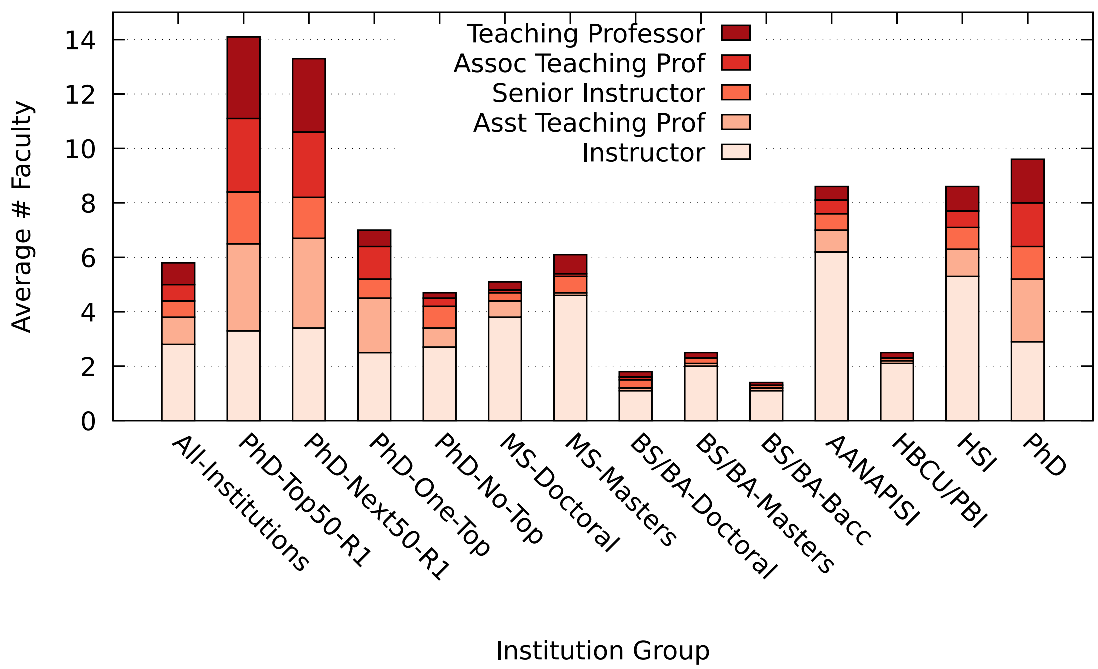

Figure 8: Average Sizes of Full-Time Teaching-Track Faculty for Institutions in Each Group

Again, the results are not surprising in that the top-ranked PhD-granting departments also have the most teaching-track faculty. The other PhD-granting and Master's institutions are more comparable in the number of teaching-track faculty. BS/BA-granting institutions have a much lower number of teaching-track faculty on average. Not shown is that on average, public institutions have 63% more teaching-track faculty than private institutions.

Figure 8 breaks down the average number of teaching-track faculty by title and rank showing Teaching Professors (Assistant, Associate and Full) as well as Instructors and Senior Instructors. Across all institutions, 47% of teaching-track faculty are Instructors with another 17% as Assistant Professors. The remaining 36% are at a higher rank for their title.

As we did for dual-track faculty, we also examine the composition of teaching-track faculty for each institution. The results of this analysis are shown in Figure 9 where we combine the faculty in Instructor and Assistant Teaching Professor positions as these are each the lowest rank for their title.

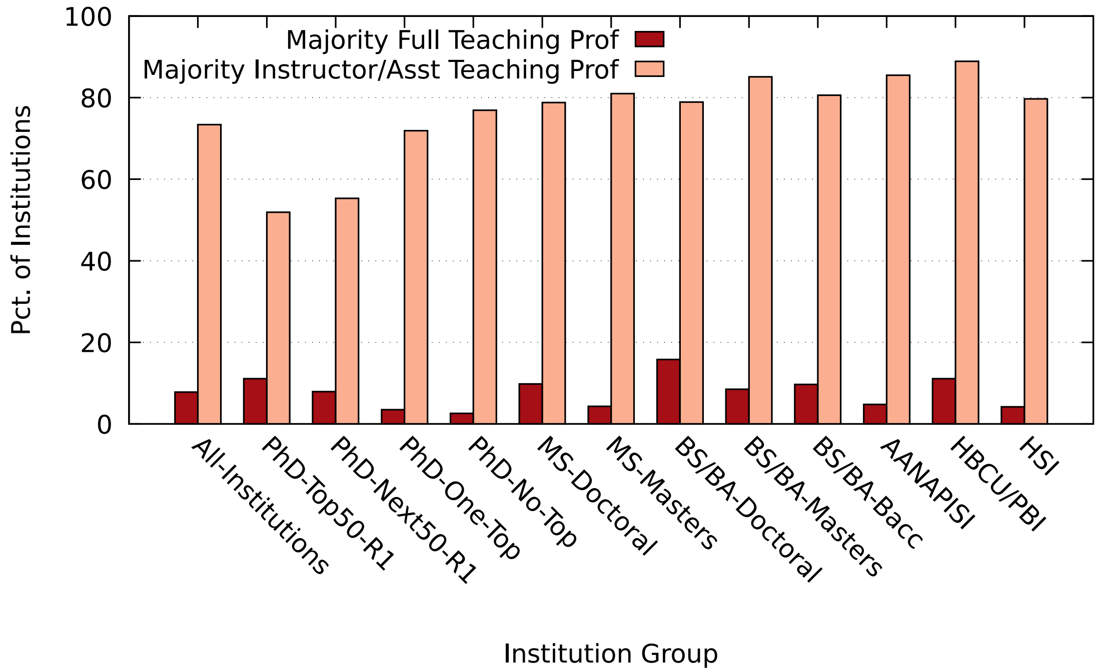

Figure 9: Rank Characterization of Teaching-Track Faculty at Institutions of Each Group

Analogous to our analysis for dual-track faculty, these results characterize the percentage of institutions within each group as having a majority of their teaching-track faculty at the Full Teaching Professor rank and as having a majority of their teaching-track faculty at Instructor or Assistant Teaching Professor rank. Other institutions have their "median" dual-track faculty rank at the Senior Instructor or Associate Teaching Professor level. In contrast to dual-track faculty, the results show that only 8% of all institutions have a majority of their faculty at the Full Teaching Professor level while 72% have the majority at the Instructor or Assistant Teaching Professor level. The top-ranked PhD institutions have smaller percentages (still roughly 50%) of institutions with a majority of teaching-tracking faculty at the Instructor or Assistant Teaching Professor level.

We did not investigate the specific reasons for the relatively high percentage of "junior" teaching-track faculty at institutions, but based on our own experience can suggest possible reasons for this situation. First, increased student demand has led to the recent hiring of more teaching-track faculty in recent years so these "more-junior" faculty are not yet in a position for promotion to higher ranks. Second, it is not clear that all institutions have mechanisms in place for the promotion in rank of teaching-track faculty comparable to what is in place for dual-track faculty. Third, it is possible that our data extraction approach did not capture all promotions, such as between numeric levels of the Instructor title. Fourth, teaching-track faculty may be more transient as the faculty take these positions based on short-term personal and department needs.

5.3 Contributions of Teaching-Track Faculty for Educating Students

In our previous sections we show results on the size and composition of faculty for the different institution groups. In this section we examine the relative percentage of full-time teaching-track faculty compared with dual-track faculty both in aggregate and across institutions within each group. We also make use of reported Taulbee survey data [25] to show the longitudinal contribution of teaching-track faculty at PhD-granting institutions.

Figure 10 shows two related results on the percentage of teaching-track faculty relative to the combined total of full-time dual-track and teaching-track faculty. The aggregate group average, shown as a single point for each group, is for all faculty across all institutions in the group. It shows that 24% of all full-time faculty (research-track faculty are excluded) across all institutions are on the teaching-track. There is variation in this aggregate average across groups with it being 20% for the top-ranked PhD group and as high as 33% for the MS-granting Masters institutions. The lowest percentage is 15% for the BS/BA-granting Baccalaureate institutions.

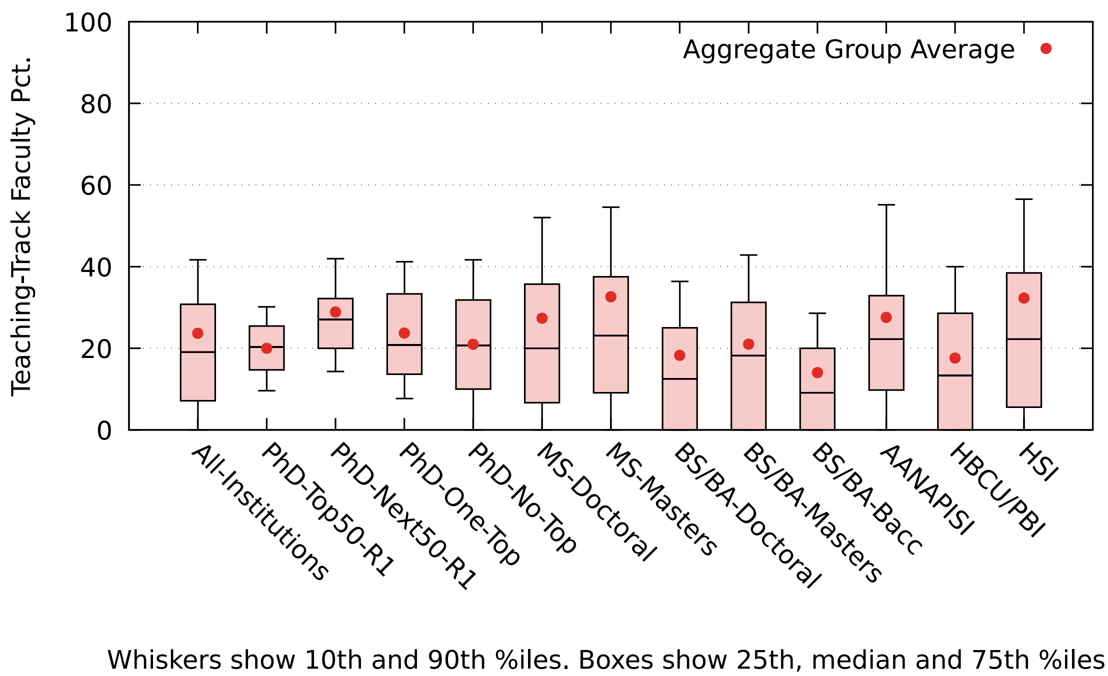

Figure 10: Teaching-Track Percentage of Full-Time Faculty

Figure 10 also contains box and whisker plots for each institution group showing the 10th, 25th, median, 75th and 90th percentiles across all institutions within a group. The results show a median of 19% across all institutions with the PhD-Next50-R1 group have the highest median at 27%. The BS/BA-Doctoral and BS/BA-Bacc groups have the lowest medians among institutions in the group at 13%.

