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Computer Science Education in Japan

Firsthand observations trace the current state, future potential, and obstacles ahead for Japanese academia.

Ask anyone who has spent time in Japan to sum up its societal characteristics and they will likely use words like "conservative," "loyal," and "tradition." Generally speaking, the Japanese have a strong sense of custom and a reverence for individuals and institutions of high status. Such attitudes pervade most areas of Japanese society, including higher education. During a recent sabbatical, I visited computer science and electronics departments at 13 universities in Japan, and I believe many of the characteristics I perceived are in one way or another consequences of these general societal attitudes.

Japanese children enter high school at age 15, where the focus is on preparation for the nationwide "center test" and subsequent university entrance examinations. These examinations are crucial, since gaining entry to a reputable university has traditionally implied a lifetime of comfortable employment thereafter, often with a single employer. It is very difficult to get a job with a reputable company, or as a civil servant, without a degree from a recognized university.

As in many other countries, the proportion of high school graduates going on to some form of higher education has increased markedly over the years, to the extent that about half of Japan's students continue on to a college or university. (Colleges generally offer two-year subdegree courses, while universities offer four-year degree courses and postgraduate courses.) The increased demand for higher education has been addressed mainly by the creation of private colleges and universities, which, with a few notable exceptions, generally have less rigorous entry requirements. Over 70% of all university students attend private universities, and 90% or more of all college students attend private colleges. By contrast, less than 30% of U.S. undergraduates attend private universities, while universities in Europe are mostly government funded.

Universities in Japan are ranked in a very clear pecking order, which has been maintained over the years by a combination of social prestige and the relative difficulty of each university's entrance examinations. Up until now there have been no effective external assessment schemes to scrutinize either teaching or research. The recent introduction of such schemes is causing quite a stir among Japanese academics, since they have traditionally enjoyed a great deal of autonomy.

Computer science education. Until recently, the central test for high school graduates did not include any questions pertaining to computer science; neither did the entrance examinations for individual universities. Consequently, computer literacy education in schools was largely ignored. Universities therefore had to provide basic computer education—not just for undergraduate students in general, but even for those embarking on a CS degree.

Japanese universities were relatively slow to introduce dedicated computer science programs to their curricula. Indeed, the nation's first five programs were not established until 1970; today there are over 130 undergraduate programs and over 100 postgraduate programs in universities throughout Japan.

Until 1991, when the Ministry of Education

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relaxed its regulations, undergraduate degree courses generally consisted of two years of general study followed by two years of subject-specific study. The object of studying a particular subject was not to become a specialist in that subject but rather to become eligible to join a company that operates in the relevant field. It is the reason most upper management personnel in many Japanese high-tech companies have degrees in electrical engineering; a stark contrast to most major U.S. and European technology companies. Once graduates from Japanese universities joined a high-tech company they would then embark on an intensive company-run education program designed to ready them for work.

Prior to 1997 most degree courses in the computing realm covered hardware in some depth but gave software engineering much less attention. This changed after the Information Processing Society of Japan (IPSJ) published guidelines that influenced many universities to address this imbalance. These guidelines state that degree courses in computer science should cover (at least) the following topics: Computer science fundamentals, programming fundamentals, discrete mathematics, computing algorithms, probability and information theory, basic logic, digital logic, formal language and automata theory, data structures, computer architecture, programming languages, operating systems, compilers, databases, software engineering, and human-computer interfaces. Undergraduates normally spend most of their final year working on a research-oriented project, so these topics must be covered in the first three years of the course.

I found the culture within the universities I visited to be quite different from my own university in several respects. For one thing, the student population in Japan is much more homogeneous since virtually all students enter universities straight from high school. Also, since they have passed the same entrance exams, professors can assume a fairly uniform level of knowledge from the outset, at least in mathematics and physics. By contrast, a typical undergraduate class in the U.S. or Europe would contain a much broader spectrum of students.

I was also struck by the high degree of inbreeding in the departments I visited. Many, if not most, of the faculty members were ex-students of the departments in which they now teach—although in some cases they had spent the early part of their careers working in industry or teaching elsewhere. With the exception of some of the top universities, I saw very few foreign academics, either as staff members or visiting.

The typical arrangement is for each professor to have his (rarely her) own lab, seating about 20 students, and an adjoining private office. The students in these labs are a mixture of Ph.D. students (if any), master's students, and final-year undergraduate project students, with perhaps one teaching assistant. The students within a lab often collaborate on ongoing research projects, with the more senior students helping the junior ones. Indeed, I noted a strong sense of camaraderie in the labs I visited.

