Computer Engineering - A Historical Perspective

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I. Introduction

The development of computers in the last half century plus has, by any criteria, been one of the major technologies impacting civilization. Electrical and computer engineering departments have shouldered much of the burden of preparing professionals to make use of this vital technology. Many of today's current faculty have lived through the entire period of the evolution of digital computers. Others, newer to the profession, have always had computers available to them but have witnessed their growth and distribution. This paper reviews the history of the changes in electrical engineering departments in the United States to incorporate computers. It ends with projections into the next century of the challenges ahead.

II. The Early Years (Before 1960)

The early years of computers coincided with rapid growth in many other areas of electronics to which electrical engineering departments, as they were then almost universally called, had to adapt. World War II saw great advances in radar and a recognition of the need for more research and graduate education, which greatly impacted electrical engineering departments in the 1940's and 1950's. The need for education in electronics gradually crowded out education in power in many departments. The 1950's was the decade of the emergence of the transistor and solid-state electronics, primarily in analog applications. [1-3]. Computers were secondary to electronics as a subject for education. In fact, computers themselves were just entering universities for administrative calculations. As the end of the 1950's , few electrical engineering departments owned or even had access to digital computers.

III. The Sixties

The 1960's saw the widespread expansion of digital computers and other digital systems. This expansion created demands for two types of computer professionals--those who could design and build computers and those who could program them. Electrical engineering departments provided courses in logic design for computer designers, but courses in computer programming and numerical analysis were usually taught elsewhere on campus, first in mathematics departments and then in the emerging computer science departments [4-5].

Despite the underlying importance of electronics to computers, electrical engineering departments were relatively slow to start offering courses on digital computers. A survey of 53 large engineering schools in 1963 found that a higher percentage of industrial engineering departments than electrical engineering departments taught computer courses. In fact electrical engineering departments required fewer semester hours of computer courses than did the average engineering department. [6]

The Ford Foundation funded a project to improve the use of computers in undergraduate engineering education in the early 1960's at the University of Michigan. The project's directors noted that electrical engineering educators were less interested in computers than other engineering educators. They thought there were two reasons for this. First, as a result of the Grinter report electrical engineering had become very science oriented. Second, most electrical engineering problems were solvable in closed form without complex computations. [7,8]

During the early and middle 1960's, while electrical engineering departments were doing little with computers, computer science programs began emerging. In 1962, before any computer science departments existed, William Atcheson, then at Georgia Tech, hosted a meeting of educators interested in computer education. The Committee on Computer Science Curricula (C^3S) resulted from that meeting. That committee, affiliated with ACM, and received a grant from the National Science Foundation which resulted in their 1968 curriculum {9,10]. By 1964-65 there were about 50 identifiable computer programs in universities, including some in electrical engineering departments, increasing to 150 in 1968-69. [11]

The initiative in computer science contrasted markedly with the situation in electrical engineering. While C^3S was being established as an official committee of the ACM, the newly merged Institute of Electrical and Electronics Engineers took no similar action.

However by mid-decade a few electrical engineering educators stepped forward. In 1965 Lotfi Zadeh, then chairman of electrical engineering at the university of California at Berkeley, wrote a paper titled "Electrical Engineering at the Crossroads" [12], expressing concern. He noted that a few courses on logic design and programming did not constitute a responsible contribution by electrical engineering departments when the U.S. government alone was spending more than a billion dollars a year on computing. Estimating that the computer industry would need more than 160,000 trained computer personnel by 1970, he called for electrical engineering departments to become more active in computer education.

Zadeh and M. E. Van Valkenburg of the University of Illinois invited electrical engineering department heads to a meeting at Berkeley in February 1965. At this meeting the COSINE Committee (originally called the Committee on Computer Sciences in Electrical Engineering) was formed. Its main purposes were to assist electrical engineering departments in developing computer engineering and to reorient traditional courses to use digital computers. The committee published a series of reports on undergraduate courses and laboratory equipment before dissolving in 1972 [13].

IV. The Seventies

Electrical engineering departments thus entered the 1970's aware of the need for computer engineering education--just in time to deal with microprocessors. By 1971 graduates of computer engineering programs were sufficiently numerous that they began to be reported separately in Engineering Education. There were about 1000 computer engineering graduates a year in the early 1970's--at first only about 1/3 at the BS level and the rest postgraduates. Not until 1973-74 did the number of BS degrees in computer engineering narrowly pass the number of MS degrees, and not until 1976-77 did the number of BS computer engineering degrees--at 1280 above 1000 for the first time--exceed the combined total of MS and Ph.D. The early emphasis on graduate degrees is not surprising. It reflects the tendency to introduce new technology at the advanced level with codified material then filtering down to the undergraduate level. Electrical engineering departments in the early 1970's offered most of their computer engineering courses at the graduate level [14].