Figure 11 shows the aggregate percentage of teaching-track faculty for public and private institutions across all institution groups. It shows that 25% of all full-time faculty in public and 19% in private institutions are teaching-track. The largest percentage discrepancies between these two types are for BS/BA-Bacc and PhD-No-Top where public institutions in these groups have over 15% more teaching-track faculty than private institutions. In contrast, private PhD-One-Top institutions have the highest percentage of teaching-track faculty relative to public institutions in the group.

As a means to gain historical perspective on the contributions of teaching-track faculty for the education of Computer Science students we extracted Taulbee faculty data from 2000 to 2023

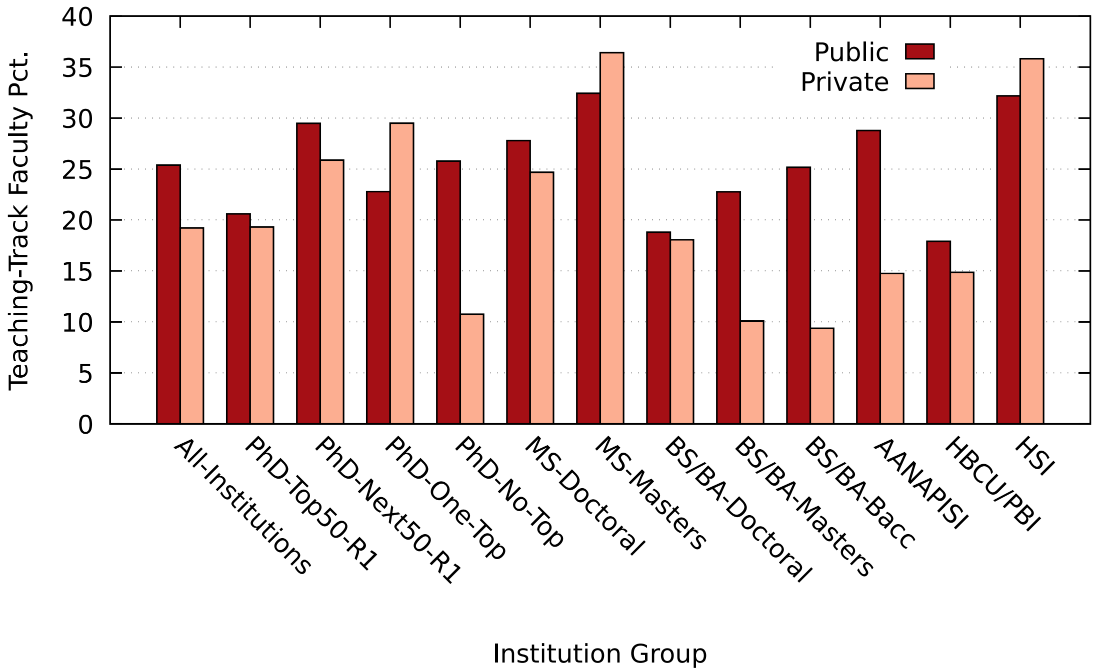

Figure 11: Aggregate Teaching-Track Faculty Percentage (Public vs. Private Institutions)

for PhD-granting departments that reported data. Results on the average number of dual-track faculty (at all three ranks), teaching-track faculty and total full-time faculty involved in educating students is shown in Figure 12. Note until 2010, information was reported for "Teaching Faculty". Since that time, teaching-track data are reported separately for "Teaching Professors" and "Other Instructors." In our analysis, we combined these two values in showing the number of teaching-track faculty.

The results in Figure 12 show that the average number of teaching-track faculty in each department has more than doubled since the early 2000s making the biggest contribution to a 72% increase in full-time faculty during this time. Since 2018, the average number of teaching-track faculty is now more than each of the number of Associate and Assistant Professors in PhD-granting departments.

Computing the percentage of teaching-track faculty relative to all full-time faculty (dual- and teaching-track) shows this percentage has grown from 17% in 2000 to 26% in 2023 for reporting institutions. In comparison, results for the 2023-24 academic year in Figure 10 show percentages between 20% and 29% for the four PhD-granting groups with an aggregate teaching-track percentage for these four groups of 23%. Although not identical, our results as comparable to the results from the Taulbee data, particularly given the differences in the set of institutions considered as not all U.S. PhD-granting institutions respond to the Taulbee survey as well as the survey also includes U.S. Computer Engineering, U.S. Information and Canadian CS programs.

We also extracted 2013 to 2022 data from the NDC publications for non-PhD-granting institutions [1]. We used these data to determine the teaching-track faculty representation for institutions offering CS Master's degrees and those only awarding CS Bachelor's degrees. There is more variability in the results, but the last five years of the data generally show that Master's-

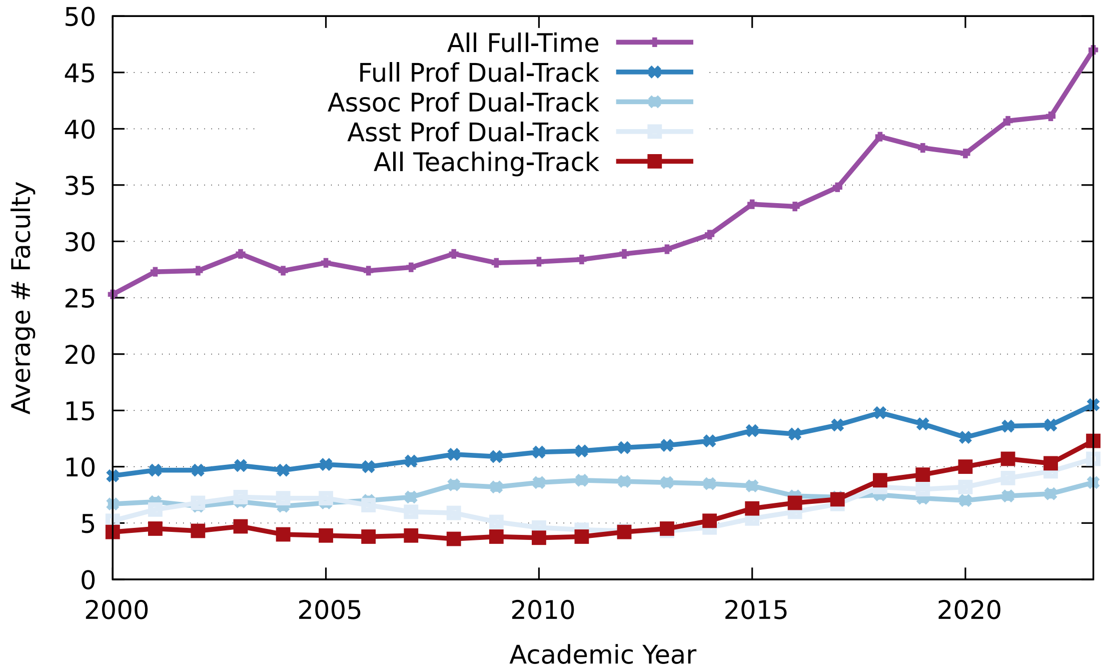

Figure 12: Longitudinal Trends for Average Number of Faculty for PhD Institutions Reporting Taulbee Data

granting institutions report 20-25% of their full-time faculty are teaching track versus 10-15% for Bachelor's-granting institutions. These results are comparable to those reported in Figures 10 and 11, particularly when the specific set of institutions reporting NDC results is not known.

5.4 Student/Faculty Ratios

In the previous section we examined the percentage of teaching-track faculty relative to the full-time faculty educating students. Here we use data from Section 2 to examine the ratio between student degree production and available full-time faculty. The results are shown in Figure 13 for each degree and each of our institution groups.

The results show that the top-ranked PhD institutions have the highest ratio between the number of annual BS/BA degrees and faculty (dual- and teaching-track) with close to five degrees per faculty member. The Baccalaureate institutions clearly have the lowest ratio with 2.5-3 degrees per faculty member. The top-ranked PhD group again exhibits the highest ratio for MS degrees with less distinctions between the remaining groups. Finally, the ratio for PhD degree production (computed based only on dual-track and not including teaching-track faculty) again show relatively better productivity for two top-ranked PhD groups.

As historical context, we again use results from the Taulbee survey [25] to compute the same ratios for PhD institutions responding each year. We were able to extract U.S. CS PhD production and faculty counts for this computation. The results for each degree are shown in Figure 14.

