

Exploring Declining CS/IS/IT Enrollments

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Abstract

Declining enrollments in Computer Science (CS), Information Systems (IS), and Information Technology (IT) programs reported by the media are a real concern to both academicians and employers. Ninety-one percent of the respondents to a brief survey confirmed that enrollment was down in their undergraduate programs. The top six reasons for declining enrollment reported were: outsourcing of CS/IS/IT jobs (67%), the economy in general (59.8%), the dot.com failure (48.8%), the cyclic nature of business (40%), decline in students' analytic abilities (29.26%) and failure of the institution to actively recruit students (26.8%). Respondents reported various attempts to increase enrollments including increased enrollment efforts to local high schools (46.35%), changing the types of courses offered (37.8%), increasing articulation agreements (36.6%), creating new major(s) with other discipline(s) (29.2%), creating new tracks within the major (29.2%), and increasing recruitment efforts to community colleges/IT schools (29.2%).

Keywords: computer careers, declining enrollment in computer careers, women 's enrollment in computer careers

1. INTRODUCTION

All of us are aware of the current buzz about declining enrollments in computer science programs in the United States. A May 2005 report from the Computer Research Association (CRA) based on a survey from the Higher Education Research Institute at University of California at Los Angeles (HERI/UCLA) shows that the number of new undergraduate majors entering computing

programs has declined nationally by 60% from 2000 to 2004. The Taulbe survey (CRA's survey of Ph.D.-granting CS departments) also reports "significant reductions in average enrollments in the computer science major" which translates into a 23% decline from 2002 to 2003; while total enrollment in computing bachelor's programs dropped 19% in the same period. Unfortunately, these reports also show that women CS majors declined 80% from 1998 - 2004, which

represents a 93% decrease since the peak in 1982.

A review of recent journal and trade publications shows many individual institutions report decreasing enrollments. For example, Stanford University reports that the number of students declaring CS or computer systems engineering (CSE) majors decreased 8% from Fall 2000 to 2001 and by 20% between Fall 2001 and 2002 (Herbert, 2004). Angelo State University reports a decline in graduating CS students from 40 per year in the 1990s to 18 in 2003 (Chabrow, 2004). Ohio State University is down 30% (Kessler, 2004). Even when enrollment levels are unchanged, other institutions report that applications are down. For example, Carnegie Mellon University reports applications are down 40% for their School of Computer Science (Chabrow, 2004).

Despite outsourcing of some computer-related jobs, a decrease in the pool of trained tech workers could become a problem in about four years if CS majors continue to decline while the U.S. tech industry grows (Kessler, 2004). The Bureau of Labor Statistics sees the need for growth in all computer science occupations by 2010, especially those requiring strategic and business knowledge, such as computer software engineers (95% projected growth), systems analysts (62% projected growth) and computer and information systems managers (48% projected growth) (<http://stats.bls.gov/oco/oco20016.htm>).

Foster (2005) reports that computer scientists see a need for growth in their ranks "to tackle such challenges as protecting the country's financial, utility, telecommunications, transportation, and defense systems from terrorist attacks" (p. A-31). She also reports that "computer scientists are already struggling to maintain basic research despite sharply reduced financial support from government agencies" (p. A-31).

The survey discussed in this paper reports on whether or not enrollments are declining in various U.S. higher education programs including computer science (CS), computer information systems (CIS), management information systems (MIS) and information technology (IT). The survey queried respondents about possible explanations and solutions for the enrollment situation.

2. SELECTION OF MAJOR

There are many factors that interact in a student's decision to select a particular undergraduate major. O'Lander (1996) collected data from 4,127 high school students who were enrolled in a computer course in New York State concerning the factors that influenced their attitude towards computing. These included: 1) enthusiasm towards computing; 2) perceptions of computing ability; 3) apprehension about majoring in CS; 4) perceptions of degree of positive instructional influence towards computing received; and 5) perceptions of career and employment opportunities in computing.

In examining how to attract women and men to CS programs, McGrath-Cohoon, Tillberg and Shwalb (2004) conducted 30 focus groups with 178 undergraduate CS majors across 17 institutions. They found that students often selected the institution first and were primarily concerned about the institutional reputation, location, cost and core curriculum. The researchers confirmed what other studies have noticed; that women, in particular, enter college undecided about their major. Many women CS majors in the focus groups switched into computer science from a different major. Once the institution has been selected, students chose the department based on, in no particular order; reputation, CS curriculum, honors programs, size of school and program, facilities and amenities, scheduling, social aspects, and faculty and staff.

