A brief survey of computer science and engineering education

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INTRODUCTION

In this paper we shall attempt an overview of some significant developments that have taken place over a span of three decades in the Computer Science and Engineering (CSE) education and to discuss some very critical issues that face the educators and the professional societies. Unlike other technologies, the computer technology has been in a state of explosive evolution. It has never been easy to define or even agree upon what should constitute an essential core of knowledge a student should obtain (learn) during a four-year period of undergraduate study of the computer technology.

With the development of the first electrical computers, Harvard (1937), Bell Telephone Laboratories (1937) and the University of Pennsylvania (1946), the computer industry has grown by leaps and bounds. Computer sales currently amounted to more than 10 billion dollars in 1975 and it is predicted that the industry will experience a 19 percent growth in revenues by 1985, with more than two million people employed in computer related jobs. One cannot forget that we as a nation are wholly dependent on the computer. It becomes therefore, very important for us to study the role and trends of CSE education especially as it attempts to satisfy the growing need for well-trained professionals in this area.

HISTORICAL DEVELOPMENTS

It is not easy to trace the evolution of CSE education. Universities such as Harvard, MIT, Pennsylvania, and Illinois were probably among the first to include CSE courses in their regular curricula. Two types of courses were most prominent; the logic design courses primarily emphasizing the computer design techniques based on the switching theory and circuit design, and programming courses emphasizing machine and assembly language programming. While the former were generally taught by electrical engineering professors, the programming courses were taught usually by the specialists of the university's computing center under the auspices of the mathematics department. As the need for computer engineers and computer programmers increased, more and more courses were added and a distinctive pattern emerged in the administration of these courses. Electrical engineering (EE) departments naturally included computer design courses in their curriculum whereas the mathematics departments generally handled programming and numerical analysis courses.

The early computers such as Harvard Mark I, ENIAC etc., were built through the support of the U.S. Army and were intended to calculate the ballistic trajectory tables. This heralded the increasing use of computers in scientific computations, which in turn placed demands for more college graduates with numerical analysis and computer programming backgrounds. Consequently, mathematics departments initiated scientific programming courses in their curricula, and expanded their numerical analysis programs. Computer science (CS) departments began to appear in the middle sixties generally as off-shoots of mathematics departments in the Colleges of Arts and Science. Stanford University's Department of Computer Science under the late Prof. Forsythe was among the earliest. At present, the CSE education in major universities and colleges are administered mainly either by separate Computer Science and Electrical Engineering Departments, or by a combined Electrical Engineering and Computer Science Department. The former pattern can be seen in universities like Illinois at Urbana, Stanford, and Texas at Austin. The latter plan of a combined department is credited to be originated at University of California at Berkeley and at MIT, and is followed at universities like Columbia, Northwestern, etc. The hardware design oriented courses are taught very naturally by the EE departments whereas the CS departments emphasize theory and programming. There are, of course, exceptions to all the above trends. Recently a few EE departments identified computer engineering as one of their major components and call themselves Electrical and Computer Engineering Departments, e.g., University of Michigan, Ann Arbor and University of Wisconsin, Madison. Also, CS programs are sometimes included in Departments of Mathematics, or Statistics or Industrial Engineering.

We have used the terms computer science (CS) and computer engineering (CE) without defining them. Perhaps the distinction between them can best be made by taking a closer look at each. The computer scientist is interested in
the theory and science of computation and programming. Thus, areas such as automata theory, formal theory of languages, complexity theory, numerical analysis and the mathematical foundations of algorithms, and data structures (thus, the science of programming à la Wirth) cover the discipline of computer science. The computer engineer is interested in the specification, design, implementation, and utilization (operation) of data processing systems including both hardware and software. Thus, computer engineering can be defined as that branch of engineering concerned with the organization, design, and utilization of digital processing systems as general purpose or specialized computers or as components of larger systems. Thus the computer engineer (including the software engineer) uses the principles of computer science and/or electrical engineering in specifying, designing, implementing, and utilizing computer systems for specific applications.

CURRICULUM DEVELOPMENT

Three basic milestones can be identified in the curriculum development of the CSE education. They are (1) ACM Curriculum 68, (2) COSINE Committee recommendations, and (3) Computer Society’s Model Curriculum Subcommittee (CSMCS) recommendations.

