Effects of Secondary Education and Media on Notions about Computer Science in College Students

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***Abstract*—Two surveys of college students were conducted to study the students' perceptions and knowledge of computer science as a profession and as a career. Ignorance of the field was consistently observed in both samples. Students with an aptitude for computing tend to blame their high schools, media, and society for their lack of knowledge. These findings suggest that high school students need to be provided with a more balanced perspective on computing.**

***Index Terms*—computer science education, computer science student advising, computer science student retention, media stereotypes of computing professions.**

I. Introduction

The authors of this paper are interested in understanding how undergraduate student opinions and perceptions about computing, computer science as a discipline, and computer science as a profession influence their decisions to pursue computing majors. The career and financial rewards of and projected continued job growth in computing professions are significant. Why then do we not see more young people pursuing computer science degrees and careers in computing? Anecdotal evidence pointed to deficiencies in secondary education and media coverage. The authors solicited students' opinions via two online surveys, in order to document what students know about computing and where their knowledge came from. The authors are also interested in understanding why these misperceptions about the field and major continue to linger throughout society. This paper summarizes data from the authors' first survey and reports data from a new survey, including an analysis of each.

Attracting to and retention of students in computing majors are likely linked to student perceptions of computing professions. Correcting skewed views of what computing majors and professions entail is a likely key factor for attracting more students and eliminating retention problems faced by many universities. Resolving the perception issue would also likely help to self-select students who are a better fit for the majors and provide a more diverse population within the major and field.

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An extensive literature search did not find many publications reporting direct survey data from an undergraduate student population. Carter (2006) surveyed high school students. The survey results supported the belief that students choose not to major in computer science (CS) because they have an incorrect perception of the field, or none at all. A large percentage of students was opposed to CS because they imagined computer scientists sitting in front of computers and programming all day. The vast majority of students could not provide a description of what CS majors learn. This paper also implies that women are not choosing to major in computer science because they are not aware of the variety of fields in which it is used. This confirms the demographic spread in most computer science programs.

Biggers, Brauer, and Yilmaz (2008) surveyed recent Georgia Tech graduates whom recently graduated with BS degrees in computer science. The authors observed that student misperceptions were a possible cause of low retention rate in computer science majors, and offer implementation strategies for improving the retention of students in this institution's computer science department.

Hail and Carter (2009) studied computer games as a cause of low retention rates in CS departments. They found that many students who game a lot perform poorer in their studies. According to the authors, literature suggests that bright males are typically the students whom are most likely to be addicted to video games, which implies the said stereotype for computer scientists. Anecdotal evidence suggests that, because these students spend a lot of time on their computers playing games, they are automatically classified as "computer whizzes" by family members and friends, thus creating this false label.

Barker, McDowell, and Kalahar (2009) surveyed undergraduate students in order to identify which environmental and student factors best predict intention to persist in the computer science major. The authors found that males are more likely to enroll in computing majors but do not offer much concrete insight into why this is the case.

Brinda, Puhlmann, and Schulte (2009) noted that often pupils have only experiences in Information and Communication Technology (ICT), and therefore develop inadequate beliefs about CS. The authors believe that high schools are not providing students with adequate information about computing majors and fields. They propose educational standards for CS in lower high school in order to bridge ICT and CS.

Schulte and Knobelsdorf (2007) studied "computing

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biographies" written by students to study their experiences with computing and how those experiences may have been a starting point to computer science study. Hewner and Guzdial (2008) studied attitudes of graduating students. Students wrote about their relationship with computing and what influenced that relationship. The data suggest that college education—including introductory CS courses designed to be engaging, relevant to student interests, and focused on the practice of programming—did not have a significant effect on the students' attitude about computing and was not a viable way to significantly increase interest in computer science as a major.

Ruslanov and Yolevich (2010) reports results from the authors' first survey.

