2006-1693: COMPUTER SCIENCE RECRUITING AND RETENTION OF UNDERGRADUATES TO MEET THE NEEDS OF THE BUSINESS COMMUNITY

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Computer Science Recruiting and Retention of Undergraduates to Meet the Needs of the Business Community

INTRODUCTION

Available information from a variety of governmental and private sources indicate an increase in the demand for computer science (CS) and information technology (IT) professionals in the coming years.[1, 2, 3, 4] As can be seen in figure 1, all thirteen of the

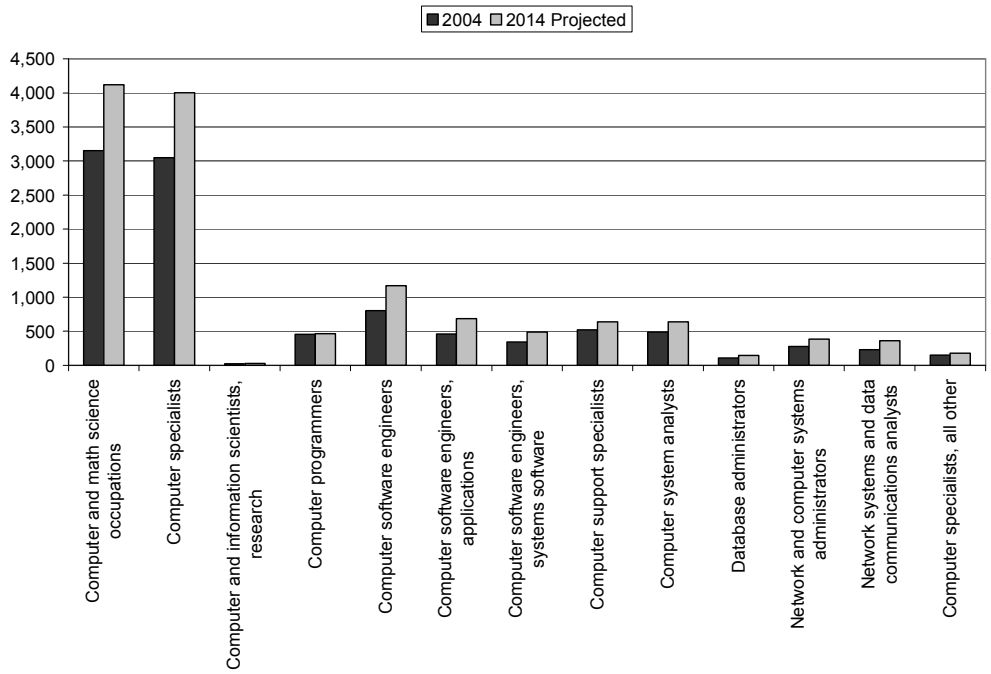

Figure 1. Computer-related Jobs in the U.S.: 2004 and 2014

computer-related careers listed are projected to show an increase in demand by the year 2014.[5] According to the Bureau of Labor Statistics, computer and mathematical science occupations are projected to increase by almost 30% by the year 2014.[6] When compared to other science and engineering occupations, the projected employment growth for CS professionals is even more startling. Figure 2 shows the projected increase in employment for computer and mathematical scientists compared to other science and engineering occupations.[7]

Unfortunately, other recent studies and surveys show a decline in the number of undergraduate students who are declaring computer science as a major.[8, 9, 10] Figure 3 shows the trends from 1971 through 2004 of incoming freshman who listed computer science as their probable major upon entering college.[8] This gap between supply and

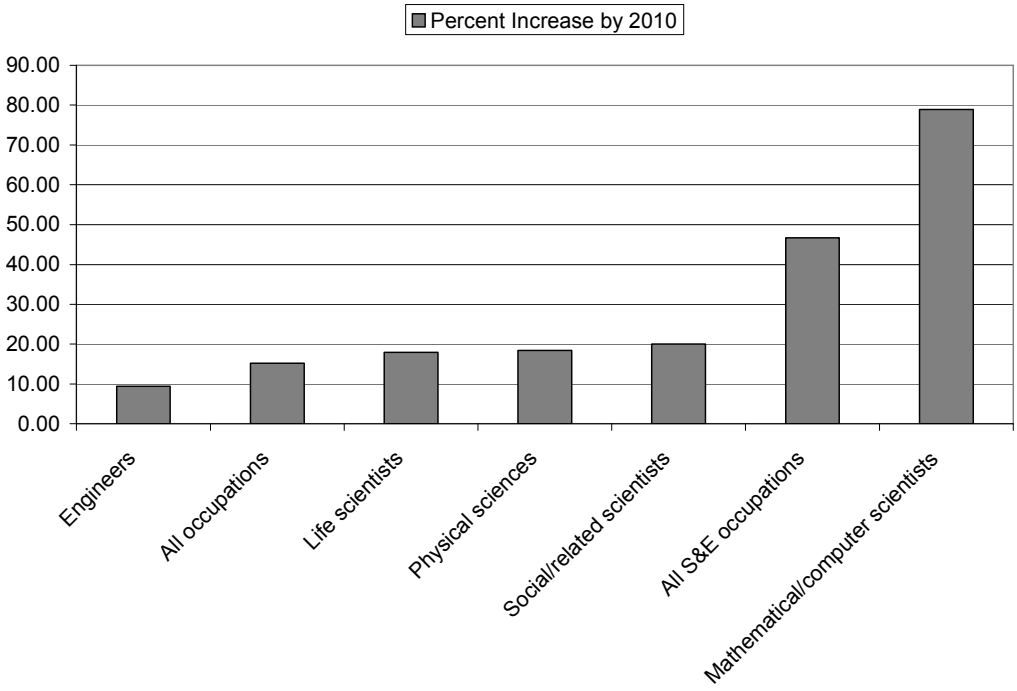

Figure 2. Projected Increase in Employment, by Occupation: 2000 – 2010

demand is further exacerbated by indications that what potential employers want and need from computer science professionals has changed over recent years.[11, 12, 13, 14]

