Factors Influencing Students' Decisions To Major In A Computer-Related Discipline

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Abstract

Too few students are entering the workforce with the technological skills required due to several factors, including under-enrollment in the computer-related disciplines by college students. Enrollment in these disciplines has made some progress since the precipitous decline of 2000 – 2007 and steps have been taken to attract more majors. However, we still do not fully understand the factors that influence students to choose to major in the computer-related disciplines. The purpose of the research described here was to: 1) explore, in-depth, specific factors that might influence a student's decision to major in a computer-related discipline and 2) determine if there were commonalities amongst these factors across the subject population.

Keywords: enrollment, recruitment, retention

1. INTRODUCTION

Preparing a technologically educated workforce is an important challenge facing the United States. The Bureau of Labor Statistics (BLS) predicts employment increases in many STEM-related disciplines and Congress has indicated concern that there will be sufficient workers to meet this demand (Stine & Matthews, 2009). Between 2006-2016, the BLS believes computer and mathematical occupations will grow the most quickly (0.8 million jobs; 24.8% growth rate) with other occupational groups related to science and engineering to grow as well, including architecture and engineering (0.3 million jobs; 10.4% growth rate), and life, physical, and social sciences (0.2 million jobs; 14.4% growth rate). Of the 30 fastest growing occupations, with a growth rate of 27% for all the occupations, many are science and technology-related; compared to the 10% average (Bureau of Labor Statistics).

There are three issues of concern: 1) The quality of preparation in science, technology, engineering and mathematics (STEM) for pre-collegiate students; 2) the low number of students majoring in the STEM disciplines in college; and 3) whether foreign students and workers are necessary to meet the workforce demands (Stine & Matthews, 2009). The second issue will be discussed in this paper.

2. LITERATURE REVIEW

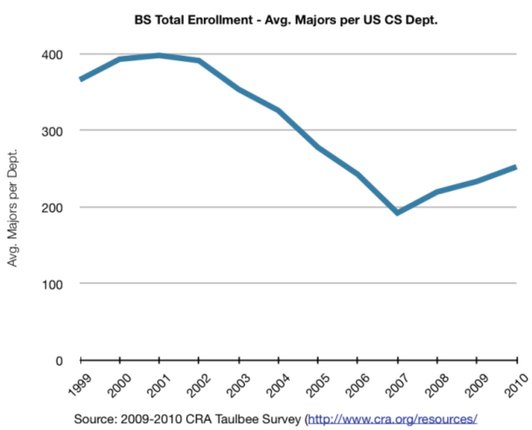

Figure 1: Enrollment Trends

From 2000 to 2007, collegiate enrollments in the computer-related fields steadily declined with a turnaround in enrollments the last three years (Harsha, 2011) (see Figure 1). This upswing in collegiate enrollment is encouraging, but insufficient to provide enough workers in STEM fields and problems are appearing in other parts of the educational system. In spite of the increase in enrollment, state budgetary cuts and low enrollment numbers of students intending to major in a computer-related discipline has jeopardized or eliminated many higher-education computer-related majors/ departments. Nagel (2009) reported that the number of students enrolled in computer science (CS) courses is declining in U.S. high schools and therefore, so is the number of advanced placement (AP) computer science courses offered. In a Spring 2009 survey of 1,100 high school computer science teachers, 65% reported that their schools offer introductory or pre-AP CS classes (2009 CSTA National Secondary Computer Science Survey). This number was 73% in 2007 and 78% in 2005. Additionally, AP CS was only offered at 27% of the schools in 2009; it was 40% in 2005 and 32% in 2007. The Commission on Professionals in Science and Technology (CPST) report commented on the decline of CS courses in high school, "One possible reason is computer science is not considered a core subject under the No Child Left Behind law, resulting in classes and resources being distributed to classes that are integral to school funding under the law. Unfortunately, this results in students growing up using computers more and more in their daily lives with no understanding of how the technology works" (STEM Trends, 2010).

Reasons For Under-Enrollment In CS Disciplines

A myriad of reasons have been hypothesized for the decline in computer-related disciplines enrollment from 2000-2007. These reasons have focused on the reported decline in the number of "good tech jobs" (Hoganson, 2004), the outsourcing of American IT jobs to foreign countries where labor costs are lower and skilled workers are plentiful (Holahan, 2007), the debate in Congress whether to increase the numbers of foreign skilled workers allowed into the country under the H-1B visa program, the dot com bust of the 2000-2001, the terrorist attacks of September 11, 2001 and their effect on the U.S. economy, and the budget cuts of many companies in the IT area.

