OUR SEED CORN IS GROWING IN THE COMMONS

Peter Denning challenges computer professionals to a new game

Peter J. Denning
George Mason University
pjd@gmu.edu
3/1/99 DRAFT

Summary: The phrase "eating our seed corn" is used to describe the attrition of computer science faculty as systems-savvy professors take to industry's higher salaries and better lab facilities. The phrase suggests that our ability to train new computing professionals for a workplace in dire need of them is being severely impaired. This crisis is familiar to old hands in the field. The actions taken during a similar crisis in the late 1970s and early 1980s slowed the grazing of the seed corn but did not eliminate the attraction of corn. When the IT market heated up again in the 1990s, the problem reappeared. The problem itself is actually a crisis of the commons. It will take a concerted effort, led by the professional societies, to change the game to one in which there is no value to any player in overgrazing the commons. The new game will feature active professional society attention to the learning needs of IT professionals, new kinds of partnerships between university and industry, and moral (and possibly financial) assistance from the government.

The Workforce Problem

For several years, industry recruiters have traded stories about the difficulties of hiring IT professionals for open jobs. They lamented that they were stealing the same people from each other, ratcheting salaries up -- but kept right on doing it. They asked universities to increase production capacity to meet the demand, but universities, while eager to help, were stymied by lack of budget and staff. Industry recruiters began to lure professors and graduate students, a process that many feel impairs the future ability of the university to train IT professionals. The phrase "eating our seed corn" is often used to describe the situation. It evokes the picture of a starving people consuming the stock of corn they saved to plant next year's crop: they survived the winter only to be vanquished by famine the year after.

Unfortunately, this vivid picture of starvation and possible famine offers little guidance for a solution to the problem. Should workforce-hungry companies be mandated to stop recruiting faculty? (Who will issue and enforce the mandate?) Should faculty be restrained from taking jobs in industry or starting their own firms? (Who will issue and enforce that mandate?) Should state legislatures increase budgets? Or require that universities transfer resources into IT education? (Who will take the lead to persuade them?)

My interpretation is that our problem is an instance of a “crisis of the commons.” The commons was a field of grass shared by members of a tribe whose personal worth and stature were measured by the number of sheep they owned. Individual sheep-owners grew their herds at no cost by grazing them on the commons. Eventually, the number of grazing sheep overwhelmed the grasses’ abilities to replenish. The sheep, having nothing more to eat, all died and their owners were ruined. In our version of the crisis, the commons is the education system; professors and graduate students are kernels of corn rather than blades of grass; the sheep-owners are IT employers. The only way to keep the sheep from eating the seed corn is to change the nature of the game: overgrazing must have a negative value to everyone in the community.

The 1970s Seed Corn Crisis

Older hands among us recall an earlier “seed corn” crisis in the late 1970s and early 1980s. It is worth reviewing what we did then, if only to see why history is repeating itself.

Experimental methods are dear to the heart of several core areas of computing, most notably the systems areas (e.g., operating systems, architecture, networks, databases, software construction and testing) and computational science. These are the areas in which universities made enormous early contributions in the 1950s and 1960s. Paradoxically, experimental computer scientists never felt completely welcome in the university. Many encountered difficulty with academic tenure processes, where the commonly-applied rules for peer recognition in mathematics and engineering science (counting publications) don’t carry over well for systems.

This paradox exacted a toll during the brain drain of the 1970s, a time of rapid computer industry expansion. In 1979 Jerome Feldman decried that universities had failed to maintain incentives for their systems people; they were losing their expertise in the areas central to computing. He warned that experimental computer science was in jeopardy. He called for more competitive academic salaries and for explicit NSF support of experimental computer science. He said, “We are killing the goose that lays golden eggs.” [feld79] The ACM Executive Committee endorsed Feldman’s report while warning against equating “tinkering” with “scientific experimentation” [denn79, denn81ecs, denn80]. The chairs of the computer science departments soon echoed similar sentiments in the Snowbird Report [denn81sno].

Salaries and lab facilities were then, as now, critical incentives for faculty. The faculty starting salary for a new PhD in 1980 was $22K. The industry starting salary for a new BS graduate was $20K. (Since then, university starting salaries have increased an average of 5% a year, surpassing wage increases and leading to salary compression.) The Snowbird Report estimated that a low-end commitment to experimental research would cost about $5K per researcher and a high-end commitment at least $20K [denn81sno].

