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Anita Jones

Viewpoint
The Explosive Growth of Postdocs in Computer Science

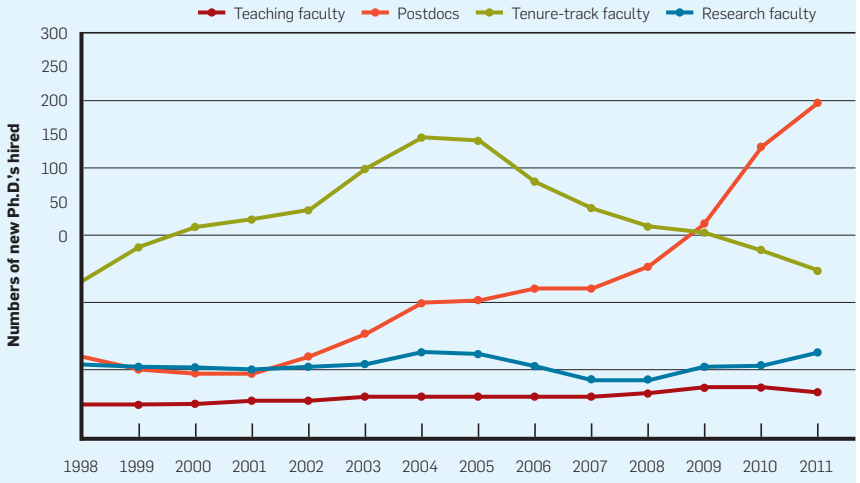
Considering the factors influencing the recent rapid increase in the number of postdoctoral positions in computer science.

THE NUMBER OF postdoctoral researchers in computer science slightly more than doubled in the decade ending in 2008. It is troubling that the number has doubled again in the subsequent three years. This changes the demographics of the academic computing research enterprise, in particular. In this Viewpoint, I discuss some of the different facets of this troubling trend.

The chart shown in the accompanying figure plots data from the 2012 Taulbee survey[a] excluding data on graduates going into industry and those in the Taulbee "other" category. The data indicates tenure-track faculty positions for new Ph.D.'s have declined steadily since 2004 from 224 to 124 in 2011 while the number of postdoc positions greatly increased. In 2011, new Ph.D. graduates accepted twice as many postdoc positions as tenure-track positions. Around 2003 there were approximately 2.5 times more tenure-track positions than postdoc positions.

Most graduate departments primarily train Ph.D. students for a tenure-track faculty position in a research institution, though there is now some diversity in career path training in some universities. The Taulbee statistics document that most graduates will not achieve an academic tenure-track position. A mere 7% of graduates were hired directly into tenure-track faculty positions in 2011. Teaching faculty and research faculty have roughly stayed constant.

Hiring of computer science Ph.D.'s in academia, as a three-year rolling average 1998–2011.



In past years computer science has been notable for the low level of postdocs. The National Science Board reports that in 2006, of the total number of postdocs in science and engineering disciplines, approximately 1% were in computer science. Engineering, physics, and chemistry each had between 4% and 9.5% of the total.[3]

The Computing Community Consortium created the CIFellows Program to provide postdocs with funds from the National Science Foundation during the economic downturn at the end of the last decade in order to retain Ph.D.'s in research and teaching when universities dramatically curtailed hiring. With an improving economy that program has served its purpose and is concluding. The three-year program

a Unless otherwise documented, the statistics quoted in this Viewpoint are extracted from the Taulbee survey, an annual survey of Ph.D.-granting departments in computer science, computer engineering, and information systems conducted by the Computing Research Association.

funded 127 postdocs, a small number in relation to the postdoc growth in computer science.[b]

Biomedical sciences have gotten very badly out of balance with respect to the number of postdocs and the long delay before they, on average, take permanent positions. The average age of first-time principal investigators obtaining R01-equivalent research funding (the major source of support for young investigators in the biomedical sciences) from the National Institutes of Health has risen to 44 years as of 2011, up from about 36 years in 1980.[2] To what degree will computer science move in the same direction?

The Postdoc Experience

A postdoc position is a *training* opportunity in which a person who has just completed a Ph.D. can deepen his or her expertise and research skills for a short period of time, en route to a permanent position. A postdoc—the person—may accept such a position for different reasons: to work under the tutelage of a specific expert, perhaps in a more highly regarded institution than his or her Ph.D.-granting university; to gain exposure in a related area; to remain research active while waiting for a faculty position; or to change fields altogether. The postdoc can have reasons that go beyond "training." For example, the postdoc may wish to strengthen a research portfolio in anticipation of a competitive job search or to synchronize job search timing with that of a spouse.

A postdoc experience can genuinely advance an individual's career: sharpen research skills, insight and knowledge; permit increase in publications; and enlarge the group of peers who know and respect the individual's work.

The postdoc experience also has negatives. First, postdocs in academia are paid at a rate that is substantially lower than close peers. Taulbee data indicates the average (not starting) nine-month salary for an assistant faculty member was $90,000 in 2010. A research faculty member was paid an average of $81,000, and a teaching faculty member was paid an average of $70,000. At the same time the comparable postdoc salary was $50,000. In some universities postdocs have fewer or lesser benefits in areas such as health care, retirement, access to childcare, and access to wellness centers.

