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The Firelighters: Understanding the Demand for Instructional Computer Science Faculty

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Abstract

Instructional faculty (those whose primary responsibility is teaching undergraduates) in computing are not well-studied, and the differences in employment conditions, education, and responsibilities of those in these roles within and between institutions are ill-understood. The capacity crisis has caused demand to exceed supply of the limited number of qualified people who want this role, so a better understanding is crucial to managing the crisis. This paper attempts to quantify and qualify the demand for instructional faculty using published and new data, and describes employment conditions for these faculty via a survey of hiring institutions in the 2015-2016 academic year (with attention to demographics and diversity). The paper concludes with an analysis of the nature of the employment gap and proposes future research to better understand these faculty and their roles in defining the future of the field.

Introduction

Despite teaching the bulk of courses at most institutions, instructional faculty in computing are not well understood. These faculty are critical to the success of the field, of individual students, and of efforts to diversify computing. They hold twin roles: first, they are educators; second, they are gatekeepers, cheerleaders, and role models for all new undergraduate students. As Plutarch wrote two millennia ago, "For the correct analogy for the mind is not a vessel that needs filling, but wood that needs igniting."

A serious gap in the literature shows these faculty to be understudied, and this ignorance may be part of the gap between demand and supply described here. As the CS capacity crisis continues unabated due to years of massive growth in undergraduate CS enrollment, the ability to serve students is constrained by the limited group of faculty who are qualified and committed to education; hiring of these faculty is failing. Demand is so great that Stanford has introduced a new MS in Computer Science Education (which requires a prior PhD in a non-computing discipline), and this program began a year earlier than anticipated [1].

The field needs to understand those responsible for lighting the fires. This research characterizes recent hiring of instructional faculty at all levels of higher education through two studies: an analysis of twenty years of job advertisement messages on a listserv for the CS education community, and a survey of department or hiring committee chairs who have hired or attempted to hire in the 2015-2016 academic year (henceforth AY 2015). The aim is threefold: first, to show the dimensions of the hiring gap; second, to define instructional faculty responsibilities, conditions of employment, and qualifications at different levels of institution; and third, to

discuss concerns raised by those trying to hire instructional faculty. Given the lack of diversity within higher education computing, it is vital to consider demographics in hiring.

Computer science and related fields, programs, and departments, which we refer to generally as *computing*, include:

- Computer science
- Information science
- Information systems
- Information technology
- Software engineering
- Computer engineering

These programs have seen undergraduate enrollment surge between 2010 and 2016 at both research institutions [2] and non-doctoral colleges and universities [3]. Personal conversation with the Taulbee authors in October, 2016, indicated that the forthcoming survey will show yet another increase. It is impossible to put a single number on enrollment, but Tracy Camp has publicized a growth of 133% between 2010 and 2015 at research institutions. Because of low response rates, it is not possible to assign a similar number to institutions covered by the NDC, but data indicate significant growth in those institutions, too.

Like all embarrassments of riches, this longed-for surge comes with problems and consequences, not the least of which may be: Who will teach these students? The CS capacity crisis has motivated CS education researchers to explore ways to maximize teaching efficiency with techniques like autograding [4]. Irrespective of the gains produced by this research, doubling demand in less than a decade requires new instructional faculty.

Taulbee reported the growth of tenure and tenure-track faculty at research institutions over the same period was 16% and teaching faculty growth was 86%, suggesting that teaching faculty are playing an increasing role in undergraduate education. This might seem to indicate that an appropriate workforce is being sought and used, but it is not clear that this approach is sustainable, and it is certainly not free from problems.

Research Overview: Supply and Demand

Supply of qualified faculty for these positions is not high. For the 2014 academic year (AY 2014), Taulbee reported 1,780 PhDs awarded in computing. However, over 60% of new PhD graduates left academia (mostly for industry) and a scant 10% went on to tenure-track academic employment at any level of institution. A PhD is not necessarily required for an instructional

faculty position, but virtually all tenure-track positions at teaching institutions do require a PhD, and many non-tenure-track positions at research institutions require or prefer a PhD.