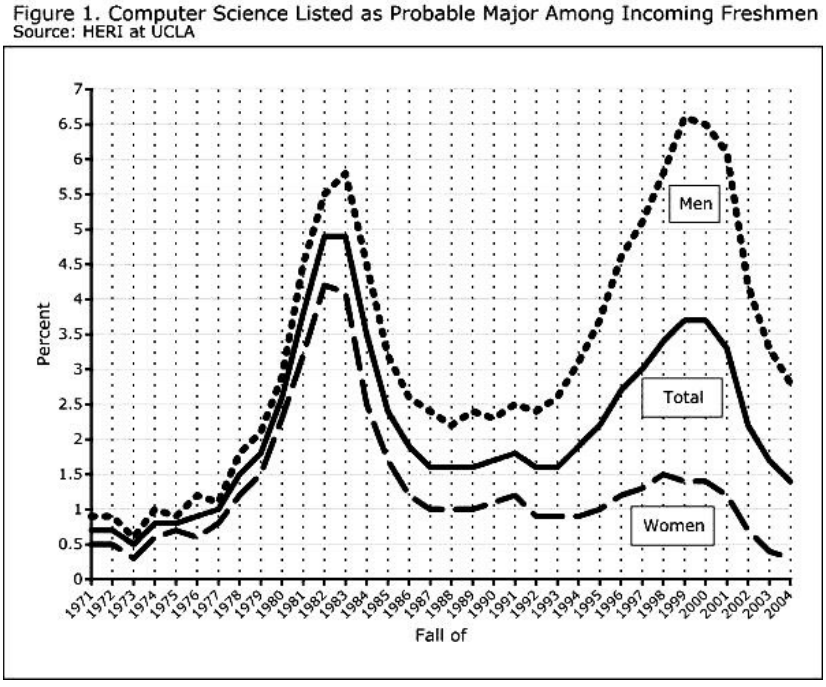

Figure 3. Computer Science Listed as Probable Major Among Incoming Freshmen

Over the past three years, Texas A&M University – Corpus Christi has worked to address these issues using a three-pronged approach. First, faculty and students have worked together, through grant funding, to design and implement a recruitment program aimed at reaching out to high school students. Second, grant funding has also been used to set up paid undergraduate fellowships and to implement a tutoring program targeted specifically for undergraduate computer science students in an effort to increase the retention rate of computer science majors. Finally, a recent survey of businesses in mainly southeast Texas was conducted in an attempt to gain some insight into current employers' experience with A&M-CC graduates and to determine what both potential and current employers expect from computer science graduates.

RECRUITMENT

The decline in the number of incoming freshmen who declare CS or IT is troubling. The under-representation of women and minorities is also a cause for concern. Figure 4 shows the decline in the percentage of CS baccalaureate degrees awarded to women since 1984.[15] Figure 5 shows the relative lack of growth in the percentage of CS baccalaureate

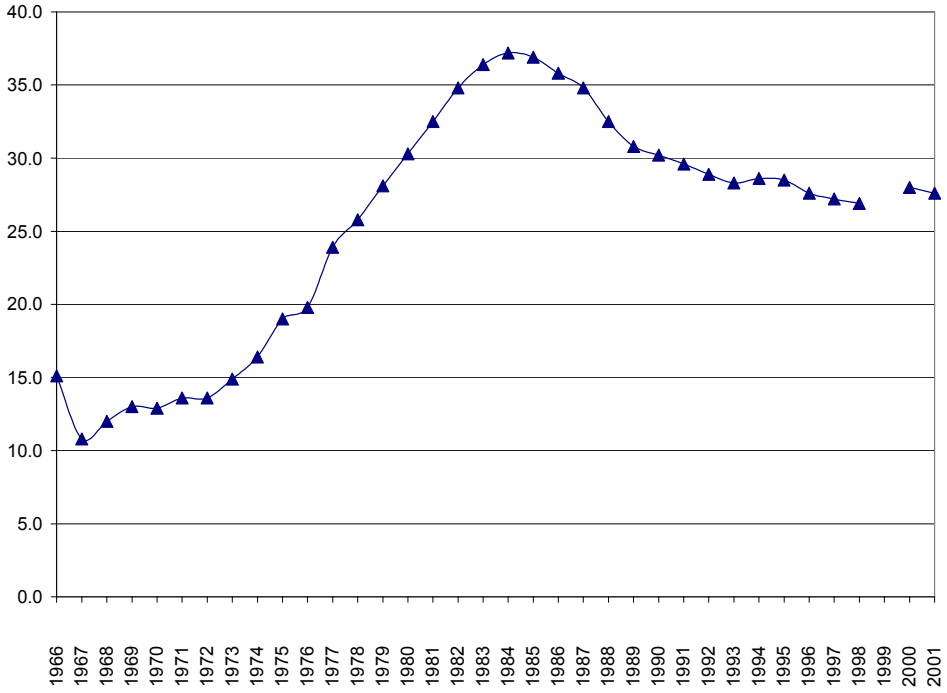

Figure 4. Percent of CS Baccalaureate Degrees Awarded to Women: 1966 – 2001

degrees awarded to various minority groups since 1992.[16] One of the ways in which A&M – CC has addressed this problem is through a recruitment program involving both students and faculty. The program was initially set up in September 2003 through funding made available from the National Science Foundation (NSF). The first step taken was to hire a graduate student who would act as a supervisor of the recruiting team and as a liaison between the team and CS faculty. The graduate student was responsible for interviewing, hiring, and training undergraduate students who would work as