In the McGrath Cohoon, Tillberg and Shwalb (2004) study, women mentioned the influence of encouragement and testimonials more often than men. They were also greatly influenced by the presence of female faculty and role models.

Why Has Enrollment Declined

A myriad of reasons have been hypothesized for the decline in CS enrollment in the early 1990s and again since 2000. Some of the reasons centered around the background of the students (e.g., students are not adequately prepared to handle traditional CS programs, lack of certified high school teachers in CS) while others concentrated on the traditional curriculum (e.g., students want to learn "hot topics" that are more IT

in nature and less suited to traditional CS/CIS programs). O'Lander (1996) also mentions inadequate salaries for CS faculty and changing demographics (fewer white male college students) as possible reasons for the enrollment decline in the 1990s.

In addition, it is clear that some students are selecting other majors which rely on high-end computing. "The introduction of new undergraduate programs in the IT field has created alternatives to the traditional CS and CE majors, possibly siphoning students who previously would have selected CS/CE programs." (Hoganson, 2004, p. 170). Many students are influenced by TV shows like CSI or Crossing Jordan (Chabrow, 2004) and select "more glamorous fields." Foster (2005) reports that these "glamorous fields" include bioinformatics, molecular biology, and biochemistry.

Another reason cited for declining enrollment in CS involves the image of a computer scientist. Students are turned off by the common image of a computer scientist as an antisocial nerd (Foster, 2005) Edward D. Lazowska, a computer-science professor at the University of Washington, states "If you ask a kid to draw a caricature of what a computer scientist does, it's some overweight, greasy male, hunched down in front of a terminal, in front of a workstation, in a little cubby-hole" (Foster, 2005, p. A-32).

However, a majority of the arguments concerning declining enrollments focus on the reported decline in the number of "good tech jobs" (Hoganson, 2004). Analysis of the U.S. Government Bureau of Labor and Statistics published in Computing Research News revealed that "Between 2001 and 2002, OES data show that employment in the professional IT occupations fell 5.0 percent, significantly higher than total US employment which fell only 1.7 percent. A variety of factors are likely to have contributed to these job losses in the IT occupations, including: the dot-com bust, the end of work

on Y2K, the terrorist attacks of September 11, 2001 and their related effect on the US economy, a downturn in corporate IT spending, the brief 2001 recession, productivity increase, and the offshore outsourcing (offshoring) of IT work" (Hoganson, 2004, p. 169).

Cyclic in nature?

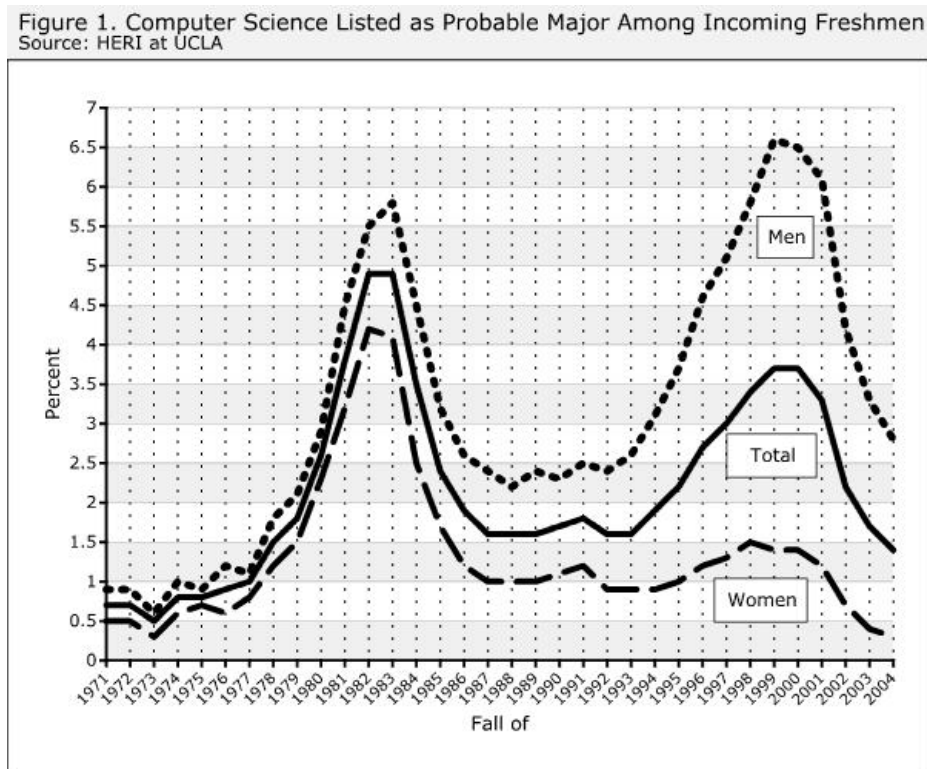
Obviously, this is not the first time that declining CS enrollments have been a concern to academic institutions. A quick examination of the National Science Foundation graphs of the number of CS degrees granted shows that the number of bachelors degrees granted in CS peaked in 1986 and again in 2001. The HERI/UCLA charts, which depict CS as a probable major among incoming freshmen, show two peaks - in 1982 and again in 1999.

