Future Growth of Software Engineering Baccalaureate Programs in the United States

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Abstract

Despite the large current number of software engineering professionals in the United States, as well as projections that it is one of the largest-growing fields in the nation for the current decade, growth in the number of Bachelor's degree programs in the United States has recently declined. There are currently only about thirty schools in the United States that offer a baccalaureate degree in software engineering (including several online programs), without many more in sight. This paper looks at the growth and development of the Bachelor's degree programs in software engineering in the United States, possible causes for the paucity of new programs, and what this might mean for the future. Included is a survey of software engineering educators in programs which do not currently have a Bachelor's degree program in software engineering, as well as comparisons with other computing fields when they were in similar stages of development.

1. Introduction

The U.S. Bureau of Labor Statistics (BLS) lists "software engineer" as one of the fastest growing job categories in the United States, over three times as fast as job growth in general expected for the period 2002-2012. In fact, according to BLS data, there are currently more software engineers in the U.S. than any other engineering discipline, and by 2012 there will be *three times* as many software engineers than the next largest engineering field; furthermore, those nearly one million software engineering jobs are in addition to nearly 1.4 million "computer scientist" positions (computer system analysts, network systems and data communications analysts, database administrators, research computer and information specialists, and other computer specialists[11]). Table 1 provides a summary of BLS growth projections between 2002 and 2012 for computer scientists, software and other major engineering disciplines, and for all occupations[9].

There have also been some significant efforts in the area of undergraduate software engineering education over the past five years. In the late 1990's, the ABET, the accreditation body for applied science, engineering, computing and technology degree programs in the United States, approved criteria for accrediting software engineering under the Engineering Accreditation Commission (EAC). Four programs were accredited in 2003, and another two in 2004[8].

Category	% growth 2002-2012	Expected total U.S. jobs in 2012
All Occupations	14.8%	165,300,000
Computer Scientist	42.6%	1,396,000
Software Engineer	45.5%	982,000
All engineers besides software	7.3%	1,590,000
Chemical Engineer	0.4%	33,000
Civil Engineer	8.0%	246,000
Computer Engineer	6.1%	78,000
Electrical Engineer	5.7%	309,000
Mechanical Engineer	4.8%	225,000

Table 1. Predictions of Job Growth Issued by the U.S. Bureau of Labor Statistics, Spring 2004.

In 1997-99, the Working Group on Software Engineering Education and Training (WGSEET) developed the *Guidelines for Software Engineering Education*[1], which subsequently became the *de facto* source for undergraduate software engineering curriculum models for the next several years. The *Guidelines* have recently been supplanted by *Computing Curricula-Software Engineering (CCSE) 2004*[6], a more comprehensive joint project of the IEEE Computer Society and the Association for Computing Machinery (ACM), the primary computing professional societies in the United States. The CCSE contains SEEK (Software Engineering Education Knowledge), which specifies what knowledge is required in order to obtain a baccalaureate degree in software engineering; drafts of SEEK have been public and in use since 2002. *Software Engineering 2004* also contains software engineering curriculum models tailored to regions and countries, including the United States.

With the combination of the software engineering job demand and the ongoing efforts in software engineering education, one would expect that there would be a large increase in undergraduate software engineering programs in the United States; however, the rate of increase has actually decreased over the past three years, and there are only about 30 such programs nationwide. This leads to the questions of why there are not more software engineering programs, why the rate of new programs has decreased, and what this may mean in the long-term for software engineering Bachelor's degree programs in the U.S. This paper attempts to answer these questions.

Section 2 discusses the growth of U.S. software engineering (SE) degree programs over the past decade, while Section 3 does the same for both computer science and computer engineering programs as points of comparison. Section 4 provides the results of a survey of software engineering educators not in SE degree programs, to get their opinions concerning program growth. Finally, Section 5 provides a summary and some conclusions.

2. Growth of Software Engineering Programs

The first software engineering programs in the United States were at the Master's degree level in the late 1970's[2]; there are still less than 50 graduate software engineering programs in

the U.S. today. As far as baccalaureate programs are concerned, the first in the world appeared in the United Kingdom in the late 1980's; in 1996, the Rochester Institute of Technology became the first U.S. school to offer a Bachelor's degree in software engineering[2].