Second, the postdoc generally focuses only on their individual postdoc objectives without other distractions and responsibilities. Unless there is good mentoring and a strong collegial relation around a postdoc, that person could become isolated. In some cases, postdocs are directed to work on research projects or take on teaching obligations that do not advance their long-term career trajectories, simply because they are cheap labor for their advisors.

Third, the postdoc is mature in her or his intellectual power. Yet, at most universities and in industry, postdocs are isolated from participation in the discussions, much less the decisions, that set the future of the organization. Typically, postdocs cannot be principal investigators on grant proposals.

Last, the postdoc position is taken shortly after the degree. This is most often the time of life when couples start families. A postdoc position is not permanent; therefore the individual must do another job search, and typically will move from one geographic locale to another with the associated career disruption, personal disruption, and expense. Relocation is more difficult for women and men who are nurturing a young family. Delaying the bearing of children has health implications for women. In summary, there are distinct downsides to the postdoc experience.

Balance in the Academic Research Enterprise

The dramatic increase in postdocs changes the overall balance in the number of participants of different kinds in the academic research enterprise, that is the number of tenure-track faculty, graduate students, research faculty, teaching faculty, and postdocs. What effect does that have on other members of the enterprise?

When a recently graduated Ph.D. moves to a new research project, that person brings fresh ideas and even different assumptions about research. It is possible that a rapidly flowing pipeline of postdocs moving through a re-

b The author has been a principal investigator on all the grants supporting the Computing Community Consortium and has been a member of its governing Council from founding to date.

search organization introduces new knowledge, broader interdisciplinary knowledge, more vitality, and a propensity to challenge assumptions—all in a way that students and the permanent faculty do not.

Perhaps the increase in postdocs is due to funding agencies insisting on project milestones that have a short duration or even a development, versus research, character. Perhaps postdocs are used to help manage research performance against tighter grant constraints.

One can make the simplistic assumption that the total computing research budget is fixed and does not increase or decrease with the number of postdocs. More postdocs means that fewer graduate students can be supported. Principal investigators make a choice among the categories—research faculty, students, and postdocs—and to a lesser degree to tenure-track faculty as they craft proposals.

Alternatively, the increase in postdocs may indicate a maturation of the field. Postdocs are more prevalent in math and the physical sciences. Postdoc positions are historically more prevalent in theoretical areas of computer science, as well.

Certainly, the explosive increase of postdocs in the life sciences is traceable back to funding. When the NIH budget doubled during the 1990s, either postdocs were the simplest way to rapidly expend the funding with no permanent obligations, or they were a way to deal with the overproduction of Ph.D.'s relative to tenure-track faculty positions. It is not clear that the life sciences *expected* to increase the number of postdocs so dramatically.

I have two principal concerns. First, I am concerned that our field is redefining "career progression" for researchers by expecting Ph.D. graduates to accept one to two years (or even more) of postdoc training before attaining a first, independent, permanent position. If that is necessary, then the community should clearly articulate why. I see no evidence that the increase derives from today's students not being as prepared as in the past.

Second, I am concerned that some academic departments and research laboratories are redefining hiring criteria so the quality of a candidate's work is correlated with the number of publications consistent with a postdoc, rather than a number of publications consistent with a recent Ph.d. degree. Over the decades we have built a vibrant industrial and academic computer science research enterprise based on hiring for quality, not hiring for extensive publication.

The increase in the number of postdocs is a major change for our field. We should manage it thoughtfully.

I conclude that the increase in postdocs derives from desires of the research organizations to meet their own changed objectives, for example, in research project management and hiring or from a shortage of supply of high-quality Ph.D. students, not from a perception of training shortfalls among Ph.D. graduates.

Community Action

I recommend the community, with leadership from the Computing Research Association, take action.

- Get the data. Taulbee surveys do not provide all the information needed to understand the increase in postdocs and their later career paths.
- Understand this trend and articulate clearly what constitutes the best balance among different categories of positions in the research community going forward.
- Better manage the postdoc experience to deliver high value to the postdocs themselves.

Postdocs are frequently isolated, and sometimes benignly neglected. If the field requires many more postdocs for its own purposes, then the sponsoring departments and laboratories—not simply the mentors—should take responsibility to ensure the experience substantially contributes to the postdoc still in training. NSF now requires a postdoc training supplement to proposals that fund postdocs. A postdoc should be given:

- A mentor who provides adequate guidance;
- A supportive set of colleagues in tenure-track faculty, other postdocs and research faculty who provide the postdoc with rich and frequent intellectual interaction;
- Skills in conducting research from proposal preparation to presentation and research group management; and
- Career development support with thoughtful exposure to alternative career paths, for example industrial research and development positions and bridges to other fields where computer science has a substantive role to play.

The sponsoring department or research laboratory—not only the mentor—should proactively support and enforce high standards for all four.

In addition, the Ph.D. advisor—who typically regards a Ph.D. student as an "intellectual descendent"—may want to continue vigilance on behalf of the Ph.D. student who accepts a postdoc position. The advisor should monitor to ensure the host organization for the postdoc is providing an experience that will genuinely advance the postdoc's career.

The increase in the number of postdocs is a major change for our field. We should manage it thoughtfully. A document outlining "best practices" for nurturing postdocs in computer science can be found on the Computing Research Association website (http://cra.org/resources/bp-view/best_practices_memo_computer_science_postdocs_best_practices/). C

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Anita Jones (jones@virginia.edu) is University Professor Emerita and past Department Chair and faculty member in the Department of Computer Science at the University of Virginia in Charlottesville.

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