However, the figures for women indicate a peak in 1982 with a severe drop off that continues to this day. Current enrollment figures for women approximate the 1973 figures.

Solutions

Just as there are many possible reasons why incoming students are not selecting CS as a major, there are many responses. One response for institutions has been to ignore declining enrollments; they are viewed as a temporary aberration that should not affect CS programs in the long run. Professor David Dill at Stanford University states, "I think there is a good chance that this will all blow over, and it will be seen in retrospect to be a short-term problem for careers in technology" (Herbert, 2004).

Another response has been to create alternate methods to provide students with the "hot topic" skills they desire. One way to do this would be to offer one credit courses/seminars on practical IT topics. Another way is to start IT programs.



A recent IT industry survey about outsourcing, in which firms were surveyed about their success in outsourcing a portion of their business functions, found that functions that were critical to the development of their product or the business enterprise's core competencies, and those that were critical in maintaining a competitive advantage in the marketplace, were difficult to outsource with success (Hoganson, 2004). Mahmoud agrees, stating "Although certain IT jobs can be outsourced, the majority of top IT jobs – including the related project management functions – will remain at home simply because they require detailed knowledge and analysis of the subtleties specific to a given company or industry" (2005, p. 98). This suggests that IT knowledge and skills that are critical to a business enterprise, and hence more difficult to successfully outsource, may form the basis for positioning computer science degree programs. Hoganson (2004) and Huen (2005) are among those researchers who suggest that Computer Science degree programs that capitalize on these observations to prepare their graduates with knowledge in areas that tend to be critical and strategic, may mitigate some of the effect on the outsourcing

movement on their graduate's job prospects and on program enrollment. Jobs such as entrepreneur, product designer, research engineer, system analyst, computer science researcher, requirements analyst, system architect, and system designer are more difficult to outsource.

In a panel discussion, Kussmaul suggests that educators should: 1) help students understand the IT work life and career; 2) emphasize problem solving, analysis and design; 3) emphasize collaboration and teamwork; 4) provide opportunities to work on distributed teams; and 5) decrease emphasis on tech skills and theories that may be less relevant or obsolete in a few years, if necessary (Ferguson, Henderson, Huen, & Kussmaul, 2005).

Mahmoud (2005) suggests that CS departments should consider implementing the following: 1) offer multidisciplinary and cross disciplinary programs; 2) change the image of computer science as just involving programming, Web site design and spam; 3) create more options in course selections and move towards a Bachelor of Arts program; 4) work to increase women's enrollment in

CS; 5) train computing science high school teachers; and 5) make CS courses fun.

A final suggestion is for academia to work closer with industry to identify skills needed to be taught (Chabrow, 2004; Ferguson, Henderson, Huen, & Kusssmaul, 2005).

3.0 METHODOLOGY

The survey used in this study was designed with WebSurveyor software from WebSurveyor Corporation. An e-mail was sent to 575 individuals requesting participation in the study. These individuals were identified from a list of institutions offering CS/IS/IT degrees. Individual e-mail addresses were obtained from the institution’s web page and were not necessarily the department chairperson. The degrees were not limited to a particular department and both colleges and universities were selected for the survey. Survey questions are shown in Figure 2.