There is no definitive list of software engineering Bachelor's degree programs. Joe Clifton and Steve Frezza, members of the Working Group on Software Engineering Education and Training, maintained a list of existing SE Bachelor's degree programs worldwide, and had identified 21 such programs in the U.S. existing at the beginning of the 2002-03 academic year[3]. Seventeen of those programs were started in 1999-2001, and just three in 2002.

The authors have extended the WGSEET list, through a search of World Wide Web, with the results found in Table 2. (The list may not be 100% complete, and some program start dates may be slightly off.) All the degrees for the schools listed have the title "Bachelor of Science in Software Engineering", with the exceptions of Auburn (Bachelor of Software Engineering) and Indiana Wesleyan University (Bachelor of Science in Computer Software Engineering). Degree programs with software engineering options (e.g. computer science-software engineering option) are included in some compilations, but are not here, nor are programs in software engineering technology.

Of these 30 programs, one was started in 1996, seventeen from 1999-2001, and only 12 in 2002-04. Furthermore, there is little discussion within the software engineering education community of new programs (see discussion of survey in Section 4). So it seems that perhaps after an initial flurry of new software engineering programs, the total number may be leveling off.

3. Growth of Computer Science and Computer Engineering Programs

Is this slow initial growth a common phenomenon for programs like software engineering? Let us consider the growth in the U.S. of undergraduate programs in two related fields, computer engineering and computer science. Each of these fields now enjoys a mature curriculum, with baccalaureate degrees offered at a large number of institutions. In the U.S. in 2004 there were 173 ABET-accredited computer engineering and related baccalaureate programs[5], and 206 ABET-accredited computer science baccalaureate programs[4]. (Computer Science programs were initially accredited starting in 1986 by the Computer Sciences Accreditation Board; ABET and CSAB "integrated" in 2002, with CSAB now existing as the lead professional society for computing and software engineering programs.) The early growth of both these programs, however, was at a slow rate:

- From 1971 to 1979, the number of ABET-accredited computer engineering and related programs grew from zero to just 16. This number then rose by 46 over the next decade, rose by another 46 in the following decade, and has increased by 65 in the past five years.

- Between 1966 and 1971, earned bachelor's degrees in computer science rose from 89 to 2,388, then to 5,664 in the next five years, to 15,233 in the next five years, and to 42,195 in 1986[7]. So the number of computer science degrees granted grew at an increasing rate throughout this period.

School	Approximate Start Date
Rochester Institute of Technology	1996
Auburn University	1999
Capitol College	1999
Clarkson University	1999
Milwaukee School of Engineering	1999
University of Wisconsin-Platteville	1999
Fairfield University	2000
Mississippi State University	2000
Missouri Tech	2000
Monmouth University	2000
University of Michigan-Dearborn	2000
Champlain College	2001
Cogswell College	2001
Montana Tech	2001
Southern Polytechnic State University	2001
University of Advancing Technology	2001
University of Texas at Arlington	2001
University of Texas at Dallas	2001
Drexel University	2002
Embry-Riddle Aeronautical University	2002
Penn State University – Erie	2002
Butler University	2003
California Poly – San Luis Obispo	2003
Florida Institute of Technology	2003
Gannon University	2003
Rose-Hulman Institute of Technology	2003
Colorado Tech	2004
Indiana Wesleyan University	2004
National University	2004
San Jose State University	2004

Table 2. U.S. Bachelor's Degree Programs in Software Engineering.

The number of CSAB-approved computer science programs did show substantial early growth, 19 in 1986 – the first year of accreditation – and 21 in 1987, progressing at a slower rate thereafter[4]. However, the CSAB accreditation program came years after the establishment of the first departments. Indeed, 1987 was a year of declining earned baccalaureates in the United States.

The slow initial growth of computer engineering and computer science programs was not caused by a lack of need for trained computer people in the U.S.; in fact, it occurred during a time of high demand for hardware and software developers. This was the era of the IBM

mainframe, with customized programs being developed uniquely by almost every major U.S. company for their core business-related applications. The mid 1970's also saw an explosive growth of minicomputers for departmental and distributed computing in manufacturing, education, and government. All this hardware was designed by somebody and had software written for it by somebody, but they were not graduates of formal computer programs.