Defining demand is not a straightforward task of counting, as there is no central repository of job postings. Despite detailed research into hiring for tenure-line positions [6], no such data are collected for instructional faculty. Our data show that many instructional faculty positions were not posted to central venues (e.g., the Chronicle of Higher Education), as a tenure-track position at a research institution surely would be. Taulbee and NDC have only recently begun tracking what they call "teaching-track faculty", and their data are not detailed. The Taulbee report for AY 2015 noted attempts to hire 199 teaching faculty at research institutions (with 67% of institutions responding), but only 174 teaching faculty were hired. For the same academic year, NDC reported attempts to hire 66 tenure-line faculty (60 hired), 10 visiting faculty (12 hired), and 24 non-tenure-track faculty (24 hired), with only 14.9% of programs responding.

To supplement these data, we analyzed a listserv for ACM SIGCSE (Special Interest Group on Computer Science Education). The SIGCSE-MEMBERS listserv (henceforth “the Listserv”) has served as a venue for discussion of computing education since 1996. Listservs and other informal methods of advertising positions offer free and easily-accessible venues to communicate about jobs to an engaged and relevant audience.

Traffic on the Listserv has increased gradually over 20 years, from 481 posts in AY 1996 to 1,101 posts in AY 2015, with 395 job-related and 863 non-job-related posts, respectively. Unsurprisingly, recent traffic on the Listserv has shown a surge of job ad posts. The number of ad posts has gradually grown over 20 years from 86 in Academic Year 1996-1997 (AY 1996) to 238 in AY 2015. We found no correlation between the numbers of job ads and non-job posts, indicating that the increased job ad posts are not principally a function of increased traffic.

The number of job ads posted has varied greatly. Prior to the current surge, there was a surge during the dot-com bubble of the later 1990s. Figure 1 shows both surges, but the current surge is much higher and steeper, and the occurrence of more than 200 job ad posts for two consecutive years indicates sustained demand.

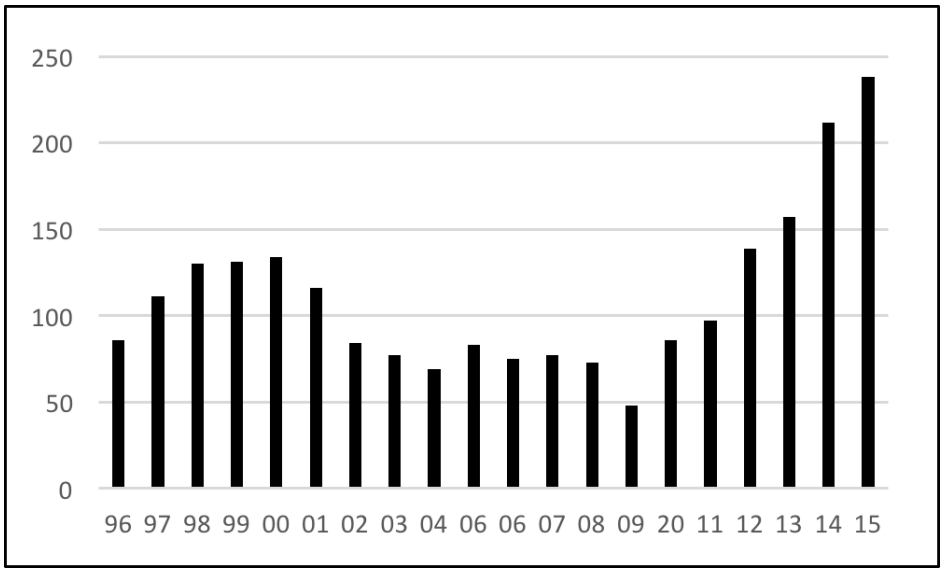

Figure 1. Job Posts to the SIGCSE-MEMBERS Listserv Per Academic Year

It is not possible to derive a precise number of jobs in each year from these data. In many situations, multiple hiring scenarios are proposed (e.g., a PhD might be hired as a Teaching Assistant Professor with security of employment, while an MS might be a hired as a Lecturer with no security of employment). Some institutions conduct multiple hires and post them separately, while other institutions post multiple positions in a single message. Some positions are reposted (often from a different account, possibly from a different domain, and using different text). However, ads seem an effective proxy to count hiring institutions; the 238 job ad posts in AY 2015 (the 2015-2016 academic year) were sent from 210 different email addresses representing 183 institutions, indicating a minimum of 77% of messages advertising unique jobs.

