Computer science education in Japanese universities

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Abstract

In this paper the early research with respect to computers in Japan is briefly described. Then it is reported how computer science education was started under the name 'information engineering' or 'information science' in most universities in Japan. The situation was not ideal, as is illustrated by the fact that electrical engineering with FORTRAN programming could also be grouped under these headings. Some efforts of the Information Processing Society of Japan to overcome this situation are discussed. Also the results of a discussion about general informatics education for noninformatics majors are reported.

Keywords

Informatics, university education, informatics majors, noninformatics majors, curriculum (general), academic requirements

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1 EARLY COMPUTER RESEARCH IN JAPAN

Research on computers started in the late 1950's in several universities, such as the University of Tokyo, Kyoto University and Osaka University. Research was also started by the electrotechnical laboratory of the Ministry of International Trade and Industry, the Musashino Electro-Communication Laboratory of Nippon Telegraph and Telephone(NTT) Company and other research laboratories of electronics companies.

Unique to Japan among these research activities is the invention of Parametron by E. Goto of the University of Tokyo. Parametron uses parameterized excitation of a magnetic core and works as a majority logic element. The Parametron was so reliable and cheap that several of the early commercial computers are constructed on the basis of this element and many computer engineers were educated in this technology. However, because Parametron has an inherent limitation of processing speed, it was superseded by semi-conductor technology.

In 1965 a computer centre was established in the University of Tokyo and a large scale transistor computer HITAC 5020 of Hitachi was installed. Hitachi had won the order in severe competition with American computer manufacturers. An operating system was developed for this system by one of the authors of this paper (Nobumasa Takahashi); the resulting computer system was used by all academic researchers in Japan.

At the same time, research on software was started in Japanese universities. For example, a research group supervised by professor Yamanouchi of Keio University did research on language processors together with computer manufacturers. A group led by aforementioned professor Takahashi of the University of Tokyo developed a time sharing system with virtual memory on the Hitac 5020 of the computer centre in collaboration with the research group headed by another of the authors (Nobumasa Takahashi) of Hitachi Central Research Laboratories.

These early research activities were very sound, but they were interrupted in October 1971 by the national decision by the Ministry of International Trade and Industry together with computer manufactures. They decided to follow the IBM architecture; enormous profits have come out from this decision. This meant that, at least in industry, no substantial research other than on the IBM architecture was allowed.

2 COMPUTER SCIENCE EDUCATION IN JAPANESE UNIVERSITIES

In 1970 formal computer science education started at five universities in Japan, although in several universities research on computer science already dated from the late 1950's. The name computer science was used as a department name in new universities, namely, Yamanashi University and the University of Electro-

Communications. However, the name Department of Information Engineering was adopted by Kyoto University and Osaka University. The name Department of Information Science was adopted by the Tokyo Institute of Technology. In these old universities the combination of the terms computer and science could not be understood by fellow professors, because they believed that a computer was just a tool.

The notion of computer science, as described in Curriculum '68 of ACM (ACM, 1968), was correctly understood in all five universities. However, in most of the departments of information engineering in other universities later following the five, computer science was understood as electrical engineering with a FORTRAN option.

Upon establishing a new department in national universities, the Ministry of Education usually offers four chairs for each department, where a chair is composed of a professor, an associate professor and a research associate. The university must propose qualified faculty members to fill these chairs. Professors must be over forty years of age and must have written a considerable numbers of academic papers. Because of this restriction almost no computer scientist could become a professor at the departments founded after the first five. Persons in computer related fields or even with no experience with computers became professors of information engineering at these new departments. The name of information engineering allowed this, because almost any field relates to information.

Although such an implementation of information engineering departments is deplorable from the viewpoint of computer science, it should be noted here that from the viewpoint of Japanese society in general it really was very effective for overcoming the shortage of human resources in electronics industry. Further details of engineering education and its relationship to Japanese industry can be found in Takahashi (1992).

In the late 1980's the Ministry of Education tried to reform the engineering departments of national universities in such a way that several departments were brought together in a large department with an enlarged chair of several professors, associate professors and research associates. For example, a department of information engineering, a department of electronics and a department of applied physics became one department of electronics and information engineering. The number of students who did something with computers automatically tripled, but no substantial increase was made for the faculty as a whole. As a consequence the quality of computer science education was degraded.