The authors of this paper developed two surveys, which were intended to find the reasons why college students as a group tend not to pursue secure and lucrative careers in computing. The objective was to ask college students a variety of questions about where their knowledge of computer science (or lack thereof) came from and gain insight into their thoughts on common stereotypes about computer science degrees, careers, and professionals. The data from these surveys confirm anecdotal evidence about students' knowledge and perceptions of computer science and where they came from; furthermore, conclusions drawn from the surveys give insight into the many social problems faced by the computing fields.

The paper presentation is organized as follows: a few notes on how the authors developed and administered the surveys, the data they obtained, analysis of the data, and their conclusions.

II. Survey Background

The first survey was designed independently by the authors and tested with two pilot groups of SUNY Fredonia college students in order to receive early feedback. The feedback from these groups was used to improve the survey. The request to participate in the survey was emailed by the Vice President of Academic Affairs to the entire SUNY Fredonia student body. A total of 354 responses were received out of the student population of approximately 6,000 individuals.

Responses and feedback from the first survey were used to improve the second. The second survey was extensively revised and enlarged. It asked for major, gender, and class standing information. Questions were added to probe deeper students' perceptions of computer science and their knowledge source. The second survey was administered in the same way to the same population approximately a year after the first. A total of 196 responses were received out of the student population of approximately 6,000 individuals.

For more information on methodology, see Ruslanov and Yolevich (2010) and the Appendix.

III. Data and Discussion: First Survey

The first survey administered to the student population at SUNY Fredonia did not ask identifiable information about the students due to hesitation by the SUNY Fredonia IRB.

Table I. Who or what the students feel is responsible for their knowledge about computer science.

High school teachers	34%
High school counselor	9%
College professors	38%
College advisor	7%
Social stereotypes	21%
Society in general	40%
Self	67%
The media	26%
Their parents	13%
Other reasons	19%

successful in computing. More than half of the survey respondents thought that only "computer savvy" people can be successful in studying computer science. This response was sadly as expected: most people confuse having expertise in computer science with "knowing how to use a computer". Similarly, almost two-thirds of the respondents thought that being on a computer a lot would give an advantage when studying computer science.

One-third of the respondents surveyed believed that playing computer games would give them an advantage when studying computer science. This confirms the existence of the common misperception that playing computer games indicates an aptitude for computing rather than a correlation that is simply attributed to common interests of the individuals.

The above data indicate that student perceptions of computer science professionals are skewed by social stereotypes.

Perceptions of the study of computer science: The survey asked the students what subjects they think are studied in computer science at the undergraduate level. The students viewed computer science as web design, software development, algorithms, building computers, databases, networking, mathematics, computer games, and surprisingly history. Responses sadly indicate the need for a learning and social environment with better balanced views of computer science.

Computing jobs: The authors were expecting the respondents to have flawed notions of the value of computer science education and the career opportunities it implies. Yet, most students were well aware of the career opportunities computer science offers. More than half of the students knew that jobs in the computer science field are not limited to programming jobs. Almost two-thirds of the respondents believed that computer science jobs rank higher in terms of salary as compared to other occupations with similar college degrees. Yet, only a quarter of the students believed that it is easier to get a job in the field of computer science compared to other fields with similar college degrees. Over two-thirds thought it was about the same. Students are well aware of the financial benefits of computing. The authors were expecting students to be aware of this if they followed current events. More often than not, current events related to computing discuss the rapid growth in computing technology and the

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Table II. Who the students feel is responsible for their lack of knowledge about computer science.

Their High School	42%
Their College	18%
Social Stereotypes	14%
Society in General	16%
The Media	13%
Their Parents	11%
They're Just Not Interested	54%

transition of developed countries to a computer-run society. Accordingly, students know there are jobs, and the rapid growth of computing implies high salaries. Less than 2% of the students thought that computing jobs rank lower than other professions in terms of salary.