Classifying Instructional Faculty

It is important to define the term *instructional faculty*, especially in contrast to the perceived classical model of a professorship at a research institution. Faculty positions are generally classified as either tenured/tenure-track (henceforth T/TT) or non-tenure-track (henceforth NTT). To best grasp the full extent of the problem, we define instructional faculty as those whose primary responsibility is undergraduate education, regardless of whether the positions are T/TT or NTT. Grouping T/TT faculty with NTT faculty is potentially controversial, but since responsibilities, titles, and qualifications overlap both groups, such controversy is largely a matter of perceptions of identity.

The model of successful T/TT employment at a research institution seems to have a predictable career path, with tenure and promotion a critical milestones granted on the basis of published

research, extramural funding, and successful graduate students. Teaching is restricted to graduate and upper-division undergraduate courses.

The model for instructional faculty seems similarly straightforward, too. At research institutions, a cohort of NTT teaching faculty, typically with master's degrees, hold titles like "lecturer" or "teaching professor" and teach mostly introductory undergraduate courses; at institutions focused more on undergraduate education, the research demands on T/TT faculty decrease and teaching loads increase to the point where tenure-line faculty at undergraduate-only institutions have low research expectations and are instructional faculty, so few NTT positions exist.

Both of these models of instructional faculty are inaccurate, as we demonstrate below. Instructional faculty employment is a mass of contradictions, with titles, employment status, permanence, and standard academic rights and privileges distributed unevenly and with little regard to institutional level.

In order to understand instructional faculty, we must understand the terms of their employment. Dimensions of employment include differences in status, freedoms, and responsibilities, which we will generally term *employment conditions*:

- Institutional Carnegie classification [5], which we simplify in four groups:
    - Research institutions (those granting PhDs, classified as R1, R2, or R3)
    - Master's institutions (those granting master's degrees, classified as M1 or M2)
    - Baccalaureate institutions (those granting undergraduate degrees only)
    - Associate's institutions (typically community colleges)
- Employment security
    - Tenure eligibility
    - Other (non-tenure) systems of employment security
    - Initial contract duration and longest possible contract duration
    - Contract renewal frequency
- Academic rights and privileges
    - Access to grievance process
    - Formal mentoring
    - Availability of professional development funds
    - Availability of sabbatical
- Research responsibilities
    - Serving as a principal investigator for extramural grants
    - Publishing at regional and national/international conferences and in journals
    - Other professional development activities to maintain proficiency

None of these dimensions are simple. A long-term contract is clearly preferable to an annual contract, but annual (or "evergreen") renewal of a multi-year contract ensures that the faculty member constantly has multiple guaranteed years of future employment. Teaching assistants allow for efficiency, but training and supervising teaching assistants is time-consuming. Teaching a smaller number of course preparations is attractive to some faculty, but constricting for others. While we have data on all of these dimensions, we only highlight some below to illustrate critical issues at different levels of institution. Although condensed analysis hides this, instructional faculty can have different employment conditions even within the same institution.

We solicited survey responses via two mechanisms. First, we sent an invitation to the SIGCSE-MEMBERS listserv, which had 1,044 recipients on the date the message was sent and produced 15 complete responses, a response rate of less than 1%. Second, we emailed individual invitations to the 210 people who posted job ads to the listserv in AY 2015. This produced 44 complete responses, a response rate of 21%. Of the 59 completed responses, 43 (73%) tried to hire at least 47 instructional faculty AY 2015. Only 13 of 43 (31%) of respondents reported hiring candidates for all positions, while 7 (16%) reported being able to hire none. Failing to find qualified candidates is virtually unknown in academic hiring; as one respondent noted, "I am jealous of my colleagues in just about every other field where even a search for a 1-year visiting position can get hundreds of applications, many high-quality."

Carnegie Level	Respondents	Hiring	Hired All	Hired Some	Hired None	Unknown
Research	23 (39%)	17 (74%)	4 (24%)	6 (43%)	4 (29%)	3 (18%)
Master's	16 (27%)	12 (75%)	4 (33%)	3 (38%)	1 (8%)	4 (33%)
Baccalaureate	19 (32%)	13 (68%)	5 (38%)	0 (0%)	2 (15%)	6 (46%
Associate's	1 (2%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)
Total	59	43	13	9	7	13

Figure 2. Institutions Attempting to Hire Instructional Faculty, With Outcomes

Perhaps the most obvious assumption is that instructional faculty are never T/TT at research institutions, mostly T/TT at baccalaureate institutions, and mixed at master's institutions. This is not correct, as can be seen in Figure 3. Of research institutions responding, 23% have mostly T/TT instructional faculty, as do 75% of responding master's institutions, and surprisingly slightly under half of baccalaureate institutions. (Note about data: numbers will not necessarily sum, as we only count declared information, remove "Other", and round percentages.)