Depreciation of computer science is also often seen in Japanese industry. The discipline in which the management of computer industries has been educated is mostly electrical engineering. Many of these managers have no real experience with computers, because when these senior engineers were the students, no computer science existed. They do not like to discuss technical details with their engineers and prefer to employ university graduates with little computer science background.

One of the reasons for this depreciation of computer science both in industry and academia may arise from the fact that in Japan very competent engineers graduate from very good engineering educational institutions. In the field of computer applications to engineering problems, the difficulties lie in the problem itself and not in programming. These engineers can do their jobs without professional training in computer science. In fact, after a two or three month course in a programming language, engineers start their professional jobs. This is true not only for electrical or mechanical engineers but also for software engineers.

3 COMPUTER SCIENCE CURRICULUM J90

Some computer scientists in Japan deplored the depreciation of computer science and started to establish a computer science curriculum for Japanese universities. In 1987 a committee was established in the Information Processing Society of Japan (IPSJ). The next year, the Ministry of Education asked the committee to propose a standard curriculum for the information engineering departments. In 1990 the results were reported as Curriculum J90 from the IPSJ. Since then this curriculum has been used for establishing new departments in computer related fields by the University Establishment Council which is organized by the Ministry of Education.

Curriculum J90 of the IPSJ is based on Curriculum '78 of ACM (ACM, 1978) with some extensions on Japanese language processing and with some modifications being made according to 'The report of the ACM task force on the core of computer science' (Denning *et al.*, 1989). The report of J90 contains examples of laboratory work and test problems to be addressed by students in computer science.

The core of Curriculum J90 consists of the following modules:

- JCS1 Introduction to programming;
- JCS2 Program design and its implementation;
- JCS3 Introduction to computer systems;
- JCS4 Fundamentals of computer hardware;
- JCS5 Information structure and algorithm analysis;
- JCS6 Operating systems and architecture I;
- JCS7 Structure of programming languages.

In addition to this core half the number of the following modules is recommended for study by computer science major students:

- JCS8 Operating systems and architecture II;
- JCS9 File and database systems;
- JCS10 Artificial intelligence;
- JCS11 Human interface;
- JCS12 Models of computations and algorithms;
- JCS13 Software design and development;
- JCS14 Theory and practice of programming languages;

- JCS15 Theory and practice of numerical nomputations.

This curriculum is now under revision by the professors of computer science who graduated from Japanese information engineering departments. The revised curriculum, Curriculum J97, is expected to be published soon.

4 COMPUTER SCIENCE CURRICULUM J97

Curriculum J90 was revised because of the changing position of universities in Japanese society. In 1991 the Ministry of Education changed its policy and removed the difference between general and specialized subjects in undergraduate university education; the emphasis was put on graduate education. Entrance qualifications were lowered so that the number of students making the transfer from junior colleges and technical colleges to university was increased. Also the need for recurrent education for engineers currently working is increasing in Japanese society. Because of these social pressures the Japanese universities are now reforming themselves.

The curriculum revision committee decided that in view of the wide variety of knowledge and abilities of the students the curriculum should cover the width of computer science, rather than address the essential elements, the clarification of which was the important objective of the J90 curriculum. Although width was pursued in the curriculum, also the central notions of computer science had to be addressed.

These were expressed as follows.

- Computer science deals with the logical concept of information in the physical world in such a way that the proposed ideas must be verified in the real physical world.
- The levels of abstraction in information processing must be carefully incorporated into the curriculum.

The notion of abstraction is central in computer science, but this notion may allow a black box solution thereby possibly hiding the real issues in the problem. To avoid this, computer science education must give the students systematic knowledge of the various abstraction levels, flexible views on computation and ability to cope with real world problems for which no single solution exists.

Currently the following subjects are proposed. Changes may however occur after the review process by the members of the Information Processing Society of Japan. In the proposal a model syllabus is given for each subject.