In the 1970's computer engineering was becoming sufficiently important that departments began including it in their title. By 1974 there were departments of computer engineering at Case Western Reserve and Syracuse universities, a department of electrical and computer engineering at Oregon State, and a department of electrical engineering and computer science at the University of California at Berkeley. In tracking departmental name changes, this paper considers departments that have the words "computer," "electrical," and "engineering" in their titles to be combined departments of electrical and computer engineering. It considers departments that have the words "computer" and "engineering" but not "electrical" to be separate departments. No note is made of computer science departments without the word engineering in their title whether within or outside engineering schools.

Microprocessors lowered the cost barrier to computer engineering laboratories while also demonstrating that all electrical engineering students, not just computer engineers, needed to work with microprocessors. There was a new impetus for curriculum development. The Model Curricula Subcommittee of the IEEE Computer Society's Education Committee published a model curriculum for an undergraduate program in computer science and engineering in 1977 [15]. In addition the NSF-funded Digital Systems Education Committee (DISE) developed programs for educating computer professionals.

Student interest in computer engineering continued to grow. By the end of the decade 1500 BS and 1200 MS degrees in computer engineering were being awarded annually. Ph. D. growth also climbed to a peak of 190 a year. Computer engineering was the only engineering field to experience growth in Ph.D.s in the 1970's [16].

Accreditation of computer engineering programs began in the early 1970's with the IEEE being the lead society for the Accreditation Board for Engineering and Technology. By 1980 ABET had accredited 17 computer engineering programs.

V. The Eighties

Growth continued in the 1980's with the number of BS degrees more than doubling to 4398 by decade's end. MS degrees also more than doubled to 2243. Ph.D. degrees increased by about 2/3 to 277.

This disparity between BS and MS growth and Ph.D. growth was a sign of the major problem of the 1980's. By the middle of the decade electrical engineering departments were alarmed at the shortage of Ph.D. faculty. Wayne Bennett for the National Electrical Engineering Department Heads Association best explained this in his paper titled "National Crisis in Electrical and Computer Engineering." [17]. The crisis was the inadequate rate of Ph.D. production to provide faculty; the solution chosen by many departments was to limit undergraduate enrollment.

By this time computer engineering was a valued part of electrical engineering departments as shown by the article's title. In 1981 there were 16 separate computer engineering departments and 21 electrical and computer engineering departments, disproportionately located in the west. Five years later there were 31 computer engineering departments and 38 combined departments with more in the east and west than in the center of the U.S.

Accreditation interest grew rapidly in the 1980's. The number of ABET-accredited computer engineering programs more than doubled in five years to 36 in 1986. A new accrediting board, the Computing Sciences Accreditation Board, was formed by ACM and the IEEE Computer Society to accredit those computing programs that did not want to meet general engineering standards. CSAB began accreditation visits in 1985.

The curriculum was stabilizing by the 1980's. One major contribution was the simplification of VLSI design by Carver Mead and Lynn Conway that led to an increase in undergraduate VLSI design classes.

VI. The Nineties

The 1990's, not surprisingly, have seen a continuation of growth of computer engineering programs. BS degrees in computer engineering reached 4897 by 1995, a modest 10% increase over four years. By 1994 there were 18 separate computer engineering programs and 73 combined electrical and computer engineering programs. With the unleashing of caps on newly started computer engineering programs, some combined departments have seen computer engineering surpass electrical engineering. Student interest has been helped by articles in publications like Money, Fortune, and the Wall Street Journal highlighting computer engineering as a fast-growing, well-paying career.

ACM and the IEEE Computer Society joined forces on the latest computing curricula, Computing Curricula 1991[18]. This curriculum is distinctive in its approach of emphasizing three processes--theory, abstraction, and design--and nine subject areas rather than individual courses. It is designed to serve programs at various points of the hardware-software continuum and contains numerous implementation examples.

VI. The Challenges Ahead

The U. S. Bureau of Labor Statistics provided additional encouragement for computer engineering programs with its December 1995 forecast for employment prospects through 2005. The BLS forecasts that computer engineering will surpass mechanical engineering to become the second largest engineering specialty behind electrical/electronic engineering [19]. The annual growth for computer engineers is forecast as 6 per cent compared with 1.7 per cent for electrical and electronics engineers. The BLS sees job expansion for computer engineers not only in computer and data processing service firms but in traditional engineering service companies and in financial, management, and accounting organizations However they see a decrease in computer manufacturing jobs as they move offshore.

Increased interest by recruiters for graduates with computer skills is another sign of growing demand. Weatherall of MIT reports that until 1991 the number of employers coming to MIT to recruit computer specialists was much the same as to recruit electrical engineers. In 1995 the market improved for both but quite unequally. There was a 31 percent increase for electrical engineers but a 74 percent increase for graduates with strong computer skills [20]. Weatherall also reported strong increases in recruiting targets of established employers such as IBM, Microsoft, and Andersen Consulting. However this strong demand has not been accompanied by increases in initial salaries as compared to other new engineers; computer engineers and electrical engineers continue to be in the middle.