Figure 2: Survey Questions

1	Which of the following best describes the undergraduate area in which you teach? <ul style="list-style-type: none"> • Business Information Systems/Management Information Systems • Computer Science • Computer Information Systems • Engineering • Information Science • Information Systems • Information Technology • Other
2	In your undergraduate program, has enrollment declined?
3	In your undergraduate program, has the enrollment in your major: <ul style="list-style-type: none"> • Decreased over the past year • Decreased over the past 2 years • Decreased over the past 5 years • Decreased over the past 10 years
4	To what do you attribute the decline in enrollment in your major at your institution? (please select all that apply) <ul style="list-style-type: none"> • technical school or community college programs • availability of certification programs • the dot.com failure • outsourcing of CS/IS/IT jobs • economy in general • cyclic nature of business • lack of your institution to actively recruit students • decline in students’ analytic abilities (math, science, etc.) • decline in students’ soft skill abilities

	(English, writing, communication skills)
5	In your undergraduate program, has the enrollment of women in your major Decreased over the past year <ul style="list-style-type: none"> • Decreased over the past 2 years • Decreased over the past 5 years • Decreased over the past 10 years
6	Has there been an effort to increase the enrollment in your major over the past year?
7	What step(s) have been taken to increase your major's enrollment? (check all that apply) <ul style="list-style-type: none"> • create (a) summer program(s) for high school students • increase recruitment efforts to local high schools • increase recruitment efforts to community colleges/IT schools • increase articulation agreements with community colleges/IT schools • decrease the number of courses required for your major • make changes in the types of courses in your major • create (a) minor(s) in your major • create new major(s) with other departments (i.e., bioinformatics) • create new track(s) in your major (i.e., networking, programming, project management) • create (an) internship program(s) • create area(s) of IT certification in your major • create an external Advisory Board for your major

4. RESULTS

A 14.26 % response rate was achieved (with 575 surveys distributed and 82 returned). Of the 82 respondents, 33 (40.2%) were from Computer Science Programs, 19 (23.2%) were from Computer Information Systems programs, 11 (13.4%) were from Business Information Systems/Management programs, six (7.3%) were from Information Systems programs, six (7.3%) were from Information Technology programs; and one each from the following programs: Information Science, Accounting, IT management (graduate only), CS/CIS, Computer Information Systems/Computer Science/Computer Engineering, MIS program in a School of Engineering and Computer Science, and Computer Science and Engineering. Figure 3 summarizes the results.

Figure 3: Respondent’s Undergraduate Teaching Area

Respondents (N=82)	%	Undergraduate Area
33	40.4%	Computer Science
19	23.17%	Computer Information Systems
11	13.4%	Business Information Systems/ Management Information Systems
6	7.3%	Information Systems
6	7.3%	Information Technology
1	1.2%	Information Science
1	1.2%	Accounting
1	1.2%	IT management graduate only
1	1.2%	CS/CIS
1	1.2%	Computer Information Systems, Computer Science, and Computer Engineering
1	1.2%	MIS in a School of Engineering and Computer Science
1	1.2%	Computer Science and Engineering

Seventy-five (91.5%) of the respondents reported that enrollment was down in their undergraduate program.

Figure 4 below summarizes the results of the question “Has your enrollment decreased over the past 1/2/5/10 years?” When questioned about enrollment decreasing over the past year, 67 respondents answered. Fifty-one (76.1%) of these respondents reported that their enrollment had decreased over the past year.

Seventy-three respondents answered when questioned about decreasing enrollments over the past two years. Sixty-four (87.7%) reported that enrollment had decreased over the past two years.

Sixty-eight respondents answered about decreasing enrollment over the past five years. Forty-three (63.2%) reported a decrease over the past five years.

Sixty-eight respondents answered when questioned about decreasing enrollments over the past 10 years. Only 16 (25.4%) of these respondents reported a decrease in enrollment in the past 10 years in their un-

dergraduate programs. The majority of these respondents, 29 (46%), said there was no decrease in enrollment in the past 10 years.