Other researchers have offered non-economic possibilities. Morris and Lee (2004) argued that the decline in undergraduate CS enrollment might be because of the way we educate our students. "… our current approaches to computer science education fail to teach the science of computing. As a result, they fail to inspire the very best and brightest minds to enter the field … Computational methods are transforming an amazingly wide range of scientific, business, and artistic practices. Computer science enables science to be both fundamental and practical at the same time."

Ways to Attract Students

Just as there are many possible reasons why incoming students were not selecting CS as a major, there are many responses including ignoring declining enrollments (Herbert, 2004). Another response has been to create alternate methods to provide students with the “hot topic” skills they desire; for example, offer one credit courses/seminars on practical IT topics. Yet another response has been to start IT programs.

Mahmoud (2005) suggested 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 was for academia to work closer with industry to identify desirable skills (Chabrow, 2004; Ferguson, Henderson, Huen, & Kussmaul, 2005).

The idea of connecting the teaching and learning of CS to the broader world perspective/ multidisciplinary approach was discussed by various researchers. A 2004 NSF effort was focused on incorporating the history of computing in to computing curricula to broaden the focus of the field off of just narrow applications. Perez and Murray (2008) discussed the development of an information technology literacy course named *Computers and your World* as a service course to the institution. The learning objectives of the course included: 1) “Become a well-rounded, confident and curious user of computers and the Internet; 2) Use computer applications to solve common problems encountered at school, work, or home, and 3) Be familiar with how computers and the Internet are used in various professions” (p. 223).

Barr, Liew, and Salter (2010) reported on strategies used at Union College, Lafayette College, and Oberlin College to build bridges between CS and other departments/disciplines. At Union College, the CS faculty worked with faculty-student pairs in other disciplines developing some form of curricular component (complete course, lab, or module). This insured computation into the study of a specific discipline. The disciplines involved were Biology, Classics, Engineering, and Economics. The CS department at Lafayette collaborated with faculty from other departments to develop tools to assist them in research and teaching. Tools were developed with faculty from Art, Engineering and Public Policy, and Social Science. Oberlin College faculty in the natural and social sciences created The Oberlin Center for Computation and Modeling (OC-CaM). The goal for the Center was to develop a unified approach to introducing computation and modeling into the curriculum (Barr, Liew, Salter, 2010). Abernethy and Treu (2010) discussed instituting two new seminars at their University to address declining CS enrollments and demonstrate the multidisciplinary nature of computing and its connection to the world. The seminars are Alan Turing’s work and life and cryptography.

Thibodeau (2011) stated that the Computer Research Associate survey done in Fall, 2010 found that men continue to dominate CS. The women who graduated in CS rose to 13.8% in 2010, but this was only an increase of 2.5% from the previous year. For the past decade the number of women who have entered CS has been dropping and many studies/reports have been done concerning the disappearance of women in the computer related fields. Some of these include: 1) National Science Foundation, 2) Women in Information Technology Project, 3) American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education, and Computing Research Association (CRA) Taulbee Survey (Geigner & Schamabach, 1999; Green, 2000; Irani, 2004, Sankaran & Bui, 1999). These studies agree that there are multiple dimensions regarding the under representation of women in the computer-related disciplines.

In 2006 Dann, Cooper and Pausch introduced the “Beginner Programming Languages” as a way to make it easier to learn the concepts and methods of programming through visual and interactive learning environments. Alice, developed by Carnegie Mellon University, is among the leading languages in this group with many researchers reporting on the pros and cons of using Alice as a programming language (Goulet & Slater, 2009; Courte, Howard, & Bishop-Clark, 2006). Bryn Mawr College and Georgia Tech introduced Artificial Intelligence and Robotics in the CS1 course in Fall, 2007 in order to make CS1 more fun (Kumar et al, 2008). Other universities like Northwestern, Kettering, and Drexel have introduced computer gaming in the CS curriculum to attract student interest.