The BS/BA degree ratios follow student enrollment trends indicating that faculty counts have not kept pace. The ratio jumps to close to six in the most recent year. These results are consistent with those shown for PhD institutions in Figure 13 considering that the College Scorecard degree

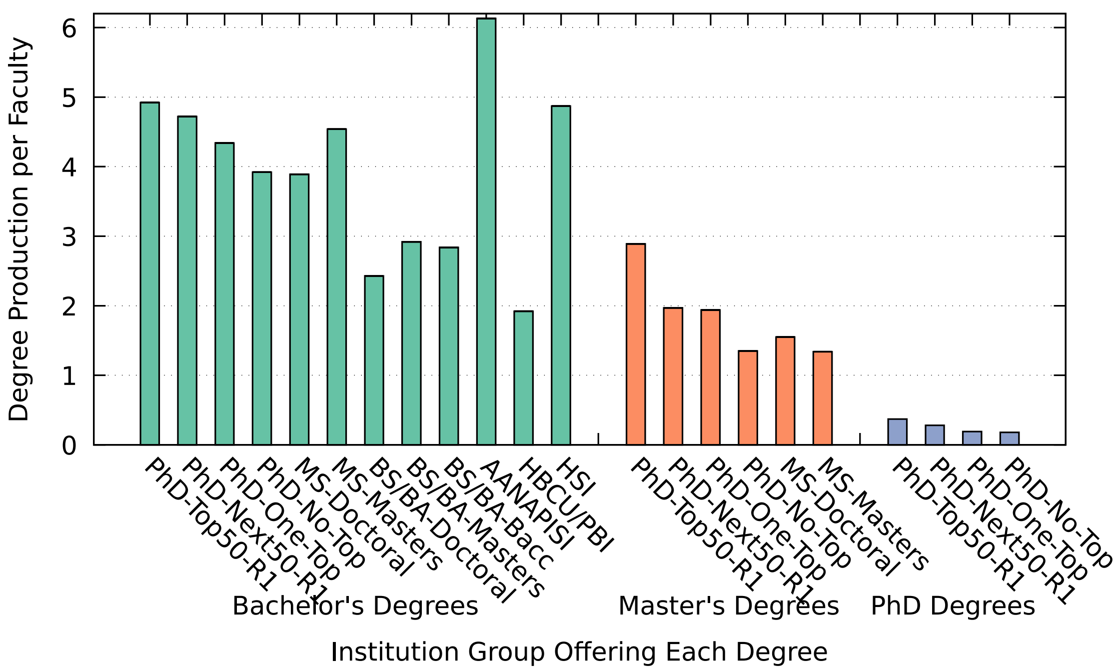

Figure 13: Ratio of Average Annual Degree Production and Full-Time Faculty Count

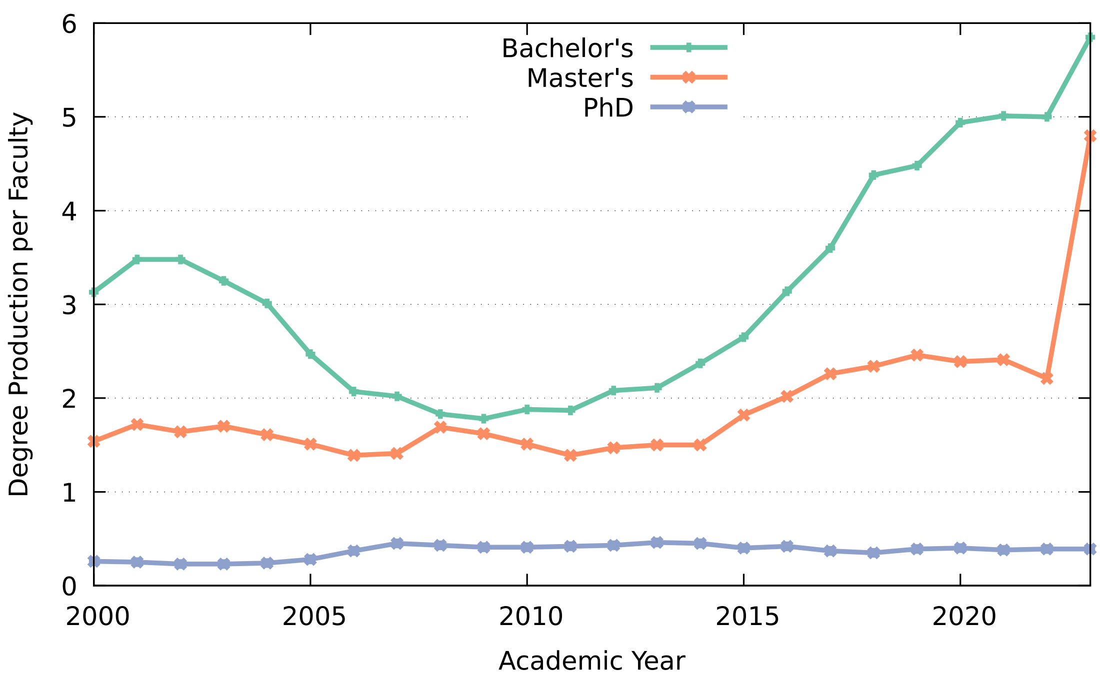

Figure 14: Longitudinal Trends for Ratio Between Average Annual Degree Production and Number of Faculty for PhD Institutions Reporting Taulbee Data

production both lag in the year and are the average over two years. The Scorecard data also include degrees in Information Science.

The MS degree production has remained relatively steady with a ratio around two until more than doubling in the most recent year. The reasons for this jump were not examined in this work. The ratio for PhD production has remained relatively even for the past many years with a ratio around 0.4, which is the same as shown for the top-ranked PhD group in Figure 13.

5.5 Faculty Demographics

Knowing more about the individual faculty educating students is important to understand, but for the work we have done thus far on the project we only reliably have name and title. Tools are available to make name-based predictions on race and gender, although prior work found that use of the U.S. census to predict the race of Computer Science faculty overestimated the percentage of Black, Hispanic and Native faculty [6]. Based on this result and our own initial investigation, we did not pursue name-based prediction for race. However, name-based gender prediction has been used with more reliability in prior studies of CS faculty [6, 4] and we did explore its use in our work.

In our own work we did not directly seek to validate the gender of faculty through means such as photo inspection or uncovering a pronoun reference on a professional Web page. Rather, we make use of available aggregate faculty gender data for PhD institutions responding to the Taulbee survey for validation. With the caveats noted in Section 5.3, these Taulbee data include reported numbers for gender of dual-track (three ranks) and teaching-track (collectively) faculty.

We investigate the use of the name-based gender identification with the tool `genderize.io`, which was used in previous work [4]. We used it to retrieve the predicted gender based on the first-name for 98% of the names in our dataset. We explored two approaches for determining the gender likelihood of a faculty member based on first name. The first approach is to employ a threshold (0.7 was used in [4]) where names with a greater gender likelihood are identified as male or female and other names are marked as unknown and not considered in the analysis. The second approach does not seek to identify the gender of individual faculty, but instead treats the prediction as a distribution accumulating the likelihood for all known faculty names. Table 1 shows the most-recent Taulbee reported data for female faculty alongside application of these two female gender-identification approaches to our gathered data for the collective set of four PhD-granting institution groups.

Table 1: Comparison of Reported Taulbee Female Gender Data for PhD Institutions with Threshold and Distribution Name-Based Female Gender Prediction Approaches

	Reported	Threshold-Based Value					Distribution
Rank/Track	**Data**	0.9	0.8	0.7	0.6	0.5	Based
Full Prof Dual Track	**18%**	15%	16%	16%	17%	17%	19%
Assoc Prof Dual Track	**22%**	19%	19%	20%	21%	21%	23%
Asst Prof Dual Track	**28%**	25%	26%	26%	27%	27%	29%
All Teaching Track	**29%**	26%	26%	27%	27%	28%	28%

The results in the table show that the threshold-based approach with a threshold of 0.5 (simply assigning gender based on whether male or female is more likely) and the distribution-based approach each perform well relative to the Taulbee PhD institutions with each within 1% of the reported data. This closeness provides confidence that the name-based gender prediction can be used to compare expected gender for different types of faculty in each institution group. We use the distribution-based prediction approach for all comparisons as it yields similar percentages as the Taulbee-reported data, includes all faculty and is consistent with not all individuals identifying with a gender.

Figure 15 shows two sets of results for predicted percentage of full-time female faculty of different types across the institution groups. The first set of results are aggregated for all faculty within a group and shown as a single point in the figure for each faculty type within each group. These results show that 21% of all Full Professors, 25% of Associate Professors and 30% of Assistant Professors are predicted as female. Results for teaching-track positions are split between those faculty at the initial rank (Instructor and Assistant Teaching Professor) and those faculty at promoted ranks (Senior Instructor, Teaching Professor and Associate Teaching Professor). These results show that 30% of teaching-track faculty at an initial rank and 26% at a promoted rank are predicted to be female.

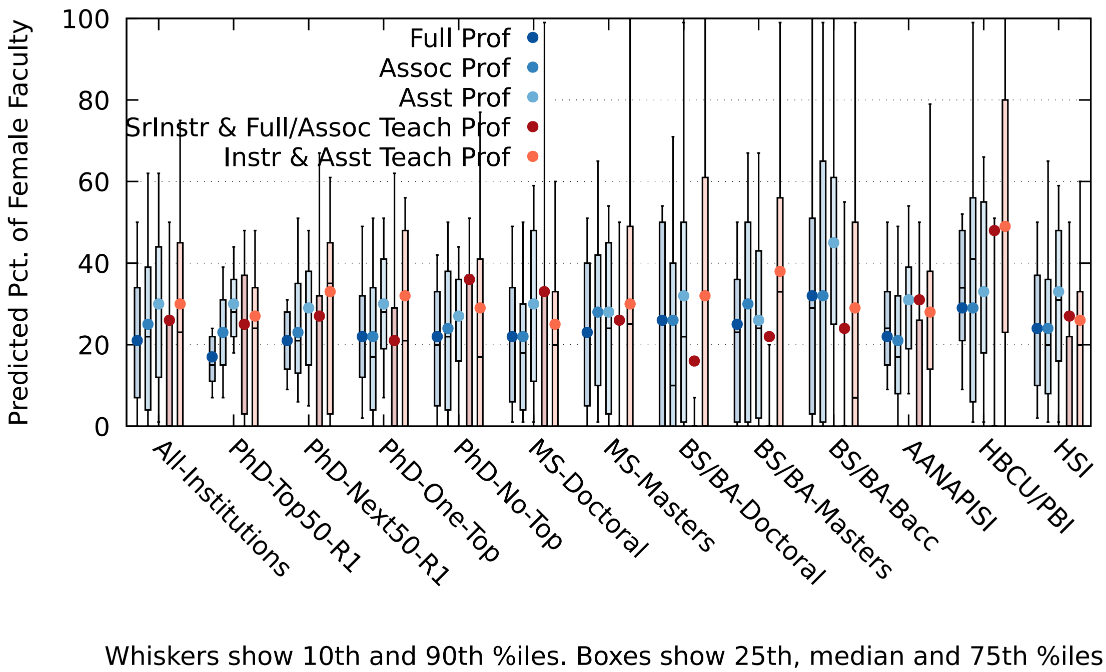

Figure 15: Predicted Percentage of Full-Time Female Faculty

The second set of results in the figure are the 10th, 25th, median, 75th and 90th percentile results for individual institutions within each group. The larger the size of the boxes and whiskers within each group indicate a faculty type and institution group with the most variation. As expected, the larger PhD institution groups tend to have the least variance and show results consistent with the aggregate average while the smaller BS/BA groups show more variance, particularly for the teaching-track faculty.