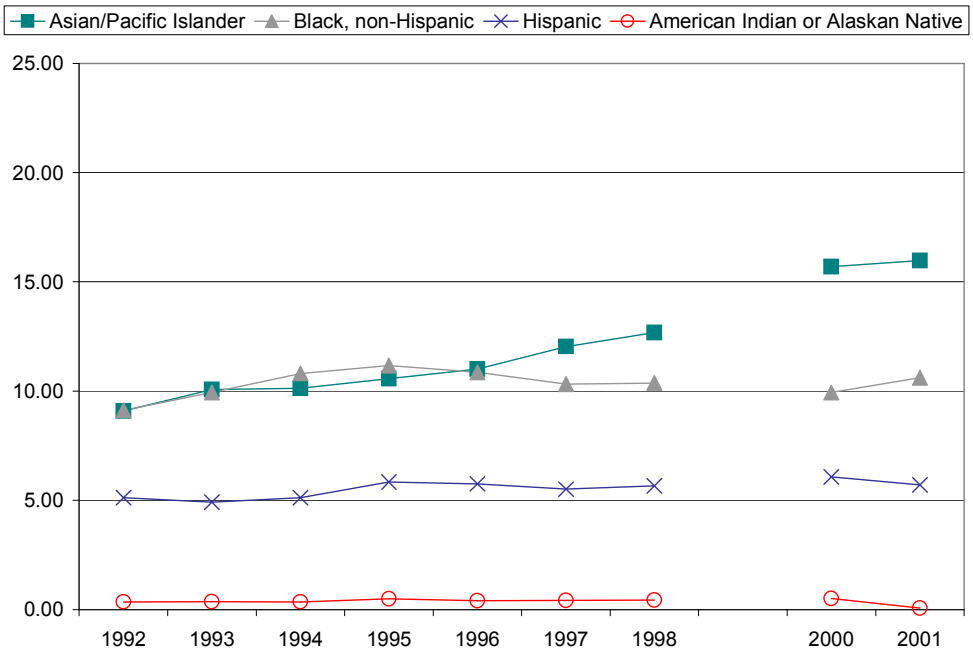

Figure 5. Percent of CS Baccalaureate Degrees Awarded to Minorities: 1992 - 2001

recruiters. One important consideration in hiring the recruiters was to create a team that would accurately reflect the diversity of the population in south Texas. By the end of October 2003, six recruiters had been hired. These recruiters not only reflected the diverse population of the area, but also represented a range of interests in the field of computer science running the gamut from the more traditional computer programming area to the more art-oriented graphics design field. In early 2004, additional funding was obtained from the Texas Engineering and Technical Consortium (TETC). This funding was used to hire three more recruiters.

Once the recruiting team was assembled, they began to brainstorm to find a variety of ways to deliver their message to both high school students and parents. Among the ideas implemented were producing a brochure describing the CS field and showing pictures of students involved in activities on campus, creating a PowerPoint presentation to be used in recruiting visits to high schools, setting up a Web site used to present information about the CS program and as a means of communication with interested students and parents, creating a display board which includes various computer components to be used at presentations, and going out to high schools, junior colleges, and other pre-college programs to give in-person presentations about the CS program at A&M – CC. These in-person presentations are followed up with the recruiters making phone calls to students who expressed an interest in the program.

The recruiting team and CS faculty also participate in Island Day Fairs. Island Day Fairs are university-sanctioned events that provide high school students and their parents with an opportunity to visit the university, explore different programs offered by the university, and talk one-on-one with both current students and faculty members. The

display board built by the team is used at these fairs and has received many compliments from attendees.

In the fall semester of 2005, the number of incoming freshmen who declared computer science as their major increased by 14%. Figure 6 shows the number of freshmen CS majors over the past 6 years. This was the first significant increase in five years. The aggressive and comprehensive approach to recruitment appears to be paying dividends.