Carnegie Level	Mostly T/TT	Sometimes T/TT	Never T/TT
Research	5 (22 %)	2 (9%)	15 (65%)
Master's	12 (75%)	2 (13%)	1 (6%)
Baccalaureate	9 (47%)	2 (11%)	6 (32%)
Associate's	1 (100%)	0 (0%)	0 (0%)
All Classified	27 (46%)	6 (10%)	21 (36%)

Figure 3. Tenure Eligibility of Instructional Faculty

Of course, tenure is not the only form of employment security, and tenure provides (or at least implies) much more than guaranteed employment; it generally indicates status within institutional governance, access to resources, and promotability to administration. When generalized to any form of employment security, the data show that most faculty (61%) have some form of employment security, although slightly less than half of faculty at research institutions have this.

Carnegie Level	Employment Security	No Employment Security
Research	9 (45%)	11 (55%)
Master's	12 (75%)	4 (25%)
Baccalaureate	11 (65%)	6 (35%)
Associate's	1 (100%)	0 (0%)
All Classified	33 (61%)	21 (39%)

Figure 4. Security of Employment for Instructional Faculty

The next area of interest is scholarship and the maintenance of proficiency. Here the data are more consistent with expectations, with different expectations of faculty at different levels of institutions; instructional faculty at research institutions have low expectations of work in this area, but there is a great deal of diversity and no consistent model. Even within the categories, there are differences; scholarship can range from publishing periodically at regional conferences to being a PI on extramural grants, and while we offered suggestions for Professional Activities ("e.g., reviewing publications, grading AP exams"), there can be a wide variety here.

Carnegie Level	Scholarship	Professional Activities	No Requirements
Research	6 (27%)	1 (4%)	16 (70%)
Master's	8 (50%)	3 (19%)	4 (25%)
Baccalaureate	8 (42%)	3 (16%)	5 (26%)
Associate's	0 (0%)	0 (0%)	1 (100%)
All Classified	22 (37%)	7 (12%)	26 (44%)

Figure 5. Professional Development Required of Instructional Faculty

Finally, we consider specific rights and privileges that are endemic to academia and considered part of faculty identity: access to a grievance process if denied reappointment, a formal mentoring program, access to professional development funds (either guaranteed or potentially available), access to sabbatical, and ability to serve as a PI on an extramural grant. As can be seen below, a great deal of variance exists in access to these benefits.

Carnegie Level	Grievance	Mentoring	Development Funds	Sabbatical	Grant PI
Research	17 (77%)	7 (4%)	20 (88%)	7 (30%)	17 (74%)
Master's	13 (87%)	5 (19%)	15 (94%)	11 (69%)	14 (88%)
Baccalaureate	13 (76%)	10 (16%)	16 (84%)	12 (71%)	17 (100%)
Associate's	1 (100%)	0 (0%)	1 (100%)	1 (100%)	1 (100%
All Classified	44 (80%)	22 (39%)	26 (44%)	31 (54%)	49 (86%)

Figure 6. Academic Rights and Privileges of Instructional Faculty

Demographics of Hires

We believe it is critical to understand the demographics of hired candidates. Since these faculty typically teach introductory classes at all levels of institution, they must represent the potential student population to allow students to better identify with futures in computing. Since we do not have applicant demographic information, this information cannot be used to evaluate bias in the hiring process, but it offers insight into hiring and points of comparison for future researchers.

It should not surprise the reader that white and Asian men were overrepresented (relative to population) in the sample's hires, and women and other minorities were underrepresented.

However, the findings, when distributed by level of institution, showed surprising variation. Note that not all respondents answered all questions, so not every hire is fully demographically identified. The one associate's institution reported failure in hiring, so is not reported here.