The aggregate results for institution groups show that only 17% of Full Professors at PhD-Top50-R1 institutions are predicted as female, which is the lowest among all institution groups. In contrast, 45% of Assistant Professors at BS/BA-Bacc institutions are predicted as female, which is the highest dual-track percentage in any institution group. The highest percentages of predicted female teaching-track faculty for both promoted and initial ranks are for institutions in the HBCU/PBI group (48% and 49%). Otherwise there are not large differences between the groups with most faculty types between 20% and 30% for the predicted percentage of female faculty.

Figure 16 shows the percentage of dual- and teaching-track faculty predicted as female for public and private institutions across all institution groups. It shows that 24% of all dual-track faculty at public and 27% at private institutions are predicted to be female. In contrast, 30% of teaching-track faculty at public and 24% at private institutions are predicted to be female. The most significant difference for percentage of dual-track faculty between public and private institutions is for the BS/BA-Bacc group, which has more than 40% of its dual-track faculty predicted to be female. Public institutions in the PhD-No-Top group are predicted as having a much higher percentage of teaching-track faculty relative to private institutions in the groups. HBCU/PBI (both public and private), AANAPISI private and BS/BA-Bacc private have the highest percentages of teaching-track faculty predicted to be female.

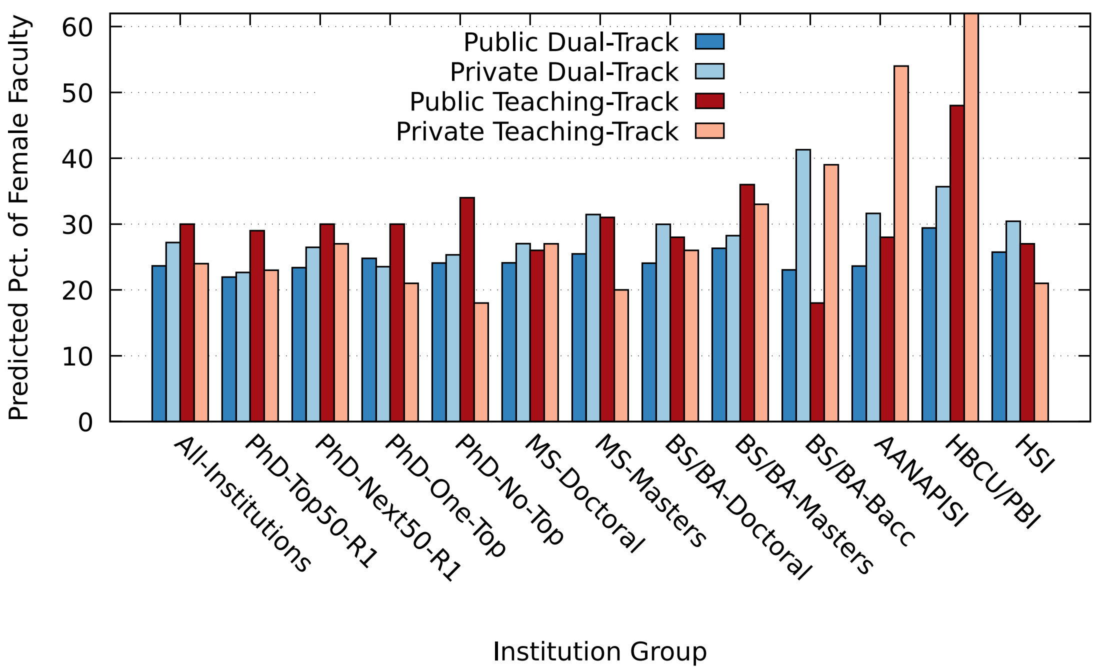

Figure 16: Predicted Percentage of Female Faculty (Public vs. Private Institutions)

We not only used the Taulbee survey results to validate the name-based prediction results for PhD institutions reporting data, but also extract the percentage of female faculty at these institutions since the early 2000s. These results for the three dual-track ranks and collectively all teaching-tracking ranks are shown in Figure 17.

The longitudinal results in Figure 17 show that the female percentage of Full Professors has increased the most from a paltry 8% in 2000 to a still low 18% in 2023. Female representation among

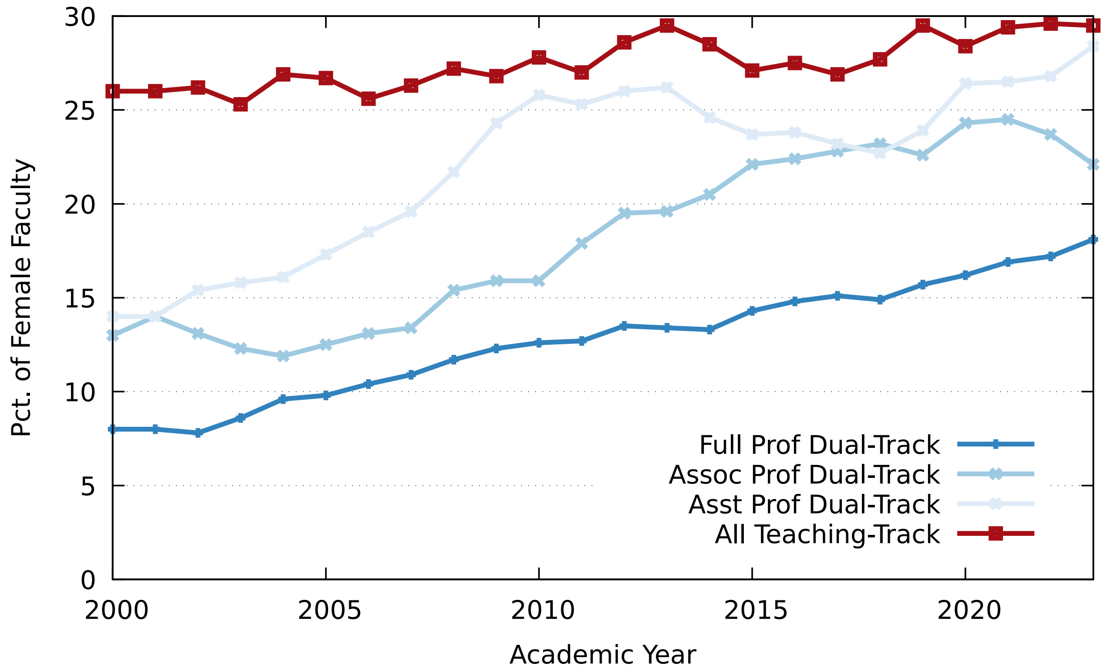

Figure 17: Longitudinal Trends for Percentage of Female Faculty for PhD Institutions Reporting Taulbee Data

Associate and Assistant Professors has also increased with the most recent results showing 28% for Assistant Professors. In contrast, teaching-track results are relatively steady with percentages between 25% and 30%.

Reported data from 2013 to 2022 for non-PhD-granting institutions again showed more variability where the female representation of Full Professors was around 20% while the representation of Associate and Assistant Professors was generally between 25% and 30% [1]. There was no gender representation data reported for teaching-track faculty in these studies.

5.6 Promotions in Academic Rank

The availability of gathered data from two consecutive years provides the opportunity to monitor changes in the status of specific faculty. Given these status changes are checked for the same name and we did observe changes in first or last names, we put checks in place to flag possible name changes for manual confirmation.

The first type of change we monitored was for faculty who earned a promotion in rank from one year to the next. For this analysis we only analyzed promotions within the dual and teaching tracks. We did not include faculty who were already at the highest rank within their track (Professor, Teaching Professor, Senior Instructor) in the previous year. We did not include faculty that were hired into a dual-track position from a visiting position or the teaching track at their same institution. As part of this analysis, and as discussed in Section 4.4, we did discover a small number of extraction errors where faculty incorrectly were shown as moving between tracks or moving from a higher to lower rank within a track. These errors were corrected and did not affect our results.

Figure 18 shows the percentage of faculty previously with one of five titles who were promoted in rank in this most recent year. These results only consider faculty who remain in the same track at their institution at a promotable rank and do not consider additions or losses. The leftmost group in the figure shows aggregate results for all faculty at all institutions. These results show that 7% of Associate Professors were promoted to Full Professor and 11% of Assistant Professors were promoted, typically to Associate Professor. The teaching-track results show 4% of Associate Teaching Professors were promoted to Teaching Professor, 9% of Assistant Teaching Professors were promoted and 5% of Instructors were promoted.

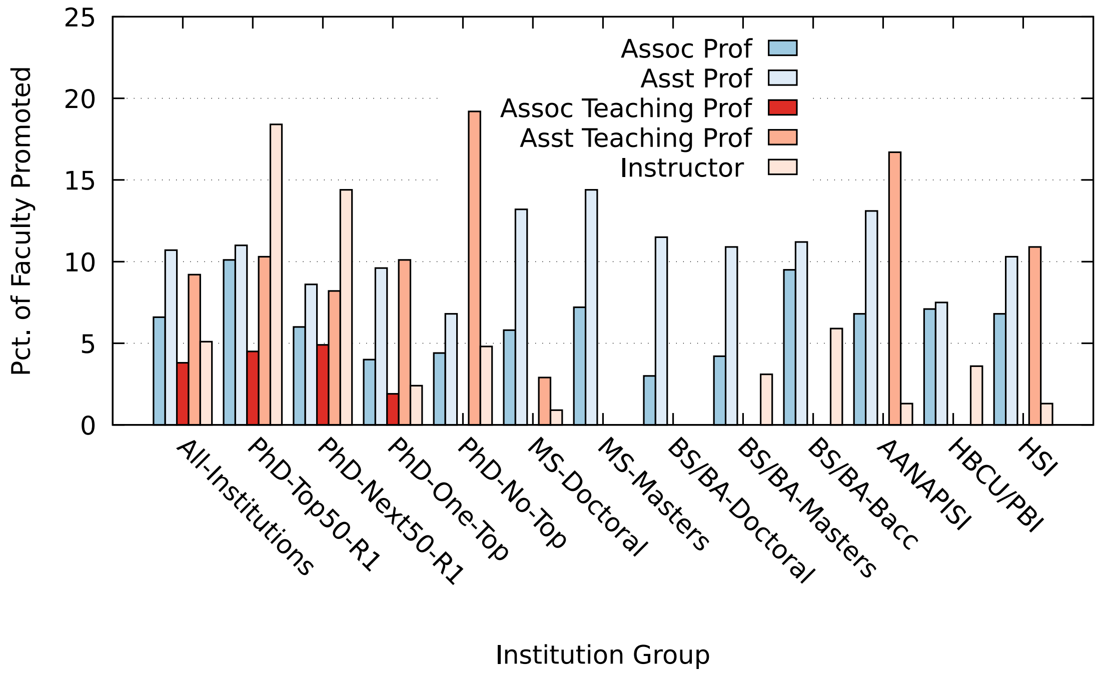

Figure 18: Percentage of Faculty Receiving Promotion in Rank

The remaining results in the figure show results for each of our 9+3 institution groups. They show that the PhD-Top50-R1 group had higher rates of promotion for each of the five promotable positions and a significantly higher percentage (18%) for promotion of Instructors. The PhD-Next50-R1 group also had a high percentage (14%) for promotion of Instructors. The MS-Masters and MS-Doctoral groups had the highest rate of promotion (14% and 13%) for Assistant Professors. The MS and BS/BA institution groups had low or non-existent promotion rates for teaching-track faculty.