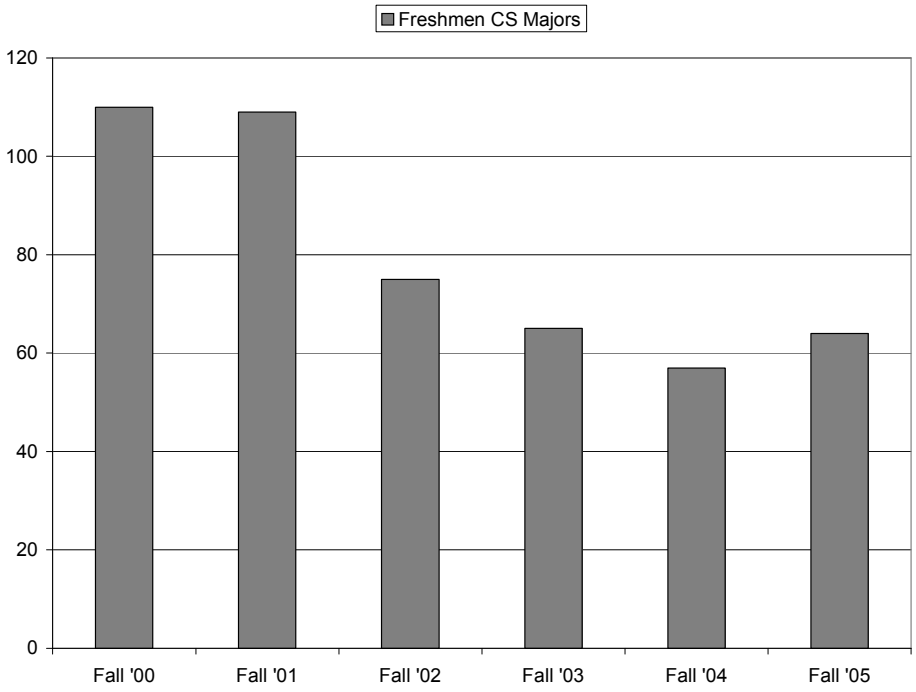

Figure 6. Number of Freshmen Declared as CS Majors: 2000 – 2005

RETENTION

While recruitment of students into the CS program is important, the issue of retention must also be addressed. At A&M – CC, the percent of CS majors who are minority students has ranged between 40% and 50% in the past 6 years.[17] The percent of CS majors who are women has ranged between 18% and 30%. Many of these students are first-generation college attendees struggling to balance one or more jobs with the demands of academia. Many students also struggle with the material being presented. All too often, students decide they either they cannot grasp the information being taught or they can't work and go to school at the same time. Without some form of intervention, these students are likely to drop out of school.

Two programs have been put in place in an attempt to address the retention issue. First, part of the TETC state grant was earmarked to fund undergraduate research fellowships. There are 15 fellowships awarded each semester, each paying $1,000. These fellows work closely with faculty members on some aspect of the faculty's research. The result of this program has been positive in several aspects. The most obvious is that it gives the

student researcher an opportunity to earn money while working in an area related to his/her field of study. Another benefit has been that the students have become more energized about not only finishing their undergraduate degrees, but are more interested in pursuing graduate degrees when they have an opportunity to participate in real, hands-on research.

The second program implemented involves using students as tutors for students who are struggling. The program, begun in 2003 through the TETC grant, pays students who are doing well in their courses to staff a tutoring center to which other students may go for help in understanding the theories and concepts taught in the introductory sequence of CS courses. While it has been difficult to empirically measure the overall effect of this program, anecdotal evidence appears to show it is beneficial. Students who might otherwise throw up their hands in despair and quit now have a resource to which they can turn for help.

EMPLOYERS' NEEDS

Efforts at recruitment and retention should be a part of any comprehensive education program. However, if the graduates of a program do not possess the qualities and skills needed by potential employers, all the work of recruitment and retention is of little value. As previously stated, the expectations of potential employers have changed over the years. In the early days of computer science, employers expected graduates of the newly-created CS and CS-related degree programs to be technically skilled in their chosen field of study. These fields were largely limited to computer science, electrical engineering, and information systems.[18] Each of these fields were well defined with little, if any, overlap between the areas of expertise. Additionally, graduates of these CS and CS-related programs were not expected to have a working knowledge of the non-technical aspects of the business into which they were being hired.

As computers have become more pervasive in every day life and can be found in almost every type of business and industry, the requirements for people with CS/IT degrees have changed. Not only are they expected to be well-versed in the technical aspects of computer and information science, but they are also expected to have at least a basic understanding of the non-computer-related areas of the business or industry into which they are being hired.[11, 12, 13, 14, 18, 19]

Researchers at A&M – CC have recently conducted a survey of current and potential employers of A&M – CC graduates in an effort to gain some insight into what the employers' expectations are. Although the number of respondents was smaller than expected, the results support the findings of other surveys showing a shift in employers' requirements and needs in the CS/IT area.

SURVEY INSTRUMENT

The survey, consisting of 18 questions, was divided up into three main sections. The first section, containing seven questions, asked the respondent to provide information

concerning the company or institution completing the survey including company size in terms of both annual revenue and number of employees, type of business, and size of the IT department. The second section, consisting of three questions, asked the respondent to provide information regarding the perceived availability and preparation of the CS/IT workforce pool in the area. The last section, containing six questions, asked the respondent to provide information about what was required from potential CS/IT employees. These questions included, but were not limited to, level of education preferred including math background, previous experience requirements, specific technical skills, and non-technical skills and qualities new employees should possess. The list of technical skills included specific programming languages, operating system (OS) and networking management, database development and management, software engineering and project development, Web-based technologies, and hardware installation. The non-technical skills included attributes such as interpersonal skills, leadership skills, communication skills, problem solving, self-motivation and initiative, accountability, and enthusiasm. The questions and format of the survey were developed in-house using feedback from associates and the business community.

The survey was placed online in an effort to maximize availability to interested companies and institutions. It was also felt that putting the survey online would reduce the cost of printing the survey, mailing it out, and providing self-addressed stamped envelopes for replies.

DATA GATHERING

Several approaches were used to inform and contact potential participants about the survey. The Public Affairs office at the university sent out press releases and announcements to all media and business journals within a 200-mile radius. This, unfortunately, was a less-than-stellar success since it appears only one media outlet announced the information.

The researchers contacted the Chambers of Commerce in cities within the same are to request their assistance in contacting their members. Several Chambers were willing to help by providing a list of their members along with announcing the survey in their e-letters. One Chamber was willing to sell their membership list, but declined any further involvement. Several others refused any form of cooperation or participation.