Regarding the reasons as to why the respondents felt that enrollment had declined at their respective institutions, 55 (67%) blamed outsourcing of CI/IS/IT jobs, 49 (60%) cited the economy in general, 49 (60%) cited the dot.com failure, 33 (40%) blamed the cyclic nature of business, 24 (29%) cited the decline in students’ analytic abilities, 22 (27%) blamed their institution for not actively recruiting students, nine (11%) cited the decline in students’ soft skill abilities, five (6%) cited technical school or community college programs, and one (1.2%) cited the availability of certification programs. The 13 (15.8%) respondents who chose the ‘other’ category cited reasons such as: competition, lack of K-12 awareness of what CS is all about, H.S. student/counselors’ perception, the perception of CS as being programming, the negative media coverage of IT problems, or the media NOT promoting lucrateness, or newspaper articles highlighting the loss of jobs, decline in student interest in IS, decline of attractiveness of IS, perceived value in the marketplace, infusion of technology into other majors, and more interest in Biomedical engineering.

Figure 5 below summarizes the question “Has the enrollment of women decreased in the past 1/2/5/10 years?” Seventy-four respondents reported on women’s enrollment in their undergraduate program over the past year. Equal numbers of respondents, 26 (35.1%) reported that women’s enrollment has not decreased over the past year and 26 (35.1%) reported that it did decrease. Twenty-two of the respondents (29.7%) were unsure.

Figure 4: Has your enrollment decreased over the past 1/2/5/10 years?

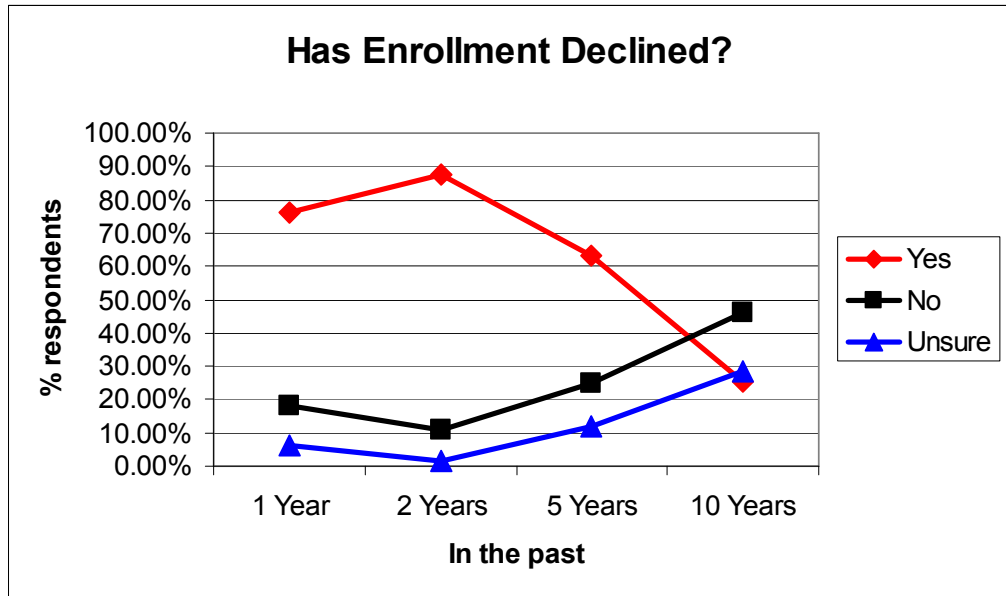


Figure 5: Reasons for decline in enrollment

Respondent (N = 82)	%	Reason for decline in enrollment
55	67%	Outsourcing of CS/IS/IT jobs
49	59.8%	Economy in general
40	48.8%	The dot.com failure
33	40%	Cyclic nature of business
24	29.62%	Decline in students' analytic abilities
22	26.8%	Lack of institution to actively recruit students
9	10.9%	Decline in students' soft skill abilities
5	6%	Technical school or community college programs
1	1.2%	Availability of certification programs
1	1.2%	Infusion of technology into other majors
1	1.2%	Lack of K-12 awareness of what CS is all about
1	1.2%	Competition

Respondent (N = 82)	%	Reason for decline in enrollment
1	1.2%	Increasing Competition
1	1.2%	Perceived value in the marketplace
1	1.2%	H.S. students/counselors perception
1	1.2%	Decline in attractiveness of IS
1	1.2%	Perception: CS = programming, need to change
1	1.2%	No need to major in IT to use computers
1	1.2%	Media NOT promoting the lucrateness
1	1.2%	Newspaper articles highlighting loss of jobs
1	1.2%	Decline in students interested in IS
1	1.2%	Negative Media coverage of IT problems
1	1.2%	More interest in Bio-medical engineering

