BUCKING THE TREND: STRONG ENROLLEMENT IN INFORMATION TECHNOLOGY

Barry M. Lunt, Han Reichgelt

Abstract - There has been a recent and somewhat long-term downturn in enrollment in technology programs. All technology programs seem to have been affected with one exception, the relatively new field of information technology.

Programs in information technology (IT) have only existed for about 12 years. Since 2000, a significant number of IT programs has emerged, with, in general, growing enrollments. Moreover, the IT community has developed a national curriculum standard for undergraduate IT programs, and has been instrumental in the establishment of accreditation standards by the CAC of ABET. Finally, a small number of IT programs have been accredited through the CAC of ABET. This paper will report on these developments, and help clarify the difference between academic disciplines in computing, including computer science, computer engineering, information systems, information technology, and software engineering. It will also speculate on the reasons why IT programs have been able to buck the trend of dropping enrollments, both in technology programs and in computing programs.

Index terms- Computing curriculum, Information Technology, Enrollment

INTRODUCTION

The Engineering & Technology Enrollments annual publication of the Engineering Workforce Commission of the American Association of Engineering Societies, Inc., shows that enrollments in engineering technology programs have declined since 1981, when they peaked at over 191,000. Enrollment numbers appear to have bottomed out in 1993, staying at about 107,000 from 1993-2001. Since 2001, enrollments appear to be on the rise, fueled in a large part by enrollments in computing disciplines.

However, the rise in computing programs has not been uniform. While there has been a general increase in computing enrollments, a trend that is to be welcomed given the projected increase in computing employment, the traditional computing disciplines of information systems and computer science, both founded in the 1960s, have seen a decline in their enrollments from about 2001 onwards. The reason that computing enrollments continue to grow, even as the traditional computing disciplines seem to be shrinking, lies in the diversification of computing offerings that have occurred in the last decade. As outlined by Bailey et al. in their paper, “Computing Curricula: The History and Status of 4-Year Computing Programs”, the world of computing education has grown to the point that additional academic programs have become essential, and indeed are thriving.

The remainder of this paper will outline the growth of the new computing disciplines of computer engineering, software engineering and, in particular, information technology, and will clarify their relationship to the traditional computing disciplines of computer science and information systems. The paper will also speculate on the reasons why information technology seems to buck the enrollment trend.

HISTORICAL PERSPECTIVE

As stated in the introduction, the traditional computing disciplines of computer science and information systems emerged in the 1960s. In the late 1980s, two additional programs began to emerge: computer engineering and software engineering. Computer engineering grew out of electrical engineering (EE). EE programs had long been teaching students the particulars of digital circuits and logic design, and many EE graduates had been going to work for computer hardware giants such as IBM and Intel. As the need for such skills continued to grow, many EE programs around the nation began to formally define a program in computer engineering. It should be pointed out that these computer engineering programs were not created ex nihilo, but were rather a formalization and renaming of an option within EE that had existed for many years.
Software engineering (SE) grew out of the need for more rigorous methods of creating software, driven by the creation of increasingly larger and more complex programs. Examples of these very large and very complex programs include military command and control systems, avionics, digital telephone switches, aerospace and launch control, ballistic missile defense, and more recently, operating systems, and increasingly realistic computer games. As it became clear that the methods for developing small, relatively simple, software applications did not scale up to the larger, more complex, programs, there was a realization that there was a need to apply rigorous and proven engineering design methods to the relatively new field of computer programming as a component of large system integration projects as well, and the discipline of software engineering was born.

Information technology (IT), the newest of the computing disciplines discussed in this paper, grew out of the explosive growth in the use of the Internet as a result of the emergence of the world-wide web (WWW), which occurred in the early and mid-1990s. This discipline has grown very rapidly, partly due to the rate of expansion of the field of networking computing.

In addition to computer engineering, software engineering, and information technology, a number of other computing programs are presently emerging, including programs in informatics, bio-informatics, and networking. Since space limitations do not allow us to discuss all emerging computing programs, we have chosen to focus on the five computing programs that have formally-defined curricula, as outlined by the ACM (Association for Computing Machinery), and as available at the ACM website (http://www.acm.org/education/curricula.html), and that have ABET defined accreditation standards. These computing programs, as outlined above, are: computer engineering (CpE), computer science (CS), information systems (IS), information technology (IT), and software engineering (SE).