Students' knowledge source: 42% of the respondents did not believe their high school counselor and/or college advisor gave them accurate and adequate information concerning the study of computer science. Although the amount of students in this category should have been lower, the authors expected this result. College advisors are usually within students' majors, and the authors did not predict that many students would credit them for their knowledge in computer science if they were not already enrolled in the major. However, it is the job of high school counselors to educate students on all areas of study and career opportunities. Only about one-third have done research about computer science in general, which is expected due to the above-shown lack of knowledge about computing we saw with most students. Table I lists who or what the students felt was responsible for their knowledge about computer science. Table II lists who the students felt was responsible for their lack of knowledge about computer science.

For their knowledge in computer science, the students credited themselves (67%), college professors (38%), high school teachers (34%), high school counselors (9%), college advisors (7%), and the media (26%). Most knowledge about computing is gained by students at the college level and not the high school level. Only 8% of the respondents claimed that their high school counselor or college advisor gave them "accurate and adequate information" about the study of

Table III. Whom students—who are strong in math and computer science but who are not interested in computer science—blame for their lack of knowledge of computer science.

High School	35%
College	13%
Social Stereotypes	13%
Society In General	16%
The Media	12%
Parents	10%
Just not Interested	40%
Other Reasons	6%

Table IV. Whom students—who are strong in math and computer science and who are interested in computer science—blame for their lack of knowledge of computer science.

High School	58%
College	22%
Social Stereotypes	22%
Society In General	26%
The Media	20%
Parents	16%
Other Reasons	10%

computer science. This is a serious indictment of high school counseling centers. Because high school counselors are one of students' main sources of career information, the authors would have liked to see more students credit them.

Stereotypes prevail: The survey questioned the students on common stereotypes about computer science. The data indicate that the students' opinions tend to follow the popular misconceptions—but not always. The media frequently portray computer scientists as "nerds." Yet, only 28% of the students believed that one must be a "computer nerd" to be successful in computer science. Another common misconception about the field is that students majoring in computer science are "geeks" and know everything about computers. The authors saw this idea prevail with more than half of the respondents agreeing that only "computer savvy" people can be successful in computer science. Only 13% of the respondents completely disagreed that playing computer games gives an advantage when studying computer science. Similarly, more than half (57%) of the students believed that using computers often gives an advantage when studying computer science. Likewise, the respondents commonly confused computer science with knowing an operating system, browsing the Web, website design, and writing programs. Yet, only 12% of the students thought that computer science jobs are programming jobs.

Not interested or undereducated? Students who excel in mathematics and computing classes in high school are expected to enjoy and be successful in the computing fields. These are individuals who would most likely succeed in a computer science career. The survey data reveal that 83 students believed that mathematics or computer science was their strongest academic subject. Out of these, 33 (40%) said they have no interest in the field and 29 (35%) said their high school did not give them adequate information about the field. See Table III for the complete list.

In addition, there were the 50 students who indicated that mathematics or computer science is their strongest subject and implied that they are interested in computer science. 58% of these students said their high school was partly responsible for their lack of knowledge about computer science. The percentage of students who believe their high school was responsible for their lack of knowledge in computer science increased 23% when considering only those students who implied they may be interested in the field. See Table IV for the complete list.

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The data obtained from the first survey suggest that misperceptions about computing fields at the undergraduate level stem from inadequate direction and education at the high school level.

IV. Data and Discussion: Second vs. First Survey

The second survey asked for some identifiable information, which provided the authors with a view of the students' demographics: gender, major, and class standing. In spite of the small sample size, the second survey confirms the data from the first.

Student Background: The most prevalent majors were business administration (38%), music (16%), computing majors (16%), and education (11%); the distribution was likely skewed toward the student populations/groups who were encouraged to take the survey. 55% of the respondents were male and 45% were female. Among computing majors who took the survey, 22% were female.

Student familiarity with computers in the second survey was similar to that of the first survey. The authors found that each group of students was using their computer to complete the same tasks, using the same operating system, and familiar with the same popular programming languages. However, differentiation was observed within the "strong subjects" of the two groups of students. The second survey observed about a 15% increase in students who excel in STEM subjects.