This leads to the challenges for the next decade.

1. Should electrical and computer engineering departments prepare more computer engineers?

There is a major disconnect between the 5000 or so computer engineering BS graduates each year and the 20,000 new computer engineers needed each year. Now most new computer engineering positions are being filled by other graduates. The profession needs to decide whether or not it wants to fill the gap.

2. Are computer engineering graduates being offered the best preparation?

The employment situation does not suggest that computer engineering graduates are particularly valued compared with those with other preparation. The paucity of articles on computer engineering education relative to the numbers in earlier decades suggests that this is more a time of business as usual rather than reflection.

3. Are the usual quality reviews of accreditation and registration important for computer engineering?

Relatively fewer computer engineering programs are accredited by ABET (or CSAB) than more traditional engineering programs. Some of this is a start up effect as new programs need to produce graduates before they can be accredited. But many programs have existed at major engineering schools for years without accreditation, suggesting that this is less important to the schools and computer engineering students. If electrical and computer engineering departments believe that accreditation is important, they must see that it happens. While registration of engineers is gradually adapting to the existence of the digital computer, it is not at all clear that exams can change often enough to appear relevant to computer engineers.

4. Where are the faculty to teach future computer engineering students?

The situation is less critical than in the 1980's but most departments seeking faculty with Ph.D.s in computer engineering find relatively few applicants. While Ph.D.s in computer engineering have been granted since the late 1960's the numbers have increased only gradually since then, not even doubling in two decades. The generation of computer engineering faculty who will be retiring in the next decade are nearly all self-taught in computer engineering. The opportunity to replace these faculty with new entrants who have grown up as computer engineers is an exciting one that the profession should meet.

Bibliography

1. H. H. Skilling, "Historical perspectives for electrical engineering education," Proc. IEEE. vol. 59, pp. 828-833, June 1971.

2. F. E. Terman, "A brief history of electrical engineering education," Proc. IEEE, vol. 64, pp.1399-1407. Sept. 1976.

3. E. A. Walker, "The major problems facing engineering education, " Proc. IEEE. vol. 59, pp. 823-828, June 1971.

4. M. E. Sloan, "The impact of digital technology on electrical engineering education," Proc. IEEE, vol. 66, pp. 880-885, Aug. 1978.

5. C. V. Ramamoorthy, "Computer science and engineering education," IEEE Trans. Computers, vol. C-25, pp. 1200-1206, Dec. 1976.

6. C. C. Cook, A Survey of Digital Engineering Instruction in Most Major U. S. Engineering Colleges, Morgantown, WV: Dep. Ind. Eng., Univ. of West Virginia, Apr. 1966.

7. Univ. of Michigan, The Uses of Computers in Engineering Education, Ann Arbor, MI: Univ. Michigan, Jan. 1, 1963.

8. E. L. McMahon, B. Carnahan, D. L. Katz, and W. D. Seider, Computers in Engineering Design Education, Vol. IV, Electrical Engineering, Ann Arbor, MI: Univ. Michigan, Apr. 1, 1966.

9. S. D. Conte, "History and activities of the ACM curriculum committee," Proc. Park City Conf. Undergraduate Education in Computer Science, pp. 399-50, 1968.

10. ACM Curriculum Committee on Computer Science, "Curriculum 68," Comm. ACM. vol. 11, pp. 151-169, Mar. 1968.

11. T. L. Booth, "Computer education," Computer, vol 17, pp. 57-65, Oct. 1984.

12. L. A. Zadeh, "Electrical engineering at the crossroads," IEEE Trans. Ed., vol. E-8, pp. 30-33, June-Sept. 1965.

13. M. E. Sloan, "The impact of the COSINE committee on the undergraduate electrical engineering curriculum," IEEE trans. Educ., vol. E-17, pp. 179-189, Nov. 1974.

14. M. E. Sloan, C. L. Coates, and E. J. McCluskey, " COSINE survey of electrical engineering departments,: Computer, vol. 6, pp. 20-38, June 1973.

15. IEEE Computer Society, A Curriculum in Computer Science and Engineering, Los Alamitos, CA, 1977.

16. L. C. Cravitz, "Talent for technology: a federal program manager's view," Engineering Education, vol. 71, pp. 391-396, March 1981.

17, A. W. Bennett, "National crisis in electrical and computer engineering," IEEE Trans. Educ., vol., E-29, pp. 175-177. Aug. 1986..

18. Computing Curricula 1991: Report of the ACM/IEEE-CS Curriculum Task Force, Dec. 1990.

19. "The opportunity matrix for engineers, 1994-2005," Engineers, vol 2, pp. 3-10, Jan. 1996.

20. R. K. Weatherall, "The market for new graduates," Engineers, vol. 2, pp. 7-11, Apr. 1996.

Biography

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