The relationship between the above computing programs has been discussed in a number of other papers. Many of these papers provide additional depth. Greater depth may also be gained by consulting the formal curriculum guidelines that have been developed by each of these computing disciplines, as well as the so-called Overview Report, a document produced by the ACM, the IEEE Computer Society, and the AIS for the purpose of providing an overview of the different kinds of undergraduate degree programs in computing that are currently available.

**ACCREDITATION**

In the academic world of computing as a whole, accreditation is quite fragmented. This section will discuss accreditation for each of the five computing disciplines, starting with computer science.

Computer science has generally been “a loosely organized network of scientists, researchers, and programmers”, rather than “a tightly organized body of practicing professionals.” Accordingly, most computer science programs have had little need or interest in accreditation. Today, only about 10% of CS programs in the U.S. are accredited. Those that are accredited have, in the past, been accredited through the Computer Science Accreditation Board (CSAB). In the year 2000, CSAB transferred accrediting responsibilities to the Computing Accreditation Commission (CAC) of ABET (formerly the Accreditation Board for Engineering and Technology; now just ABET).

Information Systems programs have sought accreditation along two different avenues. First, CAC of ABET has had accreditation criteria for IS since 2000, and currently accredits 16 programs in IS. Second, a significant number of IS programs are offered out of business schools or colleges, most of which have sought accreditation from the Association for the Advancement of Collegiate Schools of Business (AACSB). In contrast to ABET, AACSB does not accredit individual programs. Rather it accredits business schools or colleges and all programs offered by those schools or colleges.

The more recent disciplines of CpE and SE are also somewhat disparate. Most engineering disciplines have had a very strong tradition and need for professional accreditation. Many jurisdictions will not allow a graduate to work as an engineer unless they have graduated from an accredited program. Since CpE has emerged from within EE, this tradition has been maintained. Most CpE programs are accredited, or are seeking accreditation through the Engineering Accreditation Commission (EAC) of ABET.

In contrast, software engineering programs have few formal ties to traditional engineering programs, and have not been under the same amount of licensure pressure as traditional engineering programs (although a few states are reportedly considering allowing only graduates from accredited SE programs to work as software engineers.) Nevertheless, since SE is an engineering discipline, SE programs are being accredited through the EAC of ABET. The first of these accreditations took place in 2003; since then, a total of ten SE programs have received accreditation.

The CAC of ABET recently promulgated a set of accreditation standards for programs in information technology as well. In this process, CAC also followed the lead of EAC of ABET, in that it distinguished between general accreditation criteria that are applicable to all programs in computing, and program specific accreditation criteria that are applicable only to...
specific computing programs. Currently, CAC of ABET has draft accreditation criteria for programs in CS, IS and IT. Three IT programs were accredited in a pilot of the general criteria in November 2005, and the IT specific criteria were recently piloted on another IT program. It is also apparent that when the IT-specific accreditation criteria are fully approved, more IT programs will seek to be accredited. The IT-specific accreditation outcomes can be found at www.abet.org/images/Criteria/C001 04-05 CAC Criteria 2011-18-03.pdf

It should be noted here that, in the lead author’s experience, what happens in accreditation for CpE, SE, and IT programs is being and will be looked to by many people outside the U.S. as an example. Many countries are looking into accreditation for their relatively new computing programs, and one of the models most often looked to is ABET.

BRIEF DESCRIPTIONS OF THE COMPUTING DISCIPLINES

As stated earlier, the model curricula for the various computing disciplines developed under the auspices of the ACM, IEEE Computer Society and the AIS also contains the so-called overview volume. The overview volume gives a brief definition of each.

“Computer engineering is concerned with the design and construction of computers and computer-based systems. It involves the study of hardware, software, communications, and the interaction among them. Its curriculum focuses on the theories, principles, and practices of traditional electrical engineering and mathematics, and applies them to the problems of designing computers and computer-based devices.”[17-13]

“Computer science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments…” “While other [computing] disciplines can produce graduates better prepared for specific jobs, computer science offers a comprehensive foundation that permits graduates to adapt to new technologies and new ideas.”[17-13]

“Information systems specialists focus on integrating information technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in an effective, efficient way.” “All IS degrees combine business and computing coursework.”[17-14]

“Information technology … refers to undergraduate degree programs that prepare students to meet the technology needs of business, government, healthcare, schools, and other kinds of organizations.”[17-14] “IT, as an academic discipline, focuses on meeting the needs of users within an organizational and societal context through the selection, creation, application, integration and administration of computing technologies.”[16-5]

“Software engineering is the discipline of developing and maintaining software systems that behave reliably and efficiently, [and] are affordable to develop and maintain….It seeks to integrate the principles of mathematics and computer science with the engineering practices developed for tangible, physical artifacts.”[17-15]