Using the name-based gender prediction tool we analyzed the female gender distribution of promoted dual- and teaching-track faculty. These results are shown in Figure 19. The left-most results in the figure show that 23% of all promoted dual-track and 33% of teaching-track faculty are predicted as female. We observe these results are similar to the aggregate predicted gender results in Figure 15.

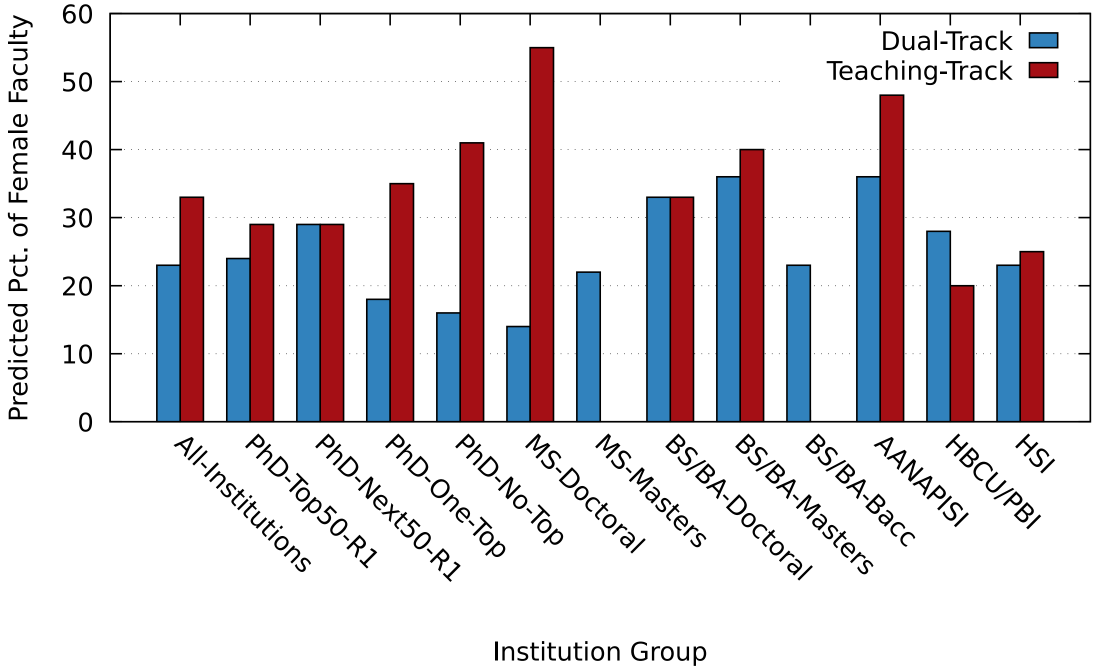

Figure 19: Predicted Female Percentage of Faculty Receiving Promotion in Rank

5.7 Changes in Faculty Composition Via Additions and Losses

Our dataset also allows us to understand the "churn" of different types of faculty at different institutions. For additions, we count new full-time faculty that were not listed (in any capacity) in the previous year and for losses we count previous full-time faculty that are no longer listed in the current year. We do not count faculty that move between tracks at the same institution.

Figure 20 shows the percentage change in the number of additions and losses relative to the number of faculty in the previous year for each institution group. These percentages are shown separately for dual-track and teaching-track faculty. The difference between the addition and the loss percentages yields the net percentage change. The total of the two percentages is a measure of the churn.

The results in the figure show that overall institutions added 9% new dual-track faculty while losing 6% for a net gain of 3%. During the same timeframe institutions added 15% new teaching-track faculty while losing 9% for a net gain of 6%. Similar results are generally found for all institution groups with more additions than losses for each track as well as more churn for teaching-track over dual-track positions. The HBCU/PBI and BS/BA-Bacc groups, which contain some of the same institutions, show a particularly large relative amount of churn for teaching-track faculty.

The PhD-Top50-R1 institutions yielded the largest relative net gain for dual-track faculty at 5% while institutions in the BS/BA-Doctoral and MS-Doctoral had an aggregate net loss in the number of dual-track faculty. MS-Doctoral and AANAPISI institutions had a net gain of over 10% for teaching-track faculty with all groups having a net positive faculty gain for this track.

Similar to our analysis for faculty being promoted in rank, we use the name-based gender prediction tool to also analyze gender distribution for additions and losses of dual- and teaching-track faculty. These results are shown in Figure 21. The left-most results in the figure show that

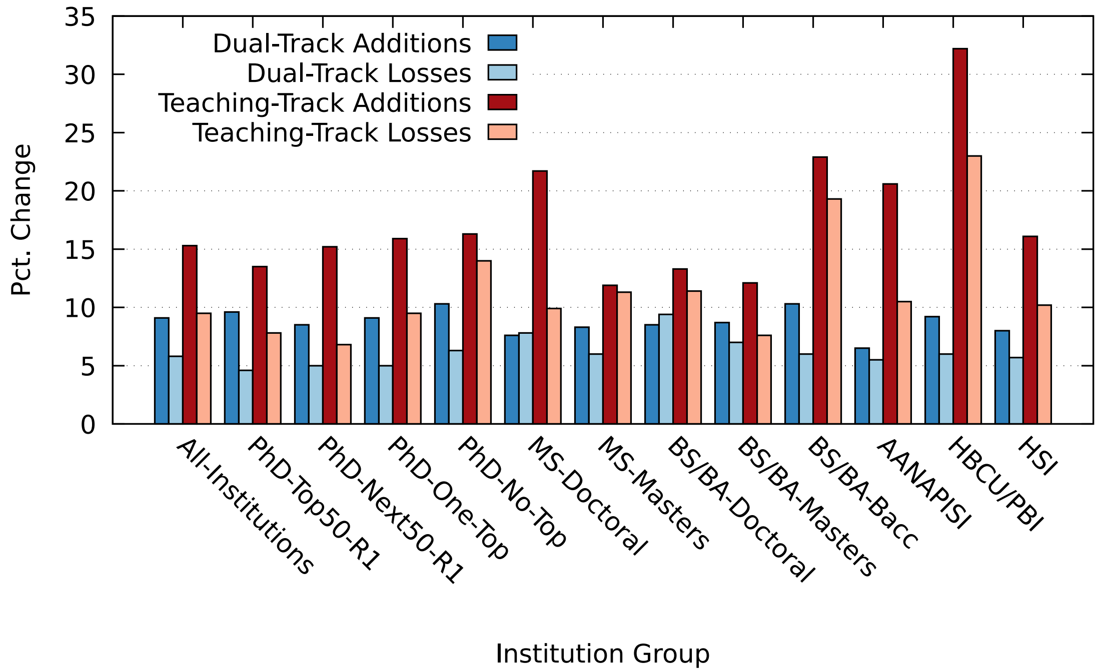

Figure 20: Percentage Gains and Losses of Dual-Track and Teaching-Track Faculty

across all institutions dual-track additions are predicted as 29% female with losses for this track as 25%. For teaching-track additions, the predicted female percentage is 31% with losses at 33%. The BS/BA-Bacc institutions have a relatively low percentage of both female additions and losses.

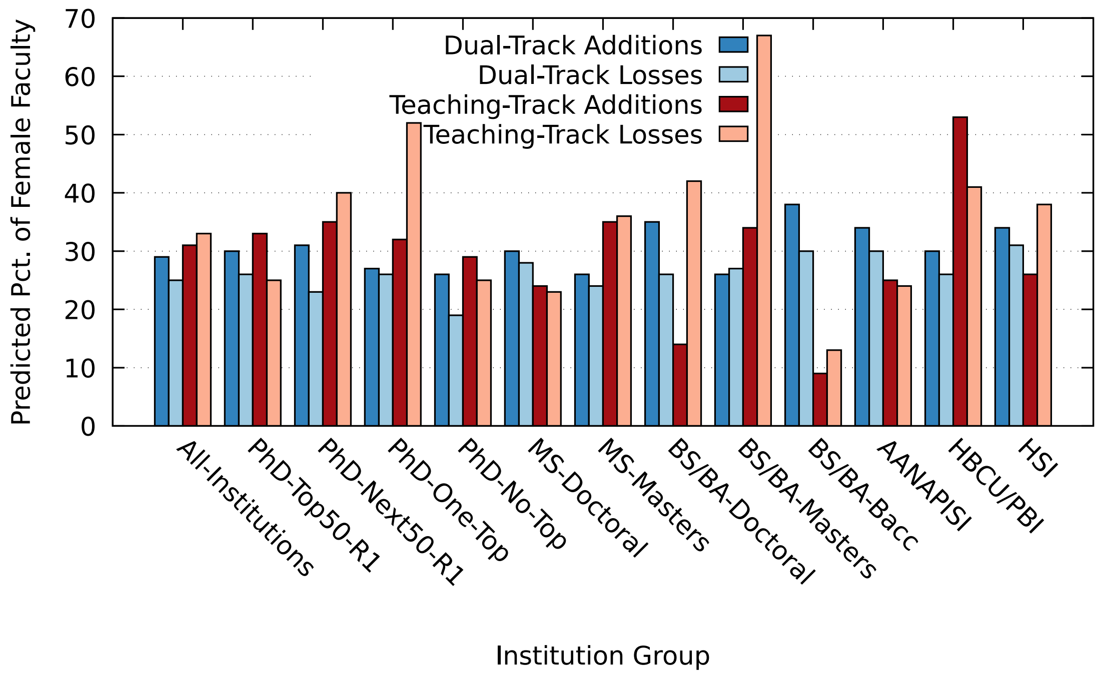

Figure 21: Predicted Female Percentage of Faculty Gains and Losses

The BS/BA-Doctoral, PhD-Next50-R1, BS/BA-Bacc and PhD-No-Top groups have the largest net gains in the percentage of predicted female dual-track faculty. The HBCU/PBI and PhD-Top50-R1 institutions show the largest net gains in the percentage of predicted female teaching-track faculty. Institutions in the BS/BA-Masters, BS/BA-Doctoral and PhD-One-Top groups show particularly large net losses in the the percentage of predicted female teaching-track faculty.