In October 1980 the National Science Foundation released a report commissioned by President Carter, called *Science and Engineering Education in the 1980s and Beyond*. This report reached two conclusions: First, there was a severe manpower problem in most disciplines of science and technology, with computer science and engineering being the worst affected. Second, there was growing scientific illiteracy among our young people, which did not bode well for future business and policy decisions requiring technological understanding. The report cited figures suggesting that the shortages in the computing field were fundamental and were likely to persist well into 1990s. The report considered that possibility ominous: Universities would not be able to expand educational capacity or maintain quality as demanded in the marketplace. Some experts thought matters would be worse than these projections because the universities do not operate inside the “free market”; most cannot respond to market conditions by increasing salaries and laboratory facilities without protracted political battles in the state legislatures that set their budgets.

Two years later, in 1982, Kent Curtis, the division director for computing research at NSF, issued a follow-on report called “Computer Manpower -- Is There a Crisis?” This passage sounds like it could have been written recently:

> Let us consider the conundrum facing the computer field in higher education first. It is experiencing an exponentially increasing demand for its product with an inelastic labor supply. How has it reacted? NSF has made a survey of the responses of engineering departments, including computer science departments in schools of engineering, to the increasing demand for undergraduate education in engineering. There is a consistent pattern in their responses and the results can be applied without exception to the computer field whether the departments are located in engineering schools or elsewhere. 80% of the universities are responding by increasing teaching loads, 50% by decreasing course offerings and concentrating their available faculty on larger but fewer courses, and 66% are using more graduate-student teaching assistants or part-time faculty. 35% report reduced research opportunities for faculty as a result. In brief, they are using a combination of rational management measures to adjust as well as they can to the severe manpower constraints under which they must operate. However, these measures make the universities’

> environments less attractive for employment and are exactly counterproductive to their need to maintain and expand their labor supply. They are also counterproductive to producing more new faculty since the image graduate students get of academic careers is one of harassment, frustration, and too few rewards. The universities are truly being choked by demand for their own product and have a formidable people-flow problem, analogous to but much more difficult to address than the cash-flow problem which often afflicts rapidly growing businesses. There are no manpower banks which can provide credit.

As a result of all these attentions, universities made increased investments in experimental laboratories and made faculty salaries competitive. The NSF initiated the CER (coordinated experimental research) program, which eventually enabled a couple of dozen universities to establish first-rate experimental laboratories; NSF also supported the CSNET project in 1981 to connect all computing research groups. For a time, at least, it appeared that we had the problem licked.

Remission, Not Cure

Our control over the symptoms of the brain drain was only temporary because we did not change the underlying game. The gap between faculty salaries and industry salaries narrowed for a time, then recently widened. Today, a new PhD in a systems specialty can expect an academic salary offer of around $60K ($72K including summer) and an industry offer in excess of $90K. More than a few deans and department chairs, strapped for funds for junior faculty, have skimped on salaries for senior faculty, making it easy for industry head-hunters to pick up senior faculty with lucrative offers in technical management.

The laboratory gap closed for a while when the major industry labs cut back on staff, but has widened again as software companies increase their R&D. (The most prominent example, Microsoft Research Labs, is hiring 2 people a week throughout 1999.) Today's low-end investment in experimental laboratory remains around $5K per researcher. Cash-strapped departments have allocated most of their paltry computer equipment budgets to instruction and general infrastructure.

In 1980, we sought greater collaboration between industry and academia. This would lead to greater understanding of each other's needs and to strong political support for a durable solution to seed-corn hunger. Moreover, collaboration would cultivate colleagues from industry who could teach in times of growing student demand. But none of this was to be. Many academic computer scientists continued to view experimentation as lower in status than theory or design. They looked to industry for outright research grants and would not consider R&D contracts to help develop product. They created few faculty or student exchange programs with industry. Their research became more theoretical and less reliant on experimental methods and validation. They created no contingency plans to deal with surges in student enrollment. They created few significant programs in continuing professional education. The National Research Council twice called our attention to this alarming drift away from collaboration, with limited success (See Hartmanis [hart92], and Snyder, 1994 [synd94]).

Given that little changed, it is no surprise that, as soon as new stresses appear in the marketplace, the same crisis precipitates in academia.