Once Chamber membership lists were obtained and reviewed for potential participants (businesses such as hair salons and convenience stores were omitted), student workers were given the lists and a standard email announcement. The students sent out emails from a central email address to the selected businesses announcing the availability of the survey. This resulted in somewhat limited success as the response rate was approximately 5%.

The most successful, and time- and work-intensive, approach involved the researchers themselves making direct telephone calls to the contacts on the lists. This effort resulted in a nearly 100% participation of those contacted.

RESULTS

A total of 68 respondents participated in the survey. Table 1 shows the distribution of respondent industries.

Advertising	1		Hospitality, Food and Beverage	2
Business Services	5		Manufacturing	1
Construction	1		Oil and Gas Refineries	5
Consulting Services	7		Retail Trade	1
Education Services	8		Transportation, Communications, and Utilities	4
Finance, Insurance and Real Estate	7		Wholesale Trade	1
Government Services	9		Other	12
Health and Social Services	4			

Table 1. Distribution of Respondents Industries

Participants were asked to rate the importance of the technical and non-technical skills on a scale from 1 to 5 with 1 being not at all important and 5 being very important. For this discussion, the technical skills were grouped into four major areas: programming language preferences, database preferences, operating system preferences, and general technical skills.

The average results for importance of knowledge of specific languages for all participants are listed in Figure 7. As can be seen, there appears to be a preference for the object-oriented languages and programming software (Java, Visual Studio, etc.). The average

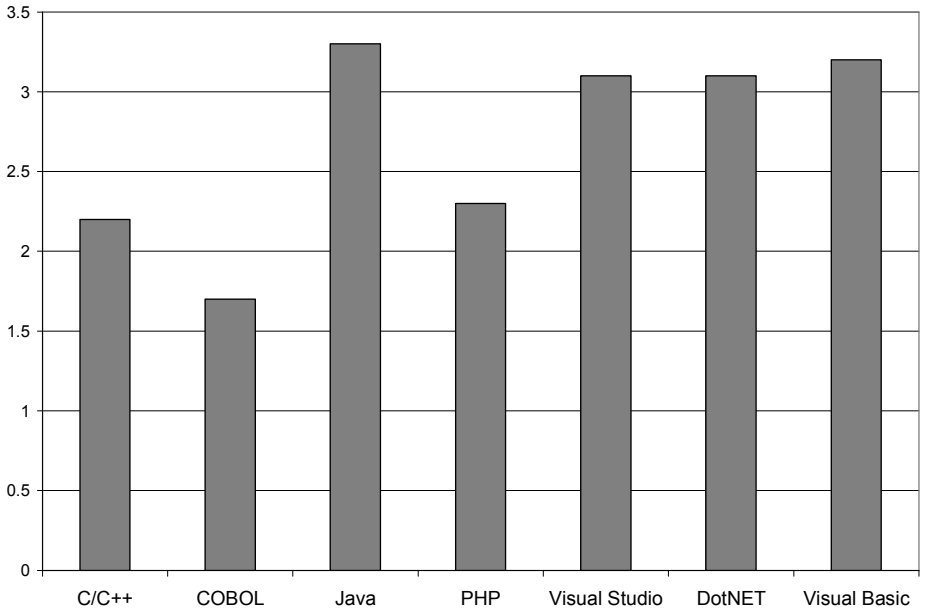

Figure 7. Average Importance of Specific Languages

rating for the object-oriented languages and programming software among respondents is 3.2. For the languages not generally considered as object-oriented in nature, the average rating is 2.1. If such an emphasis is placed on the importance of object-oriented languages, does this mean CS programs should stop teaching non-OO courses? One could argue that developing and implementing well-written programs using an object-oriented approach would be difficult if a programmer has little or no understanding of the logic and structure of basic programming.

Figure 8 shows the average results for the importance of various databases. This data, when considered in conjunction with the average preference of Windows-based operating

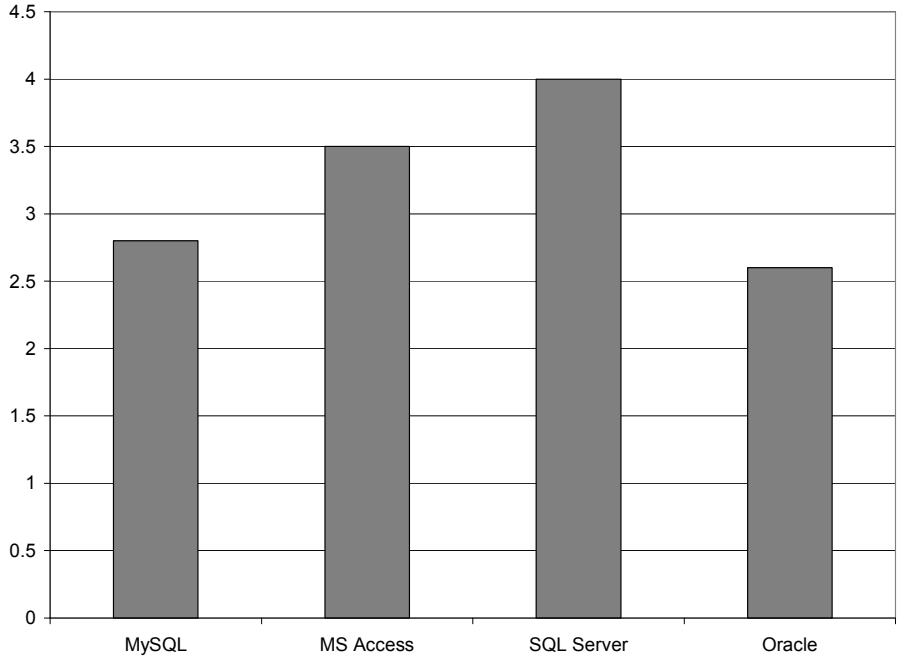

Figure 8. Average Importance of Database Types

systems knowledge (4.4) over UNIX/Linux (3.0), would seem to imply that CS programs should place more emphasis on Microsoft® software over other market choices. Yet, over 25% of the respondents rated knowledge of both operating systems as equally important.