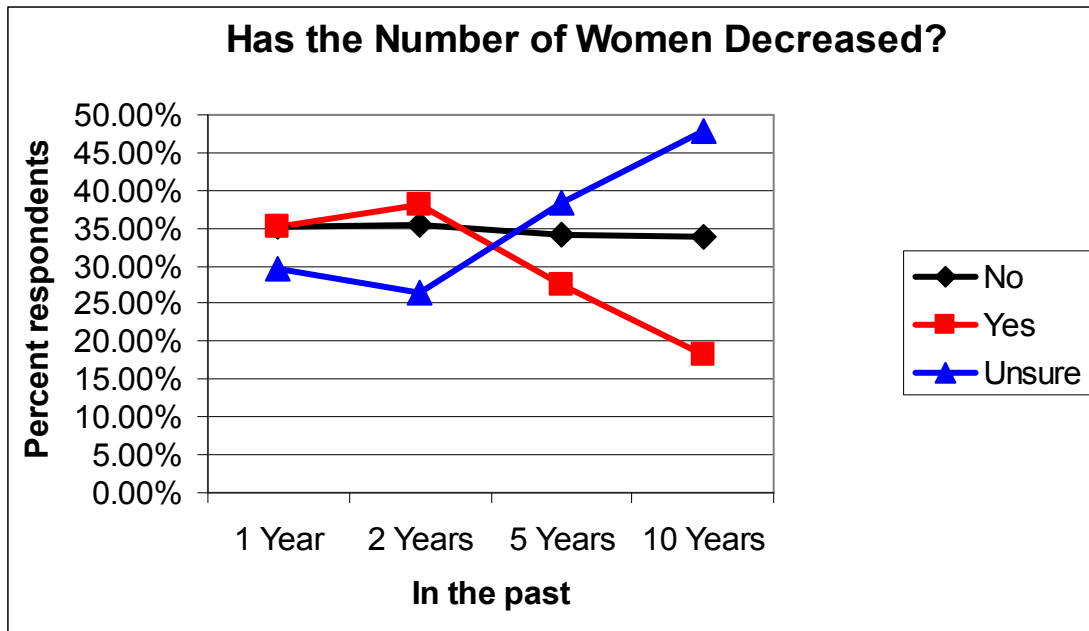
Figure 6: Has the enrollment of women decreased over the past year?

Figure 6 above shows the response to the question "Has the enrollment of women decreased in the past 1/2/5/10 years?" Seventy-nine respondents reported on women's enrollment in their undergraduate program over the past two years. Thirty (38%) reported that there has been a decrease in women's enrollment over the past two years, 28 (35.4%) say there has not been a decrease, and 21 (26.6%) were unsure.

Seventy-three respondents reported on women's enrollment in their undergraduate program over the past five years. Twenty-eight (38.4%) reported that there has been a decrease in women's enrollment over the past five years, 25 (34.2%) reported no decrease, and 20 (27.4%) were unsure.

Seventy-one respondents reported on women's enrollment in their undergraduate program over the past ten years. Thirty-four (47.9%) were unsure if there had been a decrease in women's enrollment over the past ten years, 24 (33.8%) reported no decrease and 13 (18.3%) reported there was a decrease. Figure 12 below summarizes the results (N=71).

Of the 82 respondents who were asked if there had been an effort to increase the en-

rollment in their major over the past year, 57 (69.5%) reported that there had been such effort, 20 (24.4%) reported no effort, and five (6.1%) were unsure.

The majority of these respondents reported that the efforts to increase enrollment in their major involved increasing recruitment efforts to local high schools, making changes to the types of courses in their major, and increasing articulation agreements. All of the selections on the questionnaire were chosen by at least five of the total respondents. Six respondents added other steps taken at their institution to increase enrollment. These included modifying admission criteria and adding an IT major, creating a marketing campaign geared towards parents and alumni, working on accreditation and revamping the curriculum, partnering with area professionals, and improving the communications with applicants and freshman. Figure 7 below summarizes the responses.