A New Game

A forthcoming report, “The supply of information technology professionals in the United States,” authored by a panel led by Peter Freeman and William Aspray, will be issued by the Computing Research Association in spring 1999 [free99]. This report will present impressive evidence that the workforce shortages we now experience are due to a mismatch between the higher education supply system and the workforce demands of the marketplace. The mismatch is not simply one of capacity -- which could be cured by hiring more faculty and enrolling more students, thereby doubling or tripling the graduation rate. The mismatch goes much deeper. Universities are set up to educate people for the *discipline* of computing, but not for the *profession* of information technology. The mismatch is not merely insufficient capacity and lack of resources to meet much higher graduation rates; it is also in skill-sets. Existing curricula do not allow students to follow pathways to the many, diverse professional specialties that exist, and they do not recognize professional practices as an important form of knowledge.

Information Technology is transitioning from a set of computing-related disciplines into a full-fledged profession. This transition is happening in response to the rapidly widening influence of computing technology, which is provoking broad concerns for reliable, dependable, secure, and professionally designed and managed computing systems. Others have called the profession Computing or Informatics [denn98].

The IT Profession comprises a surprising variety of professional specialties, most all the children of computer science -- i.e., subsets, extensions, or derivatives of traditional CS. They all share a common scientific technical core but have different professional standards and practices. Each seeks its own professional identity and many have organized professional societies. I counted two dozen such fields and suspect I have omitted others who would like to be included:

artificial intelligence
bioinformatics
cognitive science
computational science
computer science
database engineering
digital library science
graphics
HCI (human computer interface)
information science
information systems
instructional design
knowledge engineering
learning theory
management information systems
multimedia design
network engineering
performance analysis
scientific computing
software architecture
software engineering
system security and privacy
system administration
web service design

The mismatch will not be resolved without extensive cooperation between people in the marketplace for IT professionals and people in the education supply system. This will demand significant changes in how IT-related educators view their mission and organize themselves to deal with the realities of the markets and IT professions.

This situation is unsettling for many computer scientists. They view themselves as the “parents” of a thriving profession and are troubled by the growing tensions between segments of computer science. They no longer feel in “control” of their own discipline; many novice groups are appearing, placing demands, and claiming central roles. Many computer scientists feel as if they are often engaged in power struggles with specialties that ungratefully seek separation from computer science. Many believe that engineers want to smother the science rather than treat it as a peer. Computer science educators are overwhelmed at the magnitude of the work to be done to increase their capacity and upgrade their programs to handle professional education, and the lack of new resources available to help them do it.

To alter the game so that grazing on the corn growing in the commons is unattractive to everyone involved, we need collectively to define a new game with a new set of incentives. The incentives must be grounded in the common interests of preparing graduates for the realities of the high-tech workplace, providing professional education, certifying competence and skills of IT professionals where appropriate, maintaining professional competence, setting standards of ethical practice, and ensuring that state-sponsored licensing of IT professionals is reasonable -- and address all these needs worldwide.

A Model of Learning Needs of the IT Profession

The nature of the new game can be seen with the aid of a model of the learning processes of the IT profession. Many people visualize the processes of education as a pipeline with four main stages: Pre-College, College, Graduate School, and Career. Each stage serves a different purpose with respect to the IT profession.

	Purposes	Limitations & Problems
Pre-College (K12) System	Provides a general education in the basics, including math and science; it influences kids' perceptions of careers and professions. Many of its graduates go directly into the marketplace for jobs and many others enter college or university.	Negative influence on women and minorities toward IT careers. Inadequate math and science preparation for college majors in IT.
Higher Education system	Provides a formal education leading to accredited degrees in recognized disciplines, such as computer science, software engineering, information systems, or library science. Its graduates are able to deal with individual application domains. Most of its graduates take entry-level positions in their professions, while others seek the masters degree.	Focuses on intellectual core of discipline. Shies away from the practices core of profession on belief that learning practices equates with "vocational training". Avoids many specialties on belief that they are merely applications of core knowledge.
Graduate School System	Provides masters and PhD degrees in recognized disciplines. Most of its graduates are able to function as full-fledged professionals; they can deal with systems, not just individual applications.	Tends to regard PhD as pinnacle of achievement and to downplay other forms of mastery learned through years of professional practice. Tends to regard PhD as training for new faculty.
Career Education System	Offers continuing education and training for professionals. Much of this is accomplished outside the formal public education system -- in US, corporate training budgets exceed $60 billion, there are 1500 corporate "universities", and there are thousands of private hands-on training companies. Most university continuing education is coursework offered by a separate school or department, not integrated with the main curricula.	Most university faculty unaware of the extent of the "corporate university" network, the resources it commands, or the political power it wields. Universities tend to regard the practices leading to professional mastery as outside of "education".