A total of ten different general technical skills were polled in the survey. These are networking concepts, general programming skills, design skills (software engineering), database development, database administration, Web programming technologies (Perl/CGI, ASP, XML, etc.), mobile device programming, project management, testing and debugging skills, and hardware installation. The results seem to indicate the respondents are more interested in general technical skills than in specific skills. For example, the average rating for importance of general programming skills was 3.8. Yet, the average of the rated importance of individual programming languages (Figure 7) was 2.7. Figure 9 shows the average results for the ten different areas of general technical skills.

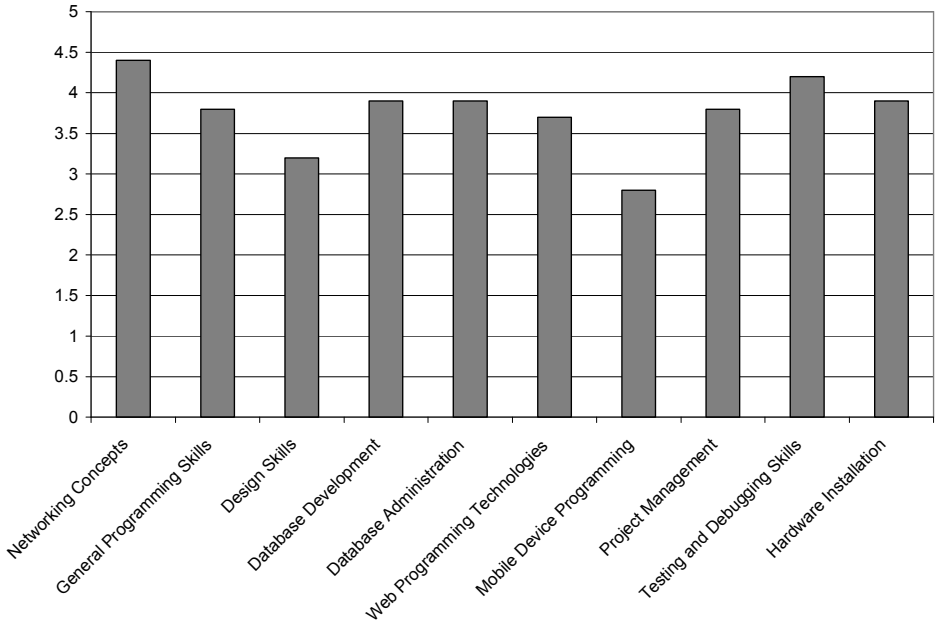

Figure 9. Average Importance of General Technical Skills

Thirteen non-technical skills were polled in the survey. The average results for these skills are shown in figure 10. The skills polled are the ability to recognize and solve

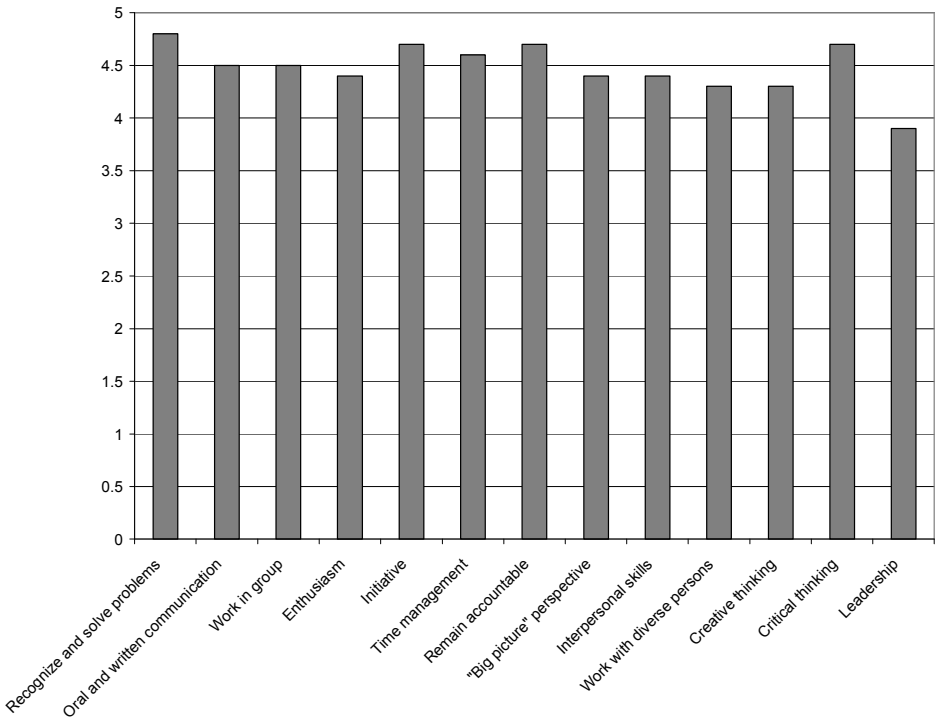

Figure 10. Average Importance of Non-Technical Skills

problems that arise on the job, the ability to communicate orally and in writing, the ability to work well in a group to achieve a goal, enthusiasm on the job, initiative needed

to fully complete tasks, the ability to manage time while working with little supervision, remain accountable for actions taken, the ability to take a "big picture" perspective on the job, interpersonal skills, the ability to work well with persons of diverse background, the ability to think creatively, problem solving and critical thinking abilities, and leadership skills. The average of the importance ratings of these non-technical skills was 4.5 compared to the 3.3 average of all the general technical skills.