5.8 Faculty Movement Between Institutions

Finally, our dataset allows us identify faculty that move from one institution to another. We do so by identifying faculty names that appear as an addition in the current year at one institution while also appearing as a loss in the previous year from another institution. Clearly not all names are unique so manual verification via Web and professional pages was used to confirm each "faculty move" that is included in our analysis. Note we did not include "expected" movements of faculty such as a research-track faculty member at one institution moving to a dual-track position at another institution.

We also performed manual investigation, again using Web and professional pages, for a sample of new senior faculty who were not discovered as moving from another institution. As expected many of these faculty were previously in a non-academic position, but we also found cases where the new faculty member came from a non-U.S. institution or a non-CS department (such as a School of Information). We found cases where the "new" faculty member is actually in another department at the same institution with a new dual appointment in the CS Department. We also found one case where the new faculty member was previously at an institution not in our previous year dataset.

Overall, we were able to verify movement of faculty from one institution to another institution for 88 dual-track and 15 teaching-track faculty in our dataset. As means to analyze this movement we determined the institution group for the previous and current institution of each faculty member in transition. Figure 22 shows a summary of this movement from the previous institution group to the new institution group for each of the 88 dual-track faculty.

The size of the box for movement within the same institution group and the width of the line for movement between institution groups is directly proportional to the number of faculty making that transition. For example, the large box in the upper-left corner indicates that 17% of all dual-track transitions are from one PhD-Top50-R1 institution to another. The next largest movement within the same group is for institutions in the PhD-Next50-R1 group with 6% of all movement. Faculty movement within the same institution group accounts for 40% of all dual-track transitions.

In contrast, the directed lines in the figure account for the remaining 60% of movement by faculty between institution groups. The largest such movement is the 9% of faculty moving from PhD-One-Top to PhD-Next50-R1 institutions, followed by 7% of faculty moving from PhD-No-Top to PhD-One-Top institutions and 6% of faculty moving from PhD-Next50-R1 to PhD-Top50-R1 institutions. As shown most movement tends to be "upward" in the figure with at least some of the "downward" movement involving an administrative role such as Head, Dean or Provost at the new institution.

Institutions in the PhD-One-Top and PhD-Next50-R1 groups were involved in the most inter-group dual-track churn. The BS/BA-Masters, BS/BA-Bacc and PhD-Top50-R1 groups were involved in the least amount of inter-group churn. Institutions in the PhD-No-Top and MS-Masters

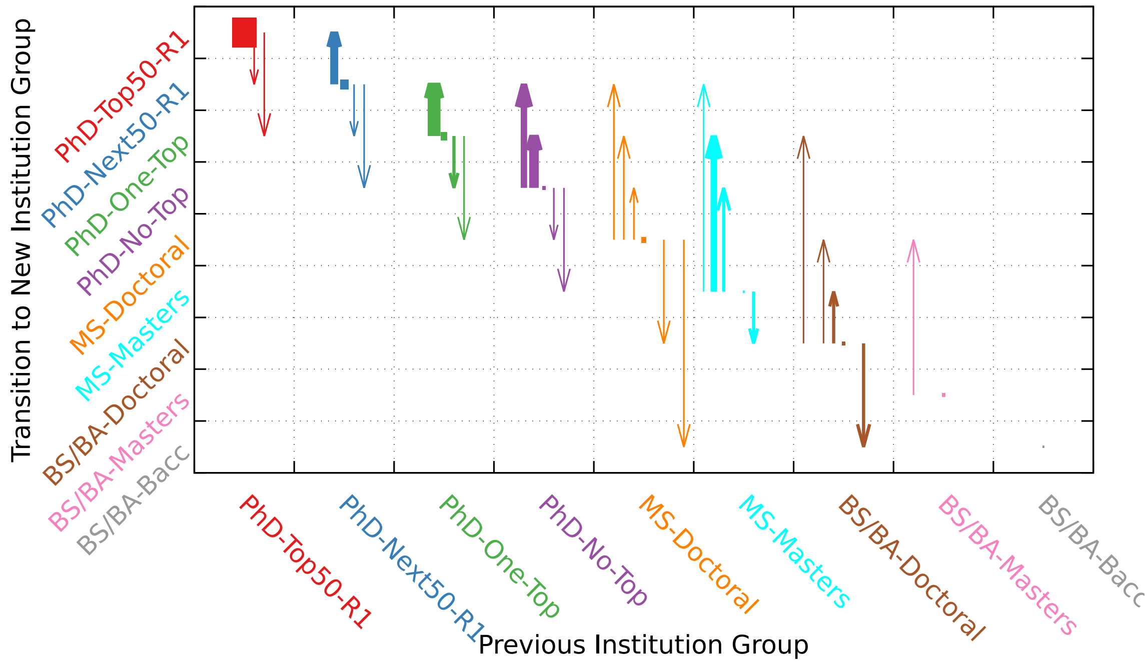

Figure 22: Movement of Dual-Track Faculty

groups had the largest net movement from the group while the PhD-Next50-R1 group had the largest net movement into the group.

Figure 23 shows a similar summary of teaching-track movement between groups. As indicated, we identified much less teaching-track faculty movement so the figure shows both fewer and smaller boxes within an institution group and the lines between them. It does show that identified movement is largely to PhD-Top50-R1 institutions with a couple of these transitions involving faculty who were previously in dual-track faculty positions at BS/BA-granting institutions.

6 Summary and Future Work

The motivation for this work is a better understanding of the faculty educating Computer Science students in the U.S. Previous work such as the annual Taulbee Report provides a wealth of data about students and faculty at CS PhD-granting institutions, but does little to distinguish results between the nearly 200 such institutions and does not include other CS degree-granting institutions so comparison of faculty at different types of institutions is not possible. A similar study of non-PhD-granting institutions had difficulty in obtaining a representative number of respondents.

A broader look at faculty educating CS students is needed. Not surprisingly, CS PhD-granting "R1" institutions account for 87% of the PhD degrees awarded and 73% of the institutions doing so. However, these percentages fall to 63% of degrees and 33% of institutions for Master's degrees, and to about half of degrees and less than 15% of institutions for Bachelor's degrees. For example, these percentages translate into over 800 non-CS-PhD-granting institutions awarding more than 50,000 Bachelor's degrees in the two years of data. PhD-granting and research-focused institutions also account for a small percentage of institutions designated as serving populations of minority

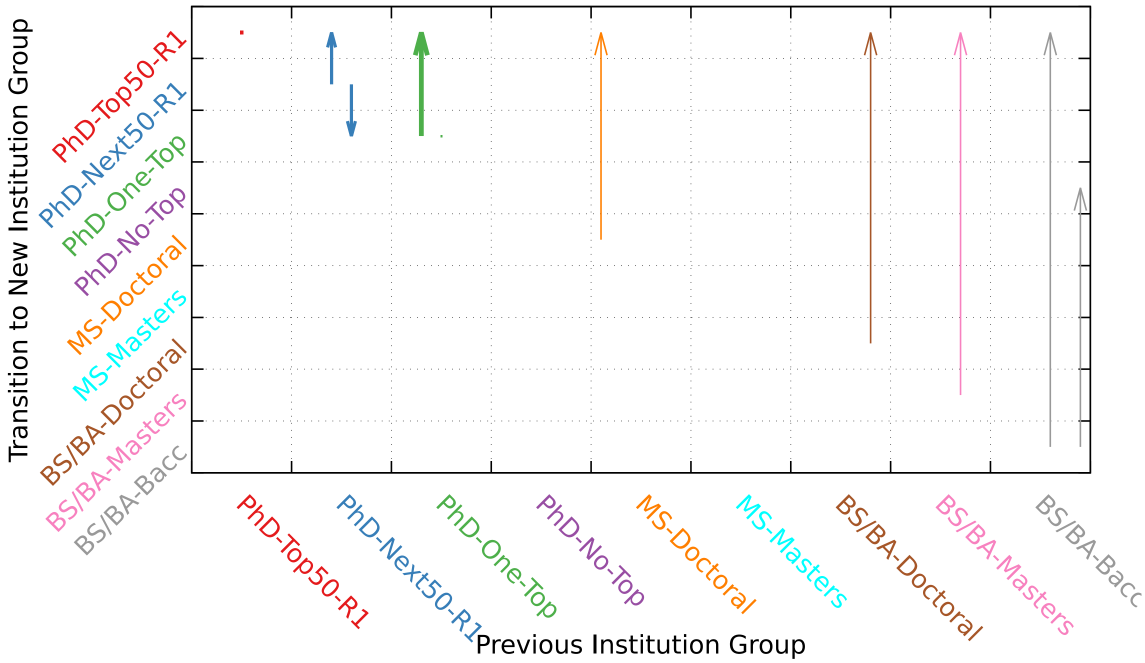

Figure 23: Movement of Teaching-Track Faculty

students.

Motivated by the need to not only examine a range of institution types, but also both "dual-track" (traditional tenure-track) and teaching-track faculty at these institutions, we take an approach where we gather public data about faculty at institutions offering Computer Science degrees. This approach allows us to select the institutions and faculty we study to ensure representations of a variety of types.

In two years we have collected data about over 16,000 Computer Science faculty from nearly 550 institutions awarding Computer Science degrees. These institutions are divided into nine distinct groups based on highest CS degree offered, Carnegie Classification of the institution and graduate CS ranking to assist in distinguishing PhD-granting institutions. We also have three groups for institutions designated as minority serving for specific population groups.