We actually see this phenomenon even today, of demand for workers far outstripping formal training in computer-related areas. According to the BLS "Nearly half of all computer programmers held a bachelor's degree [in any field] in 2002…"; this means that more than half did not hold one[10].

4. Why the Slow Growth of Software Engineering Programs?

To answer the slow growth question about software engineering baccalaureate programs in the U.S., the authors surveyed software engineering educators working at institutions which do not have software engineering degree programs. Those surveyed were asked for opinions as to why this might be, and whether or not the faculty members believed the trend would continue. The responses received fell into these groups:

Economic

The most cited reason for not developing a software engineering major was that, "Industry has been happy taking students with a software engineering capstone and one or two additional software engineering courses," so there is not an economic incentive to alter the current curriculum. Another type of response might be considered an opposing economic rationale: that a department already was experiencing decreasing enrollment, but that existing students liked the current curriculum, so any significant change could further damage this situation.

Reliance on Tradition

Several respondents said the traditional position is that computer science programs are grounded in the first principles for which they are named, and this orientation is slow to change. Some computer science faculty members believe the rest of software engineering is or should be on-the-job training. There was certainly a time when graduates going to work for large software development organizations commonly received very extensive additional training on the tools, languages, and processes used by those organizations. Though this is less common today, the conceptual demarcation lines tend to remain.

A related argument says the pragmatic aspects of software development change so quickly that it does students a disservice to train them in these areas. Industry generally leads higher education in the production of software tools and processes, so it is appropriate not to expend educational resources in these areas.

The computer science major itself now has a large set of core courses. Many people feel there simply is no room in it for a different kind of required courses. According to those who

disagree with this assessment, the result is that almost all their computer science students become software engineers anyway, and without proper grounding.

In the survey responses, the authors saw substantial impatience with the slow pace of curriculum change. Some people expressed this as seeing a failure to recognize the need, by administrators who were not in touch with the markets receiving their students.

Some very interesting responses were along the lines that, "Faculty think software engineering is a subset of computer science, and that computer science people are qualified to be software engineers or to teach it." The fact that only a small part of software engineering work is first principles casts some doubt on this view, but one can picture the claim being made.

There were also responses that professional societies have been slow to recognize a difference between the computer science and software engineering disciplines, perhaps encouraging this traditional positioning to flourish.

A final, very interesting opinion we heard on traditional computer science was the following: part of what would have been software engineering became instead "information technology" in business schools. This takeover of some of the turf of practical software engineering perhaps allowed computer science to remain very pure, because all the rest was presumed taken care of elsewhere. Thus, some people graduate from computer science programs and head for software work that have never had to learn about cost and value, the way other engineers have had the importance of the economic perspective impressed upon them.

Acceptance Curve

Several faculty members said, "Software engineering is still a new field, one which is just slow to mature." Most felt that the current situation would change, and that the growth curve would ramp up as it had for computer science. Their reasons included the following:

- Industry and student demand for better preparation will force computer science departments to offer software engineering degrees.

- The availability of software engineering majors from some schools will tilt the balance in other computer science departments.

- The current perception is that information technology is still shrinking, but this will change, creating more demand for software engineers.

5. Summary and Conclusions

Despite significant numbers and a large projected growth in the software engineering field of the U.S. labor market, there are only about 30 baccalaureate software engineering degree programs in the United States, with few additional programs expected in the near future. However, the computer science and computer engineering disciplines experienced similar slowness of growth in their respective early years.

Software engineering educators in schools without Bachelor's degree programs in software engineering see several short-term obstacles to program growth, including a sluggish economy and the perception of many computer science faculty members that software engineering is not a separate academic discipline. This parallels in some ways the perception of computer science by many mathematics and electrical engineering faculty in the 1960's and 1970's.

However, many of those same educators felt that this situation will change over time, as more companies start demanding better-prepared graduates for software engineering positions. This once again parallels the industry need for computer scientists which accelerated in the 1980's and continues to this day.

The authors therefore feel that although there will likely to be slow growth in the number of baccalaureate software engineering degree programs in the next 5-10 years, the long-term outlook for software engineering as an undergraduate discipline is likely to be much brighter.

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