Figure 7: Efforts to increase enrollment

Respondents	%	Steps take to increase enrollment
38	46.34%	Increase recruitment efforts to local high schools
31	37.8%	Make changes in the types of courses in your major
30	36.6%	Increase articulation agreements with community colleges/IT schools
24	29.2%	Create new major(s) with other departments)
24	29.2%	Create new track(s) in your major
24	29.2%	Increase recruitment effort to community colleges/IT schools
16	19.5%	Create (a) minor(s) in your major
15	18.29%	Create (an) internship program(s)
13	15.8%	Create an external Advisory Board
9	10.9%	Create (a) summer program(s) for
6	7.3%	Create area(s) of IT certification
5	6%	Decrease the number of courses required for your major
1	1.2%	Modify CS admission criteria, add IT major
1	1.2%	Marketing campaign to parents, alumni
1	1.2%	Partnering with area IT professionals
1	1.2%	Accreditation; re-vamp curriculum structure
1	1.2%	Contact applicants; start curriculum review
1	1.2%	Better communications with entering freshman

5. DISCUSSION

Based on the recently published figures, such as a 32% decline in incoming CS majors over four years (2000-2004) and the survey results reported in this paper, it is clear that enrollment has decreased for CS/IS/IT programs. There are many reasons cited by the media and by our respondents for this decline, including the per-

ceived lack of "good jobs." The research firm Gartner reports in *InformationWeek* that 30% of IT jobs in the United States will be sent offshore by 2015 (McDougall, 2005). Many of these outsourced jobs are expected to be entry-level positions that do not require high-level skills. Jobs that require customer interaction and require innovative thinking are less likely to be outsourced offshore. As CIS/MIS programs have long recognized, these jobs will require a cross-disciplinary outlook and a strong understanding of the business environment. Academic programs that focus on soft skills such as communication and interpersonal skills may better prepare students for IT jobs that require collaboration, project management and problem-solving skills (Woratschek and Lenox, 2002).

Students may be frightened away by reports that the IT industry is outsourcing most jobs or that the dot.com bust adversely affected IT careers. However, U.S. Labor statistics are clearly optimistic and employers are worried that they will not have sufficient graduates to fill available entry-level positions.

To some degree, it is a moot point whether or not the number of "good jobs" has actually decreased, since potential CS/IS/IT majors are already reacting as if the job market has dissipated. Many parents see IT as too unstable in the wake of the dot.com bust or faulting the U.S. education system in failing to provide qualified IT graduates. However, in a May 2005 interview with *ComputerWorld* Gerald Cohen, the CEO of Information Builders Inc. disagrees "That's bunk. Why do you have declining computer science majors? Because every parent is saying 'Why major in computer science when all the jobs are going offshore?' It feeds itself. And I guarantee you, if it doesn't stop, in a couple of years you're not going to have much of an IT industry here." (Tennant, 2005).

We need to sell potential students and their parents on the idea that IT is and will be a good career. Efforts to educate the next generation in seeing IT as an energetic, growing occupation must be directed to parents, college-age students and their younger counterparts in high school and middle school.

Perhaps efforts to work more closely with industry (and/or External Advisory boards)

to provide career mentoring will help alleviate students' fears about long-term CS/IS/IT careers. In the authors' experience, students who participate in internships, summer jobs, career shadowing or service-learning courses show greater enthusiasm for the field. Role models are crucial to fostering continued interest in CS/IS/IT careers.

Many of the suggested ways to increase enrollment in our programs focuses on increased recruitment of students prior to college. However, as O'Lander (1996) suggests, students, especially women, may be first attracted to the institution, and then to a particular major. CS/IS/IT faculty, along with industry partners, need to brainstorm about ideas on how to attract students, particularly women and minorities, from other disciplines.

The authors are continuing a spirited debate over whether adding new tracks/majors/minors/hot topics helps or hurts CS/IS/IT programs in the long run. Swanson (2005) reports on changes to the curriculum that Purdue University has made in response to offshore outsourcing of IT jobs. The altered focus of several courses produced positive responses from both faculty and students.

6. CONCLUSIONS

Only time will tell if the current declines in CS/IS/IT enrollment are part of cycle, as was seen in the mid 1990s. Two major differences in the current decline of students are disappearance of women students and the perception that IT careers are unstable.