The results of the survey seem to indicate that math skills are still important to potential employers. Figure 11 shows the distribution of responses regarding minimum math

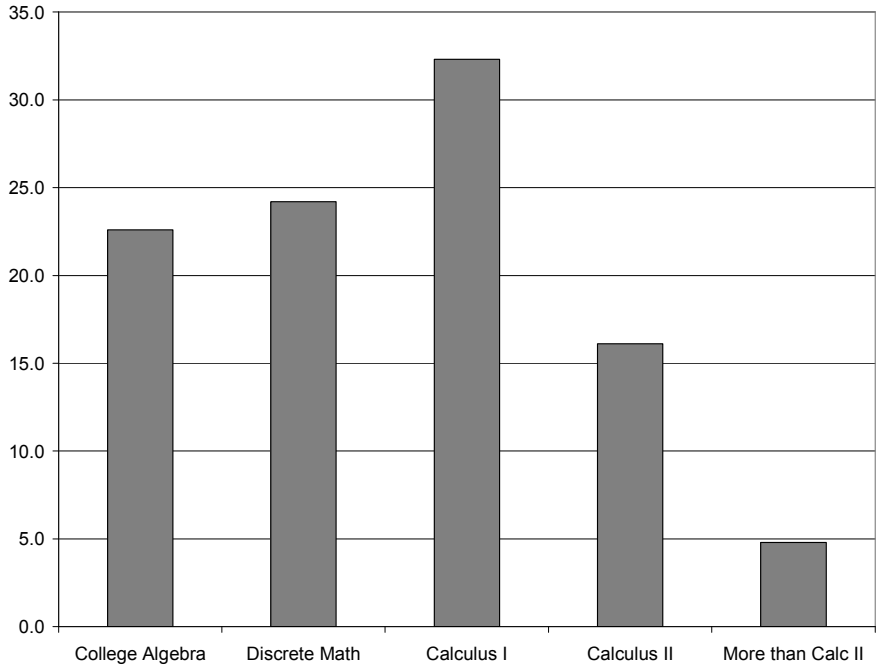

Figure 11. Distribution (%) of Minimum Math Requirements

education. It is interesting to note that almost 47% of the respondents who answered the question indicated that knowledge of math at the discrete math level or less was sufficient to do the work required of a CS or IT graduate. This information could help define how to address the problem of an apparent disconnect between what potential employers need or expect from incoming CS/IT professionals and what some incoming college students view as difficult math courses. This is particularly important in light of the number of incoming college freshman who must take remedial math courses before they can begin other college-level math courses.

Finally, there is the issue of the perceived supply of qualified CS/IT professionals. Of the 66 respondents who answered the question, 68% of them indicated a perceived shortage of qualified CS/IT personnel. Figure 12 shows the distribution of responses.

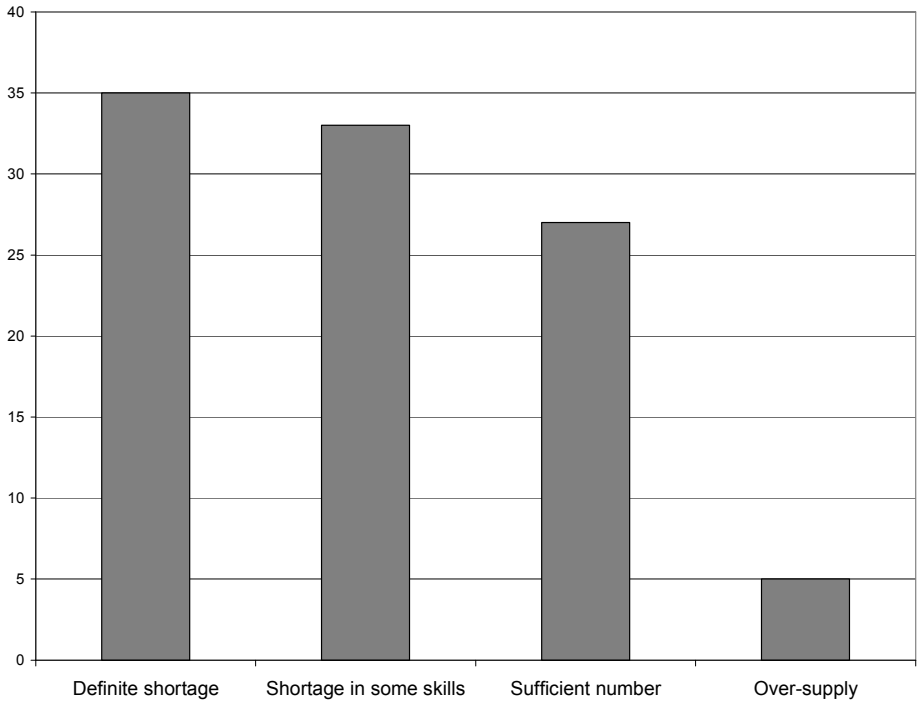

Figure 12. Distribution (%) of Perceived CS/IT Personnel Supply

POSSIBLE COURSES OF ACTION

Given the projected increases in demand for CS and IT professionals in the next eight years, colleges and universities that offer CS and CS-related degrees should be poised to aggressively address the issues related to recruitment, retention, and preparation of students if these schools wish to remain competitive and relevant. While very few people or institutions like change, if schools are going to produce graduates who can be competitive in the workplace, some changes may need to be made.