Attitudes toward Computer Science-Related Majors

What factors influence students to choose a major in computing? O'Lander (1996) collected data from 4,127 New York high school students who were enrolled in a computer course concerning the factors that influenced their attitudes towards computing. He found that these factors 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.

Carter (2006) conducted research to test a number of hypotheses. Among them was that students, regardless of gender, do not pursue education in computing fields because they have no information or incorrect information about what the study of computing involves and what sorts of careers are available to computing professional. Surveying some 836 High School students from nine different schools in Arizona and California, she found evidence to support the beliefs: 1) students choose not to major in CS because they have incorrect or no perception of what CS is, and 2) one of the reasons for this ignorance is the lack of CS education available to or required of high school students beyond the realm of computer applications.

Pollacia and Lomerson (2006) attempted to determine the factors that influence a student's decision regarding a computer information system (CIS) major. They surveyed students enrolled in a first-year introductory computer courses. They found: 1) students have limited knowledge (inadequate and/or inaccurate) of the career opportunities in CIS; 2) many of the respondents choose their major using only self-developed information and did not rely on family, peers, the media or high school counselors; and 3) there are a wide variety of causes for disinterest in a computer career (Pollacia & Lomerson, 2006).

In 2009, DiSalvo and Bruckman examined the relationship between video games and interest in computer science. They found that gaming was weakly correlated with an interest in majoring in computer science.

Woratschek and Lenox (2009) replicated and enhanced the Pollacia and Lomerson study. Their findings confirmed that of Pollacia and Lomerson: students picked their major course of study via self-collected inputs; students seem to have limited knowledge of the fields of computer and/or career opportunities in these fields; students have stereotypes regarding the computer fields; more work needs to be done regarding student's school guidance counselor experience; and that students were not interested in technical careers.

Moore, Schoenecker, and Yager (2009) conducted a survey in Fall 2007 using School of Business marketing students. This survey collected data regarding why there are not more Computer Management and Information Systems (CMIS) students at their institution. Specifically, the survey gathered data about factors that influenced business students' choice of a major and the perceptions these students have of the CMIS major. In a different survey, introductory CMIS students were asked whether they were considering a major in CMIS, and why or why not. Results of these surveys revealed two themes. One theme suggested that there are misconceptions about the CMIS major. (Respondents believed that the employment market was poor for CMIS majors. They believed the CMIS majors and graduates worked with MS Office all day. The final misconception was that CMIS majors and graduates sit in front of a computer all day.) The second theme suggests that students may avoid the CMIS major because they doubt their ability to do well in it.

In a study performed by Serapilgia and Lenox (2010), six themes were identified as factors that affect the decision of women to enter into and complete, or leave a course of study in Information Science programs. These themes were: 1) Influence by male role models; 2) positive introduction to computers/technology in the home and school; 3) a natural affinity for problem solving; 4) early positive exposure to computers/technology; 5) meeting the challenges of a dynamic field; and 6) greater opportunity for higher salaries. One of the strongest themes found by the researchers was influence of a male role model; only 2 out 25 students mentioned a female influence. Many respondents mention that they enjoyed puzzles and solving problems. They also were influenced by an exposure to technology at home, school and/or in the workplace.

The under-enrollment in computer-related majors, the continuing retirement of baby-boomers, and the increasing use of computers in all fields is expected to create a substantial number of computer related jobs in the U.S. in the future. As already has been stated by a number of authors, the shortage of qualified graduates in the computer-related profession will be a significant problem.

While the research discussed has been by quantitative survey, little research has been done in the qualitative methodology to explore why students choose to major in the computer-related disciplines. The purpose of the research described here was to: 1) explore, in-depth, specific factors that might influence a student's decision to major in a computer-related discipline and 2) determine if there were commonalities amongst these factors across the subject population.

3. METHODOLOGY

Qualitative one-on-one interviews were conducted in the Spring, 2011 term across three Western Pennsylvania higher educational institutions. Instructor prompting, class fliers, and/or word of mouth recruited students. Students were declared majors in Computer Science, Computer Information Systems, Information Systems, or Information Technology. In all 36 students were interviewed.

The majority of interviews lasted 20 minutes. The interviewer took written notes on the student's responses. No recording of the interview was done. The interviewer's notes were transcribed, and Key-Words-in Context method was used to search the text files for key words and phrases to identify commonalities and differences in the data and a content analysis performed.