The first survey results revealed that students were not aware of what constitutes a person with an aptitude for computer science. The second survey observed the same, but not to the extent of the first. Only 19% of the students who took the second survey thought one had to be a computer nerd to be successful in computer science, and only 23% believed that playing computer games would help them with the study of computer science. Although these numbers are far from ideal, they are lower than in the first survey. Perhaps the second survey respondents inadvertently were preselected from more educated, well-rounded students. It is not known if there were more computing majors in the second sample because the first survey did not ask for any personally identifiable information. However, this is implied by the increase in STEM students. Similarly, the age distribution of the first sample is not known. However, seniors represented the largest portion of the second sample at 39%.

Perceptions of the study of computer science: The second survey again questioned the students on what subjects were studied in computer science. Rather than asking this in one question, the authors split it into two: "What subjects are studied in computer science classes?" and "What subjects constitute the formal study of computer science?". The intention of the question in the first survey was meant to be similar to the latter in the second survey, but the responses indicated that the students were confused. Some of the stranger subjects students chose, such as history, are in fact studied in computer science courses (i.e. the origins of computer science and history of the Internet) but do not constitute computer science specifically. As expected, when asked what subjects are studied in computer science courses, the variance in the responses was the same (although the ranges in the percentage of students for each response was proportionately lower than in the first survey). The authors' suspicions about confusion with this question in the first survey were shown to be justified. Although students still selected strange answers such as writing viruses (40%), computer games (35%), business (27%), history (20%), accounting (14%), and political science (6%), a decrease was observed. This is likely due to the clarification in the question. However, there is still an obvious need for clarification of the major of computer science. Thus, the first survey was confirmed in this aspect.

Computing jobs: As seen in the first survey, many students are aware of the career opportunities available in the computing field. Only 7% of the respondents believed that computer science jobs were limited to programming jobs, and 75% disagreed with that statement. Fewer students thought that computing jobs rank higher than other jobs in terms of salary, but only three students said computing jobs rank lower. The same percentage of students as in the first survey believed that it is easier to get a computing-related job when compared to other fields.

Students' knowledge source: Student sources of knowledge about computer science varied from the first sample of students. The same amount of students credited themselves for their knowledge in computer science (68%). This remained the dominate source of knowledge. There was a large increase in students who credited their college professors (59%) when compared to the first survey. There was also a slight increase in the contribution of high school teachers (39%). Although it seemed as though high school counselors could not perform worse when educating students about computer science, the authors found that even fewer students accredited them. Only 3% of the students in the second sample recognized their high school counselors for their knowledge in computer science. Similarly, an increase in responsibility was put on high schools for students' lack of knowledge. 51% blamed their high schools, which is a 10% increase from the first sample. Lack of interest (38%) and social stereotypes (18%) were also among the top sources that did not provide adequate and accurate knowledge to the students.

Thus, the second survey substantiates the results from the first survey. Yolevich (2010) presents tables that compare data from similar questions from the two surveys; the Appendix presents several questions in which the data from the second survey confirmed the first.

V. New Data and Discussion: Second Survey

Although the first survey gave a good overview of students' opinions and the data from the second survey confirmed the data obtained by the first survey, the authors wished to gain more insight into the thoughts of the students. With this purpose in mind, several questions were included in the second survey. The authors will now discuss some of the more in-depth thoughts from the respondents' perspectives.

Familiarity with computers: It was confirmed that most students are only somewhat familiar with their personal computers, but it was not clear as to what extent. A number of questions were asked in order to gain an understanding of how familiar students were with every-day activities

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Table V: Do you believe X gave you accurate and adequate information concerning the study of computer science?