The first concern is recruitment. Schools cannot produce qualified CS and IT professionals if students continue to avoid declaring these fields as majors. Involving current undergraduate and graduate students in a recruitment program can produce several beneficial effects. First, potential college attendees have the opportunity to meet and talk with peers of a similar age group on a one-to-one basis. This allows students at the high school level to associate a real person who is close to his/her own age with a computer science program. Second, using undergraduate and graduate students as recruiters provides an opportunity for these students to express their enthusiasm for their chosen field of study. Finally, because the recruitment program at A&M – CC is funded through several grants, the students can earn money while recruiting for the school. While the full extent of the recruitment program at A&M – CC will not be known for several years, initial results are encouraging.

Recruitment is important. However, if no effort is made to retain the newly-declared CS and IT majors, all the recruitment in the world won't do any good. Minority-serving institutions in particular should be cognizant of the issues and struggles their students are likely to face. Providing these students with academic support through tutoring services and with financial support through scholarships, fellowships, etc., may well make the difference between whether the students stay in school or give up and leave.

Recruiting students to a particular program and working to retain those students is vitally important to the success of CS/IT programs. However, if students graduate from a program yet are unprepared for the demands of industry, all the work in recruitment and retention is worthless. The survey conducted by A&M – CC can provide some insight into how this issue should be addressed. While the number of respondents precludes any in depth statistical analysis of current trends in the expectations of potential employers and how they affect academic programs, some useful information can still be gleaned from this study.

The apparent preference of potential employers for general technical skills over specific skills might tempt one to favor teaching only general technical information in a CS/IT program. The authors would contend that students must first lean some specific skills before acquiring the general technical skills. For example, it is difficult to teach the idea of conditional or iterative language constructs if some type of programming language is not used. Once those simple constructs are mastered, the concept of language construction could be introduced. Once specific, fundamental skills are learned, the techniques and theories should then be applied to more general areas.

The strong rankings of the non-technical skills listed in the survey might lead some to think it is more important to produce CS and IT graduates who are well versed in management, design, problem solving, and critical thinking. Obviously, these skills are extremely important, particularly in light of the outsourcing of programming jobs to locations overseas. However, CS and IT graduates must still be able to communicate with those who write the code. They must also, in some cases, be able to write some or all of the computer programs. Solid technical background and training complemented by a strong knowledge of non-technical skills is essential to being successful in today's market.

So, how should a CS/IT program adjust to meet the changing demands of today's marketplace? Several different institutions have already begun to offer CS/IT degrees that place more emphasis on general technical skills and non-technical skills and less emphasis on highly specialized technical skills. For example, Ohio State University offers a Bachelor of Arts in Computer and Information Science (BA CIS). This degree "offers students a broad, liberal education, along with specialized study in computer and information science. The program permits students to combine the study of computer science with the study of some related field of potential computer application."[20] The curriculum for this degree includes 24 quarter hours of core CIS courses, 90 quarter hours of general education curriculum courses, 42 quarter hours of additional major requirement courses, and 20 quarter hours of upper-division computer science courses.

The 42-hour requirement of additional major courses is broken down to four parts. These are math/statistics, programming languages, courses in a related field of the student's choice, and additional general electives in the CIS major. Math, through calculus II, and statistics courses account for 18 hours. The student chooses one of seven programming language courses for a single credit hour. The student must take a total of 15 hours in his/her related field-of-interest. Five of those hours are at the introductory level. The remaining 10 hours must be above the introductory level. The additional general electives in the major, which account for 8 hours, may be computer science, math, or related field-of-interest courses. The increased flexibility of this degree plan affords students the opportunity to "fine tune" a degree to a specific area of interest while providing them with a solid CS/IT education.

Another approach, taken by the Rochester Institute of Technology, involves producing what they call an "Information Technologist".[21] The curriculum of this program places less stress on specific technical skills (e.g., programming) than traditional CS/IT programs. It offers a solid foundation in core computer science courses, followed by additional study in two areas of concentration chosen by the student and approved by his/her academic advisor. These areas of concentration are intended to prepare the student for advanced IT specialties and include website development, interactive multimedia development, game development, network administration, system administration, wireless data networking, database, learning and performance technology, and advanced application development. Additionally, students may elect to create a special topics sequence that would explore one of the two selected areas of concentration in more detail. This additional study of one of the areas of concentration is not required.

CONCLUSION

Given the current expectations of employers and the projected needs for qualified CS/IT professionals, it is incumbent on colleges and universities to take a cold, hard look at their computer science programs. While producing top-notch researchers bent on completing their doctoral degrees and solving all the problems of the computing and engineering world is a laudable goal, recruiting and retaining students into the CS/IT field and providing them with a marketable education is much more in line with what the "real world" needs and wants. There will always be highly gifted students who should be encouraged to pursue advanced degrees. However, the majority of students simply want to earn a baccalaureate degree and get a good job. Colleges and universities should be sensitive to these students' needs and provide them with a solid education on which they can build a career. Anything less is doing a great disservice to tens of thousands of young people.

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