The pipeline model characterizes our "common sense" about the supply system. This model has a glaring deficiency: it does not show feedback paths from the marketplace. To the extent that we do not see the feedback paths, we cannot act on them. Examples of feedback offered but not acted on effectively:

1. The **pre-college system** has not responded well to the public call for more science and technology or for basic computing literacy.
2. The **higher education system** has not collaborated well with the Pre-College system so high-school graduates are properly prepared for college.
3. The **higher education system** has not responded well to the call for more professional practice, more design and project work, or more collaboration with industry and government in designing curricula.
4. The **higher education system** has not responded well to the call for more continuing professional education, for preparation for certification, and for more use of distance-learning technologies to make offerings more accessible to working adults.
5. The **higher education system** has not responded well to the call for more collaboration in research to assist industry and government with their R&D needs.
6. The **higher education system** has not responded well to the call from industry and government for more collaboration in designing curricula.
7. The **professional societies** have not responded to the call to help develop a positive, shared identify for the IT profession, to assist professionals to meet their certification requirements, to assist public agencies intent on licensing to do so in a reasonable way, or to facilitate the changes needed in the education system.

The chronic lack of action on feedback has led to a mismatch between the capabilities of the supply system and the demands of the marketplace. That mismatch has plagued IT (among many others) and has allowed the present worker shortage to develop.

The accompanying figure (*IT Profession Learning Processes*) reframes the four stages as four sets of concerns affecting particular groups of people, and poses problem statements that are required to ameliorate or erase the mismatch between the supply systems and the corresponding marketplaces. The small lightface, reverse arrows signify the feedback offered by each stage to its predecessor. Four sets of transformations (labeled A, B, C, and D) are needed to address the four problem statements.

Strategies for Action

The professional societies (ACM and IEEE-CS) are ideally positioned as observers of the four stages and mobilizers of the people active in each stage. They can bring the global perspective needed to get everyone to play in a new game: building an education system that serves the IT market well.

I have already proposed just such an initiative within the ACM. The Executive Committee endorsed my proposal to undertake a Grand Challenge initiative to support the growth of the IT profession and its learning needs. I will seek the endorsement of ACM Council in May 1999. In the proposal I suggested which ACM units can undertake (or continue) actions in each of the four stages. For the present discussion, I will comment only actions that the universities can take, addressing transformations B and C.

In partnership with industry and government, universities can undertake actions in these areas:

- Establishing programs for continuing professional education (within the IT departments, not separately in a school of continuing education).
- Establishing and maintaining labs that support research and education in experimental computer science.
- Adding to their research portfolios contracts with industry to assist with R&D leading to product.
- Supporting chaired professorships to make the university environment more attractive for senior faculty.
- Establishing exchange programs for faculty and industry.
- Recognizing the many IT specialties by offering students appropriate pathways through the curriculum.
- Entering into partnerships with private training companies to offer students opportunities to learn professional practice in parallel with their university education.
- Entering into partnerships with industry to enable industry people to teach courses when needed to accommodate student demand; as part of this, relaxing the accreditation requirement that at least 70% of courses for majors be taught by full-time faculty and insisting instead on equal professional qualifications.
- Relying on digital technology to assist with courses and reduce the need for scheduled classroom space; for example, if 25% of classes were replaced with on-line collaborations, the same physical plant could support 25% more students and instructors.

The net effect of such changes would be to achieve a better match between the universities-as-suppliers and employers-as-consumers of professional personnel and to substitute cooperation for the current state of competition.

This would make the commons (the limited supply of IT professionals) an unsavory place to graze.

References

[denn79] Denning, P., D. Brandin, and D. McCracken. "An ACM Executive Committee position on the crisis in experimental computer science." *ACM Communications* (September 1979).

[denn80] Denning, P. "What is experimental computer science?" *ACM Communications* (October 1980).

[denn81see] Denning, P. "Eating our seed Corn." *ACM Communications* (June 1981). Copy available via the Web address <http://cne.gmu.edu/pjd/PUBS/SeedCorn.pdf>.

[denn81ecs] Denning, P. "Performance Analysis: Experimental Computer Science at its best." *ACM Communications* (November 1981).

[denn81sno] Denning, P., et al. "A discipline in crisis -- the Snowbird Report." *ACM Communications* (June 1981).