4. RESULTS

Six (16.6%) of the students interviewed were female and 30 (83.3%) were male. Eighty-three percent (30) are public schooled and 86% (31) are traditional students (ages 18-22).

Because respondents are from three different institutions, there are multiple categories of computer-related majors and not all majors are offered by all of the institutions. For example, one of the institutions does not offer a Computer Science degree. Another institution offers students the chance to double major in the discipline where the others do not (see Table 1).

DECLARED MAJOR (N=36)	
Computer Science (CS)	5
Computer Information Systems (CIS)	1
Information Systems (IS) or Management Information Systems (MIS)	21
Web Development	4
E-Commerce	1
Double: Web dev. & E-commerce	3
Double: CS & Web dev.	1
Double: Business Comm. & E-commerce	1

Table 1: College Major

ACTIVITIES	
Had computer when young	25
Video Games	13
Took apart things (may include computers)	5
"Messed" with computers	5
Played Educational Games	4
Problem Solving	4
Liked Puzzles	1

Table 2: Childhood Activities

As Table 2 indicates, the strongest themes that emerged in regard to the participant's childhood activities is that 69% (25) had a computer when they were young; i.e., before they were 13 years old. Thirteen of the respondents (36%) mentioned that they played video games as a child.

For 44% (16) of the respondents, interest in choosing a computer-related field as a collegiate major began in high school, specifically in a computer class. For all 16 of these respondents, that computer class was some type of programming. The respondents who chose a family member as a factor that influenced their college major decision spoke of a brother, father, or uncle – no female role models were mentioned (see Table 3).

INFLUENTIAL FACTORS	
High School Class	16
Family Member	4
Just liked it; learned how to program young & was good at it	4
College Class	3
Video Games	3
Liked problem solving & helping people	1
Saw it had a good future & job security	1
Friend	1
Taking the computer apart and fixing it at a young age -- it made me feel smart	1

Table 3: Factors Influencing College Major Decision

HUMAN INFLUENCES	
Family member other than parent	10
Parent	6
Teacher	4
Job	1
Advisor	1
Hollywood Film Maker	1

Table 4: Did any one person influence your decision?

INFORMATION RESOURCE?	
Internet	12
Family member other than parent	7
On-line forums	5
Professor	2
Parent	1
Other Students	1
HS Class	1
Placement Test	1
Aptitude Test on-line	1
Friends	1

Table 5: What one resource did you use to get more information about computer science?

Table 4 details the respondent's answers regarding the human influence on their decision to major in a computer-related discipline. Of the 36 interviewees, only two spoke of a female influencing their decision to choose a computer-related major. And, those two were both males. All teachers mentioned by the respondents were male. Thirteen (36%) of respondents stated that no one person influenced their decision to major in the computer-related disciplines.

On-line appears to be the way that the majority of respondents received answers to their questions regarding majoring in a computer-related discipline. Family members are the second most popular resource followed by on-line forums (see Table 5). Twenty-four (66%) of the respondents commented that their high-school guidance counselor was of no help to them in securing information regarding majoring in a computer-related discipline in college.

WHAT DID YOU SEE YOURSELF WORKING ON WHEN YOU FINISH YOUR COLLEGIATE EDUCATION?	
Not sure	15
Job	8
Programming	5
Networking	4
IT Security	3
Further education	3
Video Games	2
Military Work	1
Web Development	1
OS/UNIX	1
Hardware	1

Table 6: Future Plans

As Table 6 shows, 42% (15) of the students are not certain what their future plans are; however, the vast majority stated that some type of work/education in the computer-related disciplines was in their future plans.

Three final questions were asked of the respondents: 1) was the major what they expected, 2) did they have a family member currently working in a computer-related discipline, and 3) were they satisfied with the major. Sixty-one percent (22) said yes the major was what they expected. Twenty-eight percent (10) of the respondents have a family member who is currently working in a computer science-related job. And, 94.4% (34) of the students were satisfied with their major.

5. DISCUSSION

Mahmoud (2005) suggested that CS departments should offer multidisciplinary and cross-disciplinary programs to attract more students. College 1 offers degrees in Computer Science, Ecommerce, Management Information Systems, and Web Development. College 2 offers degrees in Computer Information Systems, Competitive Intelligence Systems, and Information Sciences. College 3 offers degrees in Computer Science and Computer Information Systems. Only College 1 offers interdisciplinary majors and students may have a double major such as web development and e-commerce (3 respondents), CS and web development (1 respondent), or business communications and e-commerce (1 respondent). (College 1 has 19 computer science majors, 6 ecommerce, 7 web development, and 3 MIS majors.)