Given this motivation and approach, we are able to answer questions about different types of faculty at different types of institutions. We summarize our results in two ways. First, Table 2 presents a profile of results for each institution group along with figure number references for more details. Second, we describe the result highlights, which include:

- In terms of dual-track faculty composition, 23% of all institutions have a majority of their faculty at the Full Professor level while 12% have the majority at the Assistant Professor level. Nearly 40% of the top-ranked PhD institutions have a majority of Full Professor. In contrast, for teaching-track faculty the results show that only 8% of all institutions have a majority of their faculty at the Full Teaching Professor level while 72% have the majority at the Instructor or Assistant Teaching Professor level.

- Teaching-track faculty represent about a quarter of full-time faculty across all institutions. This percentage ranges from 15% for BS/BA-granting Baccalaureate institutions to 33%

Table 2: Summary Profile for Each Institution Group

Fig. No.	Question	All-Institutions	PhD-Top50-R1	PhD-Next50-R1	PhD-One-Top	PhD-No-Top	MS-Doctoral	MS-Masters	BS/BA-Doctoral	BS/BA-Masters	BS/BA-Bacc	AANAPISI	HBCU/PBI	HSI
6	Ave. Full-Time Dual-Track Size	18	56	33	22	18	14	11	8	9	9	22	11	17
8	Ave. Full-Time Teaching-Track Size	6	14	13	7	5	5	6	2	3	1	9	3	9
10	Teaching-Track Pct. of Full-Time Faculty	24	20	29	24	21	27	33	18	21	14	28	18	32
13	Bachelor's Degree/Faculty Ratio	-	4.9	4.7	4.3	3.9	3.9	4.5	2.4	2.9	2.8	6.1	1.9	4.9
13	Master's Degree/Faculty Ratio	-	2.9	2.0	1.9	1.4	1.6	1.3	-	-	-	-	-	-
13	PhD Degree/Faculty Ratio	-	0.4	0.3	0.2	0.2	-	-	-	-	-	-	-	-
15	Predicted Pct. Female Full Prof.	21	17	21	22	22	22	23	26	25	32	22	29	24
15	Predicted Pct. Female Assoc. Prof.	25	23	23	22	24	22	28	26	30	32	21	29	24
15	Predicted Pct. Female Asst. Prof.	30	30	29	30	27	30	28	32	26	45	31	33	33
15	Predicted Pct. Female SrInstr&Full/Assoc. Tch. Prof.	26	25	27	21	36	33	26	16	22	24	31	48	27
15	Predicted Pct. Female Instr&Asst. Tch. Prof.	30	27	33	32	29	25	30	32	38	29	28	49	26
18	Pct. Assoc. Prof. Promotion	7	10	6	4	4	6	7	3	4	10	7	7	7
18	Pct. Asst. Prof. Promotion	11	11	9	10	7	13	14	12	11	11	13	8	10
18	Pct. Assoc. Tch. Prof. Promotion	4	4	5	2	0	0	0	0	0	0	0	0	0
18	Pct. Asst. Tch. Prof. Promotion	9	10	8	10	19	3	0	0	0	0	17	0	11
18	Pct. Instructor Promotion	5	18	14	2	5	1	0	0	3	6	1	4	1
20	Pct. Gain Dual-Track Faculty	9	10	8	9	10	8	8	8	9	10	6	9	8
20	Pct. Loss Dual-Track Faculty	6	5	5	5	6	8	6	9	7	6	6	6	6
20	Pct. Gain Teaching-Track Faculty	15	14	15	16	16	22	12	13	12	23	21	32	16
20	Pct. Loss Teaching-Track Faculty	10	8	7	10	14	10	11	11	8	19	10	23	10

for MS-granting Masters institutions. Teaching-track faculty represent 25% of all full-time faculty in public and 19% in private institutions. Making use of Taulbee reported data for PhD-granting institutions shows this percentage growing from 17% in 2000 to 26% in 2023. Since 2018, the average number of teaching-track faculty is now more than each of the number of Associate and Assistant Professors in PhD-granting departments.

- The top-ranked PhD institutions have the highest ratio between Bachelor's degrees and full-time faculty (dual- and teaching-track) with close to five degrees per faculty member. The Baccalaureate institutions have the lowest ratio with 2.5-3 degrees per faculty member. Based on longitudinal Taulbee data, the Bachelor's degree ratios follow student enrollment trends indicating that faculty counts have not kept pace.

- We employ a name-based gender prediction tool treating the prediction as a distribution accumulating the likelihood for all known faculty names. We validate this approach with Taulbee-reported data showing it provides results within 1% across different types of faculty groups. This closeness provides confidence in using it for aggregate results showing that 21% of all Full Professors, 25% of Associate Professors and 30% of Assistant Professors are predicted as female. Results are similar for teaching-track faculty with 26% of those faculty at a promoted rank and 30% at an initial rank predicted to be female. Private BS/BA-granting Baccalaureate institutions are notable for having more than 40% of their dual-track faculty predicted to be female. Longitudinal results for PhD-granting institutions reporting Taulbee data show that the female percentage of Full Professors has increased the most from a paltry 8% in 2000 to a still low 18% in 2023. In contrast, teaching-track results have stayed relatively steady with percentages between 25% and 30% during this time.

- With data from two consecutive academic years, we are able to identify faculty who have been promoted in rank. Across all institutions, these results show that 7% of Associate Professors were promoted to Full Professor and 11% of Assistant Professors were promoted, typically to Associate Professor. The teaching-track results show 4% of Associate Teaching Professors were promoted to Teaching Professor, 9% of Assistant Teaching Professors were promoted and 5% of Instructors were promoted. The top-ranked PhD institution group had higher rates of promotion for each of the five promotable positions and a significantly higher percentage (18%) for promotion of Instructors.

- We are also able to determine the number of additions and losses relative to the number of faculty in the previous year for each institution group. The results show that overall institutions added 9% new dual-track faculty while losing 6% for a net gain of 3%. During the same timeframe institutions added 15% new teaching-track faculty while losing 9% for a net gain of 6%. Similar results are generally found for all institution groups with more additions than losses for each track as well as more churn for teaching-track over dual-track positions. The HBCU/PBI and BS/BA-Bacc groups, which contain some of the same institutions, show a particularly large relative amount of churn for teaching-track faculty.

- We were able to verify movement of faculty from one institution to another institution for 88 dual-track and 15 teaching-track faculty in our dataset. Faculty movement within the same institution group accounts for 40% of all dual-track transitions with 17% of all transitions from one top-ranked PhD institution to another. The remaining faculty transitions were between institution groups with the most movement (generally "upward") involving institutions in the next two groups of PhD-granting institutions. The Bachelor's-granting institutions were involved in the least amount of inter-group churn. A similar analysis for teaching-track faculty shows it is largely to top-ranked PhD institutions with even a couple of these transitions involving faculty who were previously in dual-track faculty positions BS-granting institutions.

In addition to the results obtained thus far in our work we have established a baseline for future directions. These directions include:

1. Continue to improve the automated collection and extraction of faculty data. Improvements will reduce the already low error rate and need for corrections.
2. Perform longitudinal analysis to understand faculty trends across the broad range of institutions.
3. Continue to combine the public data with other sources of information for insight as we have done in this work using IPEDS data for degree production and Taulbee data to validate and provide historical context.
4. Use the data to identify particular faculty of interest, such as new or lost faculty, for demographic and background information to better understand the pathways taken by CS faculty at different types of institutions.

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A Public and Private Members in Each Institution Group

The following are the public and private members in each of the 9+3 institution groups as defined in Section 4.3. Each institution is in one and only one of the first nine institution groups. The three remaining groups contain the institutions designated as minority-serving for certain populations.

Note: Distinct, but shortened institution names (with spaces removed) are shown for brevity.

PhD-Top50-R1 Public (31):

ArizonaSt, California, Colorado, Florida, GeorgiaTech, Illinois, Indiana, Maryland, Michigan, Minnesota, NorthCarolina, NorthCarolinaSt, OhioSt, PennSt, Purdue, Rutgers, StonyBrook, Texas, TexasA&M, UCDavis, UCIrvine, UCLA, UCSantaBarbara, UCSantaCruz, UCSD, UMass, Utah, Virginia, VirginiaTech, Washington, Wisconsin.

PhD-Top50-R1 Private (24):

BostonU, Brown, CalTech, Chicago, CMU, Columbia, Cornell, Dartmouth, Duke, Harvard, JohnsHopkins, MIT, Northeastern, Northwestern, NYU, Penn, Princeton, Rice, Rochester, Stanford, USC, Vanderbilt, WashUStLouis, Yale.

PhD-Next50-R1 Public (29):

Arizona, Auburn, Binghamton, Buffalo, Clemson, ColoradoSchoolMines, ColoradoSt, Delaware, FloridaSt, GeorgeMason, Georgia, Iowa, IowaSt, MichiganSt, Nebraska, NewJerseyIT, Oregon, OregonSt, Pittsburgh, Temple, Tennessee, UCF, UConn, UCRiverside, UIChicago, UMBC, UTArlington, UTDallas, WashingtonSt.

PhD-Next50-R1 Private (9):

CWRU, Drexel, Emory, Georgetown, GeorgeWashington, NotreDame, Rensselaer, Syracuse, Tufts.

PhD-One-Top Public (50):

Alabama, Alabama-Huntsville, Albany, Arkansas, Cincinnati, ColoradoDenver, CUNYGraduateSchool, FloridaIntl, GeorgiaSt, Hawaii, Houston, Kansas, KansasSt, KentSt, Kentucky, Louisiana-Lafayette, Louisville, LSU, Maine, Memphis, Mississippi, MississippiSt, Missouri, Montana, MontanaSt, Nevada, NewHampshire, NewMexico, NorthDakotaSt, NorthTexas, Ohio, Oklahoma, OklahomaSt, OldDominion, SouthCarolina, SouthernMiss, TexasTech, UAB, UCMerced, UNCCharlotte, UNLV, USF, UtahSt, UTEP, UTSA, VirginiaCommonwealth, WayneSt, WestVirginia, WilliamMary, Wisconsin-Milwaukee.

PhD-One-Top Private (10):

Baylor, Brandeis, Denver, IllinoisTech, Lehigh, Miami, RIT, Stevens, Tulane, WPI.