Computer literacy

L-1 Introduction to computer science

L-2 Introduction to programming

Mathematics for informatics

M-1 Information algebra and coding theory
M-2 Discrete mathematics
M-3 Computation theory
M-4 Probability and information theory
M-5 Mathematical programming
M-6 Mathematical logic

Undergraduate education subjects

U-1 Logic circuits
U-2 Formal languages and automata
U-3 Data structures and algorithms
U-4 Computer architecture
U-5 Introduction to programming languages
U-6 Logic design
U-7 Operating systems
U-8 Compilers
U-9 Digital communications
U-10 Databases
U-11 Artificial intelligence
U-12 Information network
U-13 Design and construction of programs
U-14 Numerical computations
U-15 Integrated circuits
U-16 Signal processing
U-17 Image processing
U-18 Pattern recognition
U-19 Human interface
U-20 Computer graphics
U-21 Natural language processing

Advanced subjects for graduate students

A-1 Advanced logic circuits
A-2 Advanced computer architecture
A-3 Advanced operating systems
A-4 Advanced databases
A-5 Advanced image processing
A-6 Advanced computer graphics
A-7 Advanced signal processing

Other subjects for graduate students

G-1 Algorithms for hardware
G-2 Logic design and CAD
G-3 Semantics of programs

G-4 Network architecture
G-5 Distributed systems
G-6 Software engineering
G-7 Functional programming
G-8 Object-oriented programming
G-9 Voice signal processing
G-10 Information security

5 GENERAL INFORMATICS EDUCATION

In 1991 the Ministry of Education asked the Information Processing Society of Japan to develop a curriculum for general informatics education of noninformatics majors students. A committee of 21 members was formed for this purpose and discussions lasted two years. The members of the committee were computer scientists, computer users and company engineers chaired by one of the authors (Hajime Ohiwa).

The results of the discussions were:

- clarification of the philosophy of general informatics education;
- the contents of such an education;
- guidelines as to how to carry out such education.

As to the philosophy, the committee concluded that general informatics education should make the students understand the notions of computers and information and should develop the ability to utilize these notions for the benefits of society. The philosophy also stressed that the foundation of this general education should be computer science. As to the contents, computer literacy, 'programming', and concepts of the computer and information were proposed. Here, computer literacy covers topics from keyboard training to word processing and communication through computer networks.

Generally speaking, programming education for noninformatics majors did not work well in Japan until then. This was because students were only taught programming language rules and were not taught how to write a program. The committee recommended that 'programming' education should be a problem solving activity. Starting from the definition of the problem a design process should follow. Then implementation and its evaluation should be done. The whole process must be reviewed and re-definition of the problem or re-design may come afterwards. As for the concepts of the computer and information, it was stressed that the important concepts of computer science should not be directly taught, but in the form of concrete examples.

It should be noted that most of the contents of computer literacy education should be taught at elementary and secondary level. However, computer education for this level is at the moment virtually non-existent in Japan and for those students entering universities computer literacy education must for the moment be done at university level.

Finally, the committee stressed that the education should be performed by instructors who have sound knowledge and experience in computer science and that not only lecturing, but also hands-on experiences with computers are essential for this education.

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7 BIOGRAPHY

Hajime Ohiwa received his BSc, MSc and DSc in physics from the Faculty of Science, University of Tokyo in 1965, 1967 and 1971, respectively. He became a research associate of the Faculty of Science, University of Tokyo. He joined the foundation of Toyohashi University of Technology as a lecturer in 1978 and became associate professor and professor of computer engineering in 1980 and 1985, respectively. In 1992, he became professor of environmental information, Keio University. He was a British Council Scholar visiting the Cavendish Laboratory, University of Cambridge from 1974 to 1976. He also was a visiting associate professor of Applied Physics, Cornell University in 1980.

Nobumasa Takahashi received his BSc degree in mathematics and PhD in operating systems research in 1957 and 1975, respectively. After graduation he worked in the Central Research Laboratory of Hitachi Ltd. Mr.Takahashi was the first digital computer programmer at Hitachi. In 1977 he became professor in the newly established Department of Computer Science at the Tokyo University of Agriculture and Technology. In 1997 he moved to his current post at Takusyoku University. He is now a vice-president of the Information Processing Society of Japan.

Tsurayuki Kado currently holds the unique position of chief instructor at Hitachi Ltd. He graduated at the Department of Science, Gakushuin University in 1964 and immediately started work with Hitachi. Since then, he has worked in the information systems field during thirty three years. Ten of these years were spent as a designer of hardware and software, twelve as a systems engineer. Since 1986, he is in charge of education and training.