Score	2010	2009	2008	2007
5	183	134	102	116
4	178	161	105	137
3	95	63	59	78
2	35	51	42	52
1	125	124	117	105
Total	616	533	425	488
Mean	3.42	3.24	3.08	3.22

Table 7: Pennsylvania Totals – School AP Grade Distribution for Computer Science A Exams

Mahmoud (2005), and many others, suggested training computing science high school teachers will improve collegiate enrollments. In the current study, 44% (16) of the students were influenced by a high school programming class, but only one student mentioned their high school class as a source of information about majoring in a computer-related field. Four students mentioned the influence of a high school teacher on their career choice. Carter's (2006) research showed that students have incorrect or no information about CS. She found that this was partly due to the lack of CS education available to high school students beyond the how to use computer applications. Unfortunately, Pennsylvania, where the colleges in this study are located, does not certify K-12 computer science teachers. It is difficult to find data on the number of high schools offering computer science courses (i.e., programming rather than application software), so we have examined the number of students taking the Advanced Placement Exam A in Computer Science as a measure of high school preparation. Table 7 below shows the past four years in Pennsylvania where the number of students has increased from 488 in 2007 to 616 in 2010 (http://www.collegeboard.com/student/testing/ap/exgrd_sum/).

The Computer Science Teachers Association (CSTA) looks at strong teaching certification requirements in each state and has used the state of Maryland as a positive example. (http://csta.acm.org/ComputerScienceTeacherCertification/sub/CertificationResearch.html). Maryland has instituted the stricter teaching certification requirements and has seen increases in the numbers of students taking the AP Computer Science A exam from 808 in 2007 to 1,352 in 2010 (see Table 8 below).

Score	2010	2009	2008	2007
5	352	215	149	162
4	301	202	138	180
3	177	128	86	118
2	84	84	54	61
1	438	266	148	287
Total	1352	895	575	808
Mean	3.03	3.02	3.02	2.84

Table 8: Maryland Totals – School AP Grade Distribution for Computer Science A Exams

Several studies (Woratschek & Lenox, 2009; Pollacia & Lomerson, 2006) found that students picked their major course of study via self-collected inputs. Table 5 shows that 19 of the 36 students (53%) used the Internet or an on-line forum as their primary source of information about majoring in a computer-related field. Other self-collected inputs appear to be (in decreasing order of mention): family member other than parent and professor; and with one mention each: parent, other students, high school class, placement test, aptitude test on-line, and friends. A follow-up study should examine the types of websites and on-line forums used as resources by potential majors.

Serapilgia and Lenox (2010) found that women were strongly influenced by male role models.

In the current study, only two of the 36 students spoke of a female influencing their decision to choose a computer-related major. Both those respondents were male. All teachers mentioned by the respondents were male also.

In 2009, DiSalvo and Bruckman found that playing video games was weakly correlated with an interest in majoring in computer science. In the current study, 13 of the 36 students (36%) mention playing video games; however, only three of the 36 (8.3%) stated that video games had an effect when selecting a major. Two of the students plan on careers in video game development.

6. CONCLUSIONS

Information about computer science-related majors and jobs is not found in the high schools. Early ideas about boosting interested in majoring in the computer-related disciplines suggested college/university departments sending newsletters to the high schools, professor visitations to the high schools, guidance counselor meetings, and collegiately run high-school computer science camps. Many of these ideas have been tried with mixed success. Recently, some colleges/universities have begun to explore high-school college partnerships. This idea may be a better way to educate K-12 teachers on technology careers and to better educate ourselves on how to build bridges between potential majors and ourselves.

In this study students stated that they found information about majoring in a computer-related discipline on-line. This begs the question of how accurate and complete is this on-line information? It is one thing to secure information from a collegiate web page, but quite another to secure information from social media or an on-line forum. Perhaps a collegiately controlled on-line forum for our discipline is in order. Regardless, as a discipline, we need to find better ways to disseminate information about our field to encourage students and understand the role of digital media in doing so.

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