Carnegie Level	Male	Female	Unknown	Total
Research	14 (82%)	3 (18%)	0	17 (36%)
Master's	5 (50%)	5 (50%)	0	10 (21%)
Baccalaureate	10 (50%)	5 (25%)	5 (25%)	20 (43%)
All Classified	29 (62%)	13 (28%)	5 (11%)	47

Figure 7. Gender Demographics of Hires

Carnegie Level	White	Asian	All Others	Unknown	Total
Research	9 (56%)	6 (38%)	1 (6%)	0 (0%)	16 (36%)
Master's	9 (90%)	1 (10%)	0 (0%)	0 (0%)	10 (23%)
Baccalaureate	10 (56%)	2 (11%)	1 (6%)	5 (28%)	18 (41%)
All Classified	28 (64%)	9 (20%)	2 (5%)	5 (11%)	44

Figure 8. Racial Demographics of Hires, Collapsing All Other Than White/Asian

We intentionally collapsed the the categories of underrepresented races to highlight the fact that only two of the 44 hires whose races were reported were not white or Asian. One hire was reported as American Indian/Native Alaskan and one was reported as multiracial; *not one hire was reported as Black/African American or Native Hawaiian/Pacific Islander*. The Census and EEOC identify Hispanic/Latino heritage as a separate category from race, labeled "Ethnicity"; two hires (both at research institutions) were identified as Hispanic or Latino, while 35 were identified as not Hispanic/Latino and 8 were identified as unknown with respect to this category.

Given these data, issues of representation abound. One respondent stated "We are striving to diversify our faculty, but there are not enough women and ethnic minorities in the applicant pool". This claim is not unreasonable; the research institution instructional faculty hiring ratio of 82% men and 18% women precisely matches the Taulbee-reported awarding of CS PhDs in AY 2014. However, information science and information systems PhDs were awarded at a much more balanced ratio 57% to men and 43% to women (although in much smaller numbers). Also, many of these positions require only a master's degree, so the CS master's degree award ratio at

these institutions of 75% men and 25% women (and the information science and information systems master's degree award ratio of 52% men and 48% women) indicate that the issue is not exclusively one of an insufficient pipeline. Actively seeking candidates from beyond traditional pools seems warranted by both overall failure to fill positions and the extreme lack of diversity of hired candidates.

While unknown genders for hires at baccalaureate institutions add a confound, it seems that non-research institutions are more effective at hiring women than research institutions. Whether this is due to the applicant pool, efforts on the parts of these institutions to hire from underrepresented groups, or both, is unknown. Sadly, no level of institution seems to have been effective at hiring underrepresented minorities.

One issue not addressed is country of origin. The survey did ask respondents about the employment eligibility of hires; 37 of 45 reported hires were identified as US nationals, seven were hired on employment visas (one NAFTA), and one was hired on OPT, meaning that 8 (18%) of hires were not US nationals. Given possible forthcoming challenges to visa employment, this does not bode well for a challenging hiring market.

Conclusions and Future Work

The data here are necessarily descriptive and not comprehensive. However, the high response rate to our survey allows us to consider these data at least somewhat representative of institutions that have recently hired. It is not possible to perform reliable statistical analysis with 59 data points, but the data presented here show clear trends away from consistency and toward ad hoc models of employment. Even given the constraints of the data, this research has conclusively established that no simple employment model or scale of instructional faculty exists, and while more consistency is attractive, it seems unlikely that a standard model can be constructed. Instructional faculty are not monodimensional and do not exist on a limited continuum consistent with institutional level.

More insight into these roles will allow for comprehensive strategies to deal with the gap between qualified applicants and demand, and allow for these faculty to become more than mere second-tier players on the academic stage. While research is vital, education is a primary aim of academia, so educators warrant attention and care.

Our hope is that institutions will be able to use these data to better support future hiring and changes to employment conditions. We hope that better, more consistent employment conditions will attract talented new educators to these roles, and that an improved working environment will positively affect students. Given the lack of hiring of women and underrepresented minorities,

targeted recruitment of candidates from these groups seems an obvious approach that will benefit from improved employment conditions.

In addition to continuing data collection and providing further analysis, future research on instructional faculty must obviously consider two perspectives: the perceptions of the instructional faculty themselves and the perceptions their institutions have of them. Given current findings, we anticipate a large and concerning gap between the two sets of beliefs.

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