KNOWLEDGE AREAS: DIFFERENCES

Each of the five computing disciplines discussed in this paper have included in their model curriculum a one- or two-page list of knowledge areas that constitute their body of knowledge. In an effort to graphically portray these disciplines juxtaposed against each other, the detailed descriptions of each of these knowledge areas were compiled into pie charts that can assist in understanding the differences between these programs. There are 83 total knowledge areas. Many of them overlap or have much similarity, so these 83 knowledge areas were reduced to 15 emphasis areas for this study. Additionally, since each formal curriculum also gives an idea how much time should be spent on each knowledge area, it was possible to combine subtopics within some knowledge areas. It is acknowledged that the graphs derived from this study (Figures 1-5) are somewhat oversimplified, but this was essential in order to reduce the complexity of the data as a whole.

In general, the graphs give great insight into each discipline. Computer engineering has a very strong emphasis on computer hardware (Figure 1); CS has a strong emphasis on algorithms & complexity, computer hardware, programming, and software life cycle (Figure 2). Information systems has a strong emphasis on developing information systems (Figure 3), and IT has emphasises in human-computer interaction, information management (databases), development of information systems, networks, programming and security. Software engineering has their major emphasis in the area of the software life cycle. Additionally, each computing discipline has a substantial body of knowledge that could not be adequately compared to the other computing disciplines. This is shown in the graphs under Other; details can be found by consulting the individual knowledge areas for each computing discipline.
Figure 1: Knowledge areas for Computer Engineering

Figure 2: Knowledge areas for Computer Science
Figure 3: Knowledge areas for Information Systems

Figure 4: Knowledge areas for Information Technology
It is not a surprise that there are substantial differences among the five computing disciplines considered in this paper. Nevertheless, it would be very surprising if there were not some commonalities, since they all claim to be computing disciplines. Analysis of the formal curricula shows that all five programs cover:

- Computer foundational topics
- Computer programming (including algorithms, implementation, and software quality)
- Capabilities and limitations of computers (including societal impact)
- Software lifecycle issues
- Processes, both computing and professional
- Advanced computing topics
- Professionalism (including interpersonal communications, teamwork, management, ethics, and legal constraints)
- Applications to join theory and skills (including labs, assignments, projects, etc.)
- Capstone projects

**CONCLUSION**

Since the emergence of the computer in the 1950s, computing devices have exponentially dropped in cost, size, and power consumption, while exponentially growing in speed, storage, and capability. These dramatic changes have made computing elements the most versatile and widely adopted electronic devices ever created. In turn, this versatility and wide adoption for diverse application domains have created the need for more sub disciplines within computing. Over the last 15 years this need has driven the creation of the computing disciplines of computer engineering, software engineering, and information technology. Each of these new computing disciplines has completed accreditation standards, has had some programs already accredited, and has formally defined a model curriculum. These three new computing disciplines now take their place alongside the older and more familiar computing disciplines of computer science and information systems. This study of their accreditation and model curricula has described the character of each discipline in terms of their differences and similarities.
The emergence of the three additional computing disciplines of computer engineering, information technology, and software engineering explains how it is possible for enrollments in computer science and information systems to be declining, while enrollments in computing disciplines overall is rising. It also seems to be the case that this increase in enrollment is most pronounced for programs in information Technology. This obviously raises the question why IT bucks the downward trend for most computing programs. One possible explanation is that, because of its more applied nature, it is more attractive to students than the more theoretical discipline of computer science, while at the same time striking a more appropriate balance between technology and application domains than information systems. It may also be the case that IT programs prepare students for jobs that are less easily outsourced overseas, or at last are perceived to be less easily outsourced. Students interested in computing in general may therefore be attracted to IT programs than other computing programs because they are convinced that their employment opportunities are better with a degree in IT. Clearly, all of this is speculation and we are currently conducting research to determine the reasons. However, there is little doubt that, as far as enrollment numbers are concerned, IT programs buck the trend. Employers seeking to fill vacancies in computing are therefore well advised to look beyond the traditional programs in CS and IS to the newly emerged programs in IT.

REFERENCES


[12] “CC 2001 Curriculum Guidelines for Undergraduate Degree Programs in Computer Science”;

[13] “CE 2004 – Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering”;

[14] “IS 2002 Curriculum Guidelines for Undergraduate Degree Programs in Information Systems”;


2007 CIEC Conference February 3-10, 2007