While the culture seemed quite different, the general CS syllabi were familiar. With such courses in mind, the IPSJ recently developed a body of knowledge for software engineering. They identify the milestones of software engineering as:

1. Structured programming (E.W. Dijkstra)
2. Use of tree structures for processing files (E.H. Sussenguth, Jr.)
3. Solution of a problem in concurrent programming control (E.W. Dijkstra)
4. Programming semantics for multiprogrammed computations (J.B. Dennis and E.C. van Horn)
5. An axiomatic basis for computer programming (C.A.R. Hoare)
6. A relational model of data for large shared data banks (E.F. Codd)
7. Program development by stepwise refinement (N. Wirth)
8. A technique for software module specification with examples (D.L. Parnas)
9. Communicating sequential processes (C.A.R. Hoare)

It is interesting to see that none of these milestones is attributable to a Japanese computer scientist. I quizzed a number of academics about this, and found there is really no curriculum content particular to CS courses in Japan. Although the Japanese are world leaders in electronics, they have a tendency to follow rather than lead when it comes to software technology.

There are two routes to obtaining a Ph.D. in Japan. One is to complete a doctoral program within a university's graduate school, as is the norm in the U.S. This is known as a "course doctorate," and involves taking a prescribed course of study as well as completing a dissertation. There are currently approximately 500 students on the CS doctoral program path throughout Japan. The alternative route is referred to as a "dissertation doctorate;" in which the candidate produces a dissertation based on his or her professional work and presents this to a graduate school for examination.

The Future

Despite the fact some world-class research has been occuring within Japanese universities, it appears academia has contributed comparatively little to the success of Japanese industry. There are many strong links between companies and universities, but it has been suggested that money flowing from the former to the latter has sometimes been given with a view to recruitment of good students rather than genuine research collaboration.

However, levels of recruitment are not what they once were. The Japanese economy is just beginning to recover from a deep, decade-long recession, during which time many companies were forced to cut staff in unprecedented numbers. There is now greater pressure on universities to undertake more of the applied research and professional education of graduates.

Many of the academics I encountered seemed well aware of the problems they face. For example, I watched one prominent academic deliver this very frank public statement at an international symposium on e-learning: "We are discovering that higher education in Japan cannot compete internationally. Through councils and committees raising these issues, the national government is showing concern, and dissatisfaction and criticism of higher education, especially undergraduate education, is erupting on all sides. Japanese higher education has a huge task before it if we are to bring its curricula, educational methods, credit system, degrees, quality level, and methods of evaluation into synch with those of the world."

Japanese universities are also bracing for a reduction in size within the higher education sector. While the proportion of high-school graduates going on to higher education has been growing, the total number of students is in decline. Over the past decade alone the population of 18-year-olds has fallen from around 2 million to under 1.5 million; in fact the Ministry of Education predicts there will only be 1.19 million 18-year-olds in Japan by 2012. Furthermore, since the university student population in Japan is overwhelmingly within the 18–23 age group, this drop in numbers will have a more direct impact on enrollment than it might in other countries where mature students compromise a greater proportion of the student population. It seems unlikely that the proportion of students entering universities can increase much beyond the present level of around 50% to compensate for this drop in numbers. Very few Japanese universities are inclined to accept foreign students, so it also appears inconceivable that an influx of foreign students can make up the shortfall. The changing demographics are bound to result in continued downsizing and mergers for some universities. The national universities are facing new pressures due to the semiprivatization thrust upon them, while the existing private universities are likely to be increasingly short of cash.

In terms of the quality of education, one positive development is in the area of evaluation and accreditation. The Japanese University Accreditation System (JUAA), established in 1947, has long been considered ineffective in this regard. However, the Japan Accreditation Board for Engineering Education (JABEE), established in November 1999, is similar in scope and strength to the Accreditation Board of Engineering and Technology in the U.S. JABEE addresses specific course accreditations, while the JUAA has a much broader range. Based on years of experience educating incoming graduates, some of the large high-tech companies in Japan have also influenced JABEE guidelines. The IPSJ now conducts inspections on behalf of JABEE, and it seems likely the combined efforts of JABEE/IPSJ will prove increasingly dominant in shaping future university CS programs in Japan. C

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