(1) ACM Curriculum 68—The ACM’s Curriculum Committee on Computer Science (C²S) published a set of recommendations called the Curriculum 68,¹ in March 1968. This was a comprehensive set of proposals for four-year undergraduate programs and some graduate programs. It also included description of contents of supporting courses in mathematics. In a previous set of recommendations, the committee devoted considerable attention to the justification and description of computer science as a discipline. Curriculum 68 was adapted by several universities as a model for their computer science programs. Its major effort had been to help standardize the undergraduate and graduate programs in many CS departments. The Curriculum 68 provided a clear description of course contents together with pertinent technical references. It also specified a sequence of core or essential courses that should be taught in a four-year undergraduate curriculum. Aiming primarily at programming and mathematically oriented computer science areas, it shied away from any recommendations for engineering oriented computer education.

(2) COSINE Committee—In the middle sixties, the COSINE Committee of the National Academy of Engineering studied the computer options in Electrical Engineering Departments. In a series of reports, they discussed various aspects of computer education in electrical engineering, including courses in computer organization,⁴ digital subsystems,²,⁵ digital systems laboratories,⁶ and minicomputers.⁸ An important COSINE report known as the Coates Committee’s report³ defined the computer option in electrical engineering which set forth a basis for the development of many future computer engineering programs. Also, the COSINE Committee’s report on operating systems⁷ provided the first comprehensive course description in that important area. Judging from the number of electrical engineering departments having computer science and engineering options patterned after COSINE Committee reports, it can be said that COSINE has been quite successful. The COSINE Committee’s workshops and reports helped to initiate several faculty in EE department into computer engineering and helped make CE a major component of EE.

(3) Computer Society’s Efforts—The Model Curricula Subcommittee of the Computer Society’s Education Committee started efforts in 1974 to develop a four-year curriculum in CSE. “Development of model curricula that mesh computer science and engineering has, over the past decade, been a tar pit and many great and powerful beasts have thrashed violently in it.”¹⁰ The Subcommittee divided the CSE program into four subject areas and have provided course definitions and contents in each. The subject areas are digital logic, computer organization and architecture, operating systems and software engineering, and theory of computing. It is evident that these subject areas are quite broad and no single four-year curriculum could treat them adequately. Hence, the Subcommittee has proposed model curricula which are formed with elements considered essential in each of these subject areas. A number of options in the proposed curricula would provide some specialization. Increased specialization is provided at the graduate level. In a way, the Computer Society’s Model Curriculum objectives were different from those of ACM’s Curriculum 68, the major difference being that the former recognized the need for both computer science and computer engineering in a single curriculum. In that sense, the Computer Society’s Model Curriculum recommendations “define curricula that are interdisciplinary in nature with emphasis placed both on computer engineering and computer science.” This was also the first effort to bridge the gap between computer science and computer engineering and hardware and software. To date, a number of reports have been published by the Model Curricula Subcommittee which discuss some critical issues and rationale for their recommendations.¹⁰¹¹ Another significant contribution of the Computer Society is the report on Computer Architecture Curriculum.¹² In this study several well-known educators, engineers, and scientists have identified the functions and the role of the computer architect and then proposed a broad based curriculum consisting of both computer science and computer engineering subjects to educate future computer architects.

In effect, the recommended curricula stress good basic scientific and engineering education which provide the student the potential to continue education all through the professional career to assimilate and use the advances of computer technology.

DISE committee’s work

Digital Systems Education Committee (DISE) was formed in 1974 with the support of National Science Foundation with the object of providing quality educational materials in the general area of digital systems. The purposes of the
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project and the goals are [CAIN]: (1) to develop and/or coordinate the development of educational/instructional materials in the digital systems area; (2) to achieve widespread dissemination and use of developed materials; and (3) to encourage, develop and facilitate mutual cooperation and information transfer between the academic and industrial sectors. The ultimate objective of the DISE project was to help the educators to keep the courses and curricula current and in step with the rapid technological and theoretical developments. The committee solicited and supported proposals for developing educational materials such as textbooks, lecture material, videotapes, and self-paced instruction books in various digital system topics. The Committee also provided support for review, evaluation, and testing of these materials. A repository was established under the direction of Prof. C. L. Coates of Purdue University to collect unpublished digital systems educational material and to disseminate information regarding the items in the collection. DISE Committee has closely collaborated with the Computer Society’s Model Curriculum Subcommittee using the latter’s curriculum recommendations for developing their educational materials. They sponsored workshops on Microprocessors and Education which brought the industry and university engineers together to exchange latest technological information.

CONCLUSION

An extended and more comprehensive evaluation of CSE education will appear in the September issue of the IEEE Proceedings.

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