PhD-No-Top Public (31):

AlaskaFairbanks, Arkansas-LittleRock, Augusta, BoiseSt, ClevelandSt, ColoradoColoradoSprings, FloridaAtlantic, Idaho, IUPUI, LouisianaTech, MichiganTech, MissouriSciTech, NewMexicoSt, NorthCarolinaA&T, NorthDakota, Oakland, PortlandSt, RhodeIsland, SouthAlabama, SouthDakotaSt, SouthernIllinois, TennesseeTech, TexasSt, UMassBoston, UMassLowell, UMKansasCity, Vermont, WesternMichigan, WichitaSt, WrightSt, Wyoming.

PhD-No-Top Private (14):

BYU, Catholic, Clarkson, Dayton, DePaul, FloridaIT, Fordham, Howard, Marquette, NovaSoutheastern, SantaClara, SMU, StLouis, Tulsa.

MS-Doctoral Public (64):

Akron, ArkansasSt, BallSt, BowlingGreenSt, CentralArkansas, CentralMichigan, CSUEastBay, CSUFullerton, CSULongBeach, CSUSanBernardino, CUNYCC, EastCarolina, EasternKentucky, EasternMichigan, EastTennesseeSt, FloridaA&M, FresnoSt, GeorgiaSouthern, GrandValleySt, IdahoSt, IllinoisSt, IndianaSt, JacksonSt, JamesMadison, Kean, KennesawSt, Lamar, Marshall, MarylandEasternShore, MiamiOH, MiddleTennesseeSt, MissouriSt, MontclairSt, MorganSt, Nebraska-Omaha, NewOrleans, NorthernArizona, NorthernIllinois, NorthernKentucky, NorthFlorida, Rowan, Rutgers-Camden, SamHoustonSt, SanDiegoSt, SanFranciscoSt, SIUEdwardsville, SouthDakota, Southern, TAMUCommerce, TAMUCorpusChristi, TAMUKingsville, TennesseeSt, TexasSouthern, UHClearLake, UMassDartmouth, UMFlint, UMStLouis, UNCGreensboro, UNCWilmington, UTChattanooga, UTRioGrandeValley, UTTyler, WestChester, WesternKentucky.

MS-Doctoral Private (17):

Adelphi, American, Bradley, Duquesne, Hofstra, LoyolaChicago, LoyolaMarymount, MississippiCollege, Pace, Pacific, RegisCO, SanFrancisco, Seattle, StThomasMN, Villanova, WakeForest, WilmingtonDE.

MS-Masters Public (66):

AlcornSt, AngeloSt, AppalachianSt, AustinPeaySt, BowieSt, BridgewaterSt, Brooklyn, CalPolyHumboldt, CalPolyPomona, CalPolySanLuisObispo, CentralMissouri, CentralOklahoma, CentralWashington, Charleston, ChicoSt, ChristopherNewport, Citadel, CSUBakersfield, CSUDominguezHills, CSULosAngeles, CSUMontereyBay, CSUNorthridge, CSUSanMarcos, CSUStanislaus, CUNYQueens, DakotaSt, DistrictColumbia, EasternWashington, FitchburgSt, FloridaPoly, FortHaysSt, JohnJay, MetropolitanSt, MetropolitanStDenver, MidwesternSt, NewMexicoTech, NorfolkSt, NortheasternIllinois, NorthwestMissouriSt, SacramentoSt, SanJoseSt, SonomaSt, SouthernConnecticutSt, SouthernOregon, SouthernUtah, StCloudSt, SUNYNewPaltz, SUNYOldWestbury, SUNYOswego, SUNYPoly, Towson, Troy, UAPineBluff, UISpringfield, UMDearborn, UMDuluth, UTPermianBasin, UWBothell, UWLaCrosse, UWRiverFalls, UWWhitewater, WeberSt, WesternIllinois, WesternWashington, WestFlorida, WestVirginiaSt.

MS-Masters Private (9):

FairleighDickinson, Mercy, Monmouth, NewYorkIT, OralRoberts, StJohns, StMarys, StPeters, Wentworth.

BS/BA-Doctoral Public (17):

AlabamaSt, FloridaGulfCoast, IndianaPennsylvania, PrairieViewA&M, Radford, Rutgers-Newark, Stockton, TarletonSt, TexasWomans, Toledo, UHHilo, ULMonroe, UWOshkosh, ValdostaSt, WesternCarolina, WestGeorgia, Winston-SalemSt.

BS/BA-Doctoral Private (46):

AbileneChristian, AzusaPacific, Barry, Belhaven, Bellarmine, Belmont, BethelMN, Biola, BostonCollege, Carson-Newman, Chapman, ClarkMA, Creighton, DetroitMercy, Drake, Elon, Gannon, GeorgeFox, Gonzaga, Hampton, Harding, Hardin-Simmons, Hartford, LaSalle, LaVerne, Lipscomb, LoyolaNewOrleans, MaryHardin-Baylor, Mercer, PacificOR, Pepperdine, Quinnipiac, Samford, SanDiego, SeattlePacific, SetonHall, Shenandoah, Simmons, Springfield, Suffolk, TCU, UnionTN, WesternNewEngland, Wilkes, Xavier, Yeshiva.

BS/BA-Masters Public (59):

AdamsSt, AlabamaA&M, AlaskaAnchorage, AlbanySt, Baruch, BemidjiSt, CentralConnecticutSt, ClaytonSt, CoastalCarolina, CollegeNewJersey, CoppinSt, CUNYYork, EasternConnecticutSt, EasternIllinois, EasternNewMexico, FayettevilleSt, FrancisMarion, GeorgiaCollege, GramblingSt, Hunter, Lehman, Longwood, MontanaTech, MSUMankato, MSUMoorhead, MurraySt, NewJerseyCity, NorthAlabama, NortheasternSt, NorthernMichigan, NorthGeorgia, Salisbury, Shepherd, SlipperyRock, SouthDakotaMines, SoutheasternLouisiana, SouthernIndiana, StephenFAustinSt, SUNYBrockport, SUNYFredonia, SUNYOneonta, SUNYPlattsburgh, SUNYPotsdam, TAMUSanAntonio, TrumanSt, UHDowntown, UNCPembroke, USCAiken, UTMartin, UWEauClaire, UWPlatteville, UWStevensPoint, UWStout, VirginiaSt, Washburn, WesternColorado, WilliamPaterson, WinonaSt, WorcesterSt.

BS/BA-Masters Private (9):

CaliforniaBaptist, CaliforniaLutheran, Faulkner, HawaiiPacific, LaSierra, Siena, StXavier, Tuskegee, XavierLA.

BS/BA-Bacc Public (12):

AirForce, Army, AtlantaMetropolitanSt, CentralSt, DaltonSt, FortLewis, LincolnMO, MaryWashington, MedgarEvers, Navy, UMMorris, UNCAsheville.

BS/BA-Bacc Private (48):

Amherst, Barnard, Bates, Berea, Bloomfield, Bowdoin, BrynMawr, Bucknell, Carleton, ClaremontMcKenna, Colby, Colgate, ColoradoCollege, ConnCollege, Davidson, Denison, DePauw, Dickinson, FranklinMarshall, Furman, Grinnell, Hamilton, HarveyMudd, Haverford, HolyCross, Lafayette, Macalester, Middlebury, Morehouse, MountHolyoke, Oberlin, Occidental, Pomona, Richmond, Sewanee, Skidmore, Smith, Spelman, Swarthmore, TrinityCT, Union, Vassar, WashingtonLee, Wellesley, Wesleyan, Whitman, Williams, Wooster.

AANAPISI Public (29):

Baruch, Brooklyn, CalPolyPomona, CSUEastBay, CSULosAngeles, CSUStanislaus, CUNYCC, CUNYQueens, GeorgiaSt, Houston, Hunter, Minnesota, PortlandSt, Rutgers-Newark, SacramentoSt, SanDiegoSt, SanFranciscoSt, SanJoseSt, SUNYOldWestbury, UCDavis, UCIrvine, UCMerced, UCRiverside, UHHilo, UIChicago, UMassBoston, UMBC, UNLV, Washington.

AANAPISI Private (8):

Adelphi, HawaiiPacific, NewYorkIT, Pacific, PacificOR, SanFrancisco, StJohns, StMarys.

HBCU/PBI Public (29):

AlabamaA&M, AlabamaSt, AlbanySt, AtlantaMetropolitanSt, BowieSt, CentralSt, ClaytonSt, CoppinSt, CUNYYork, DistrictColumbia, FayettevilleSt, FloridaA&M, GeorgiaSt, GramblingSt, JacksonSt, LincolnMO, MarylandEasternShore, MedgarEvers, MorganSt, NorfolkSt, NorthCarolinaA&T, PrairieViewA&M, Southern, TennesseeSt, TexasSouthern, UAPineBluff, VirginiaSt, WestVirginiaSt, Winston-SalemSt.

HBCU/PBI Private (9):

Belhaven, Bloomfield, Faulkner, Hampton, Howard, Morehouse, Spelman, Tuskegee, XavierLA.

HSI Public (64):

AdamsSt, AngeloSt, Arizona, ArizonaSt, CalPolyHumboldt, CalPolyPomona, ChicoSt, CSUBakersfield, CSUDominguezHills, CSUEastBay, CSUFullerton, CSULongBeach, CSULosAngeles, CSUMontereyBay, CSUNorthridge, CSUSanBernardino, CSUSanMarcos, CSUStanislaus, CUNYCC, CUNYQueens, DaltonSt, EasternNewMexico, FloridaAtlantic, FloridaIntl, FresnoSt, Houston, Hunter, JohnJay, Kean, Lehman, MetropolitanStDenver, MontclairSt, NewJerseyCity, NewMexico, NewMexicoSt, NewMexicoTech, NortheasternIllinois, Rutgers-Newark, SacramentoSt, SanDiegoSt, SanFranciscoSt, SanJoseSt, SonomaSt, SUNYOldWestbury, TAMUCorpusChristi, TAMUKingsville, TAMUSanAntonio, TexasSt, TexasTech, TexasWomans, UCF, UCIrvine, UCMerced, UCRiverside, UCSantaBarbara, UCSantaCruz, UHDowntown, UIChicago, UTArlington, UTEP, UTPermianBasin, UTRioGrandeValley, UTSA, WilliamPaterson.

HSI Private (13):

AzusaPacific, Barry, Bloomfield, CaliforniaBaptist, CaliforniaLutheran, FairleighDickinson, LaSierra, LaVerne, Mercy, NovaSoutheastern, StMarys, StPeters, StXavier.