The serious decline in women and minority students leads the authors to believe that this is more than just a simple cycle that will correct itself in the future. Despite the fact that the message has been heard numerous times, it bears repeating: Women, and also minorities, are an important part of the CS/IS/IT future and a way must be found to actively engage and retain them in the profession.

It is important to communicate to our target audience (parents, students and employers) that careers in CS/IS/IT are important and obtainable and that as the CS/IS/IT field changes, so does the educational approach to preparing qualified students. An increased awareness of the cross-disciplinary

nature of CS/IS/IT and increased collaboration with other disciplines will help produce graduates with strong CS/IS/IT skills. In addition, we must utilize the same soft skills we desire to instill in our students to work with industry and with the media to change the perception of CS/IS/IT careers.

7. BIBLIOGRAPHY

- Chabrow, E., (2004). By the book: Declining computer-science enrollments should worry anyone interested in the future of the U.S. IT industry. *InformationWeek*, August 16, 2004. <http://www.informationweek.com/shared/printableArticleSrc.jhtml?articleID=29100069>. Retrieved April 26, 2005.
- Ferguson, E., Huen, W., Henderson, P. B., and Kussmaul, C. (2005). IT offshore outsourcing: impact on CS/IS curriculum. *SIGCSE '05*, February 23-27, 2005. St. Louis, Missouri. pp. 258-259.
- Foster, A. L. (2005). Student interest in computer science plummets. *The Chronicle of Higher Education*, May 27, 2005, pp. A31 - A32.
- Harris, C. CS classes see deep in enrollment after tech-bubble burst. *Brown Daily Herald - Campus News Issue* 10/12/04. <http://www.browndailyherald.com/global/user.elementes/printpage.ffm?storyid=750102>. Retrieved April 25, 2005.
- Herbert, D. CS enrollment plunges in bad economy. *Stanford Daily*, April 7, 2004. http://daily.stanford.edu/empol!page=print-table&repository=0001_article&id=13649. Retrieved April 26, 2005.
- Hoganson, K. (2004). Computer science curricula in a global competitive environment. *Journal of Computing Sciences in Colleges*, Vol. 20, Issue 1, October, 2004, pp. 168-177.
- Kessler, M. (2005). Fewer students major in computer. *USA Today*. http://www.usatoday.com/money/industries/technology/2005-05022-computer-science-usat_x?csp=34. Retrieved June 13, 2005.

- Mahmoud, Q.H. (2005). Revitalizing computing science education. *Computer* 05/05 Vol. 38, No. 5, pp. 98-100.
- McDougall, P. (2005). 20% of tech jobs at risk from offshoring, Gartner says. *Information Week*, April 4, 2005. <http://www.informationweek.com/story/showArticle.jhtml?articleID=160401701>.
- McGrath-Cohon, J., Tilberg, H., and Shwalb, R. (2004). Attracting women and men to CS programs. SIGCSE '04, March 3-7, 2004, Norfolk, VA.
- O'Lander, R. (1996). Factors effecting high school student's choice of computer science as a major. CQL '96, Philadelphia, PA. pp. 25 - 31.
- Schoenberger, K. U.S. students shun computer sciences. *Mercury News*, March 24, 2004. Retrieved April 26, 2005.
- Swanson, D. A. (2005). Offshore Outsourcing drives curriculum. Proceedings of the 2005 ASCUE Conference, June 12-16, 2005, Myrtle Beach, SC.
- Tennant, D. (2005). Q&A : Information Builders CEO blasts Gates' H-1B stand. *ComputerWorld*, May 2005. <http://www.computerworld.com/printthis/2005/0,4814,101493,00.html>.
- U.S. Department of Labor Bureau of Labor Statistics. (May 18, 2004). Occupational handbook. <http://stats.bls.gov/oco/oco20016.htm>. Retrieved April 26, 2005.
- Vesgo, J. (2005). Interest in CS as a major drops among incoming freshmen. <http://www.cra.org>. Retrieved June 13, 2005.
- Woratschek, C. R. and Lenox, T. L. (2002). "Information Systems Entry-Level Job Skills: A Survey of Employers." Information Systems Education Conference (ISECON 2002). San Antonio, TX. October 31 - November 3, 2002.*
- Zweben, S. (2005). 2003-2004 Taulbee Survey. Record Ph.D. production on the horizon; undergraduate enrollments continue in decline. *Computing Research News*, Vol. 17 (3).