[denn98] Denning, P. "Computing the Profession." Educom Review (November 1998). Copy available via the Web address <http://cne.gmu.edu/pjd/PUBS/ProfComp.pdf>.

[feld79] Feldman, J., et al. "Rejuvenating experimental computer science -- A report to the National Science Foundation and others." *ACM Communications* (September 1979).

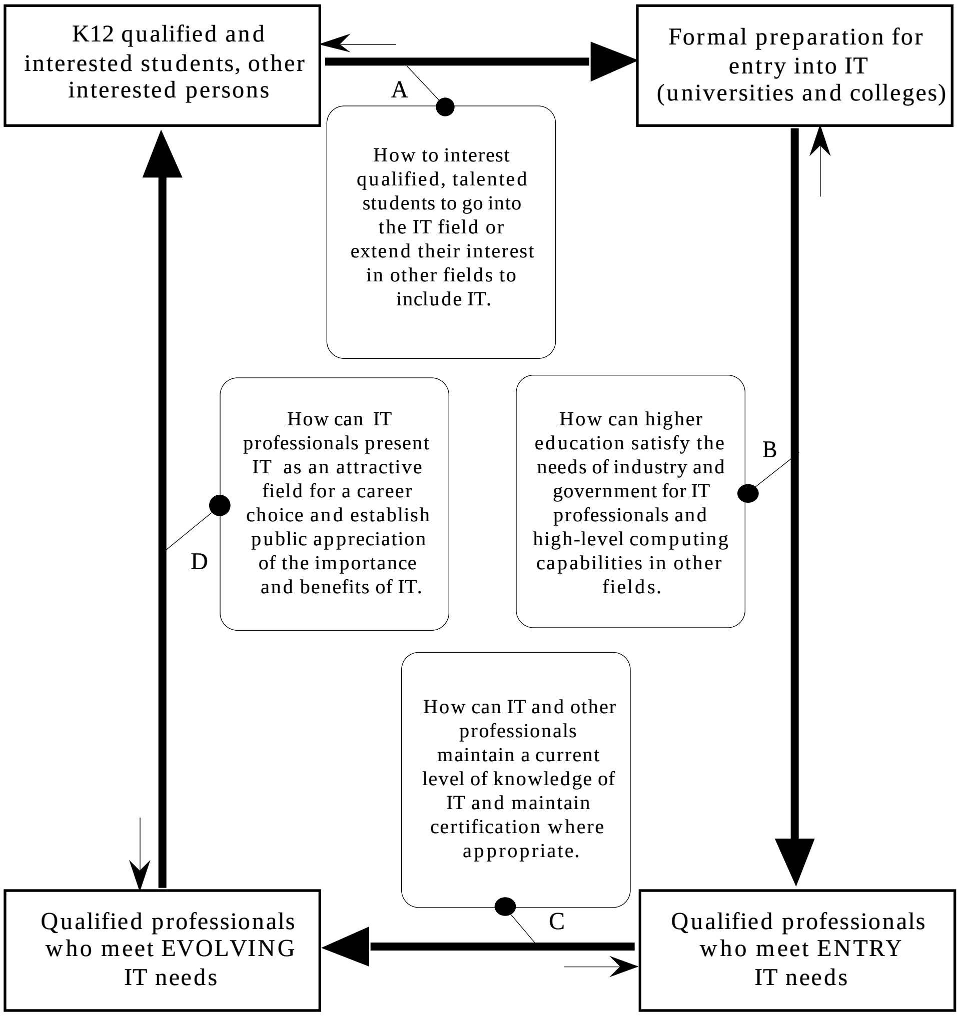
[free99] Freeman, P., and W. Aspray. "The supply of information technology workers in the United States." Computing Research Association, to appear spring 1999. <www.cra.org>.

[hart92] Hartmanis, J., et al. *Computing the future*. National Academy Press (1992). <http://www.nas.edu>

[moor91] Moore, G. *Crossing the Chasm*. Harvard Business (1991).

[snyd94] Snyder, L., et al. *Academic careers for experimental computer Scientists* (1994). National Academy Press. <http://www.nas.edu>

IT Profession Learning Processes



How to interest qualified, talented students to go into the IT field or extend their interest in other fields to include IT.

How can IT professionals present IT as an attractive field for a career choice and establish public appreciation of the importance and benefits of IT.

How can higher education satisfy the needs of industry and government for IT professionals and high-level computing capabilities in other fields.

How can IT and other professionals maintain a current level of knowledge of IT and maintain certification where appropriate.