Responses\X	your high school teachers	your high school counselors	your college professors	your college advisor	the media	your parents
I strongly disagree	20%	35%	9%	18%	11%	19%
I disagree	26%	28%	10%	21%	30%	17%
Neutral	29%	24%	27%	36%	31%	37%
I agree	16%	4%	35%	13%	19%	14%
I strongly agree	2%	2%	14%	4%	3%	7%
I do not know	6%	5%	3%	6%	6%	5%

performed on computers. Students were asked how familiar they were with their firewalls and anti-virus software, two aspects of a computer that should be understood by an everyday user. Surprisingly, 23% knew nothing about their firewalls, and 11% knew nothing about their anti-virus software. When asked what was the most important feature of an operating system, 14% of the respondents indicated that they did not know (implying that they did not know what an operating system was); however, 27% claimed the security was most important to them, and 48% claimed stability was most important to them. The authors expected more familiarity with such every day computing knowledge, considering that college students are required to perform computer tasks, the current generation's exposure to information technology and that nearly 100% of SUNY Fredonia students own a computer.

When asked what they knew about some more complex terms used in computer science, many students were familiar with the terms such as file manager (80%), virtual memory (69%), device manager (68%), and process manager (58%). Fewer students were familiar with the terms scheduler (32%), kernel (30%), shell (29%), interactive processing (24%), bootstrapping (23%), and dispatcher (23%). Although some of these numbers are low, the authors expected them to be consistent with the number of students who are strong in STEM subjects, which was 33% in the second survey.

Computer science as a profession: The survey respondents were asked what they thought was necessary for success in the field of computer science. Most students were aware of the traits needed to be successful in computer science. 82% felt that strong problem solving skills were necessary. Similarly, 71% thought one would need to be able to troubleshoot errors, and 59% thought strong math skills would be useful. This shows that most students are aware of the attributes seen in and necessary for a successful computer scientist.

Table VI. Do you believe there should have been more Computer Science classes offered at the high school level?

Yes	86%
No	12%

Students' knowledge source: who is responsible? The second survey administered to the SUNY Fredonia campus went beyond asking the students who was responsible for their knowledge in computer science; it reached deeper into specific sources. Students were asked specifically whether or not each listed knowledge source gave them accurate and adequate information pertaining to computer science. When asked specifically, only 6% believed their high school counselors gave them proper knowledge. Similarly, high school teachers (18%), college professors (51%), college advisors (17%), media (22%), and parents (21%) were attributed by the respondents for their contribution to the respondents' knowledge, see Table V for complete data. Thus, according to the students, their high school teachers and counselors failed as a good source of knowledge concerning computer science.

Although most students did not credit their high schools for their understanding of computer science, more than half of the students were exposed to it at the high school level. 64% of the respondents said that their high schools offered computer science courses. About half of the students believed these classes were of adequate quality, and 86% of the students believed that there should have been more of these classes offered, see Table VI. Table VII illustrates the ways in which respondents believed their high schools communicated the importance of computer science.

VI. Conclusions

The surveyed college students were found not to be well-informed about computer science. The students who are

Table VII. In which ways did your high school show that it realized the importance of computing to innovations in the 21st century, if any?

Adding more Computer Science classes	33%
Adding more Computer Science teachers	16%
Adding additional funding to the Computer Science department	15%
My high school did not have Computer Science classes	28%
My high school HAD Computer Science classes, but did not add any of the above	32%

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most likely to succeed in the major mostly hold their high schools responsible for their lack of knowledge; furthermore, students are subconsciously aware of the traits needed for success in computer science. Based on the survey data, the authors conclude that high schools, media, and society should do a better job at providing students with a well-balanced perspective on career opportunities in computing fields.

APPENDIX

The tables presented here are examples of similar questions from the two surveys and the corresponding data obtained. The first column contains the answer selections while the second and third contain the number of students who selected that particular answer from the first and second survey respectively (out of a total of 354 and 196 responses respectively).

Compared to other occupations with similar college degrees, where would computer science jobs rank in terms of salary?

Lower than most other jobs	5	3
About the same as most jobs (average)	140	49
Higher than most other jobs	207	118

Compared to other fields with similar college degrees, how hard do you think it is to get a job in the field of computer science?

Easier than most other fields	90	49
About the same as most fields (average)	228	90
Harder than most other fields	32	16

Who or what do you feel is responsible for your knowledge about computer science? (check all that apply)

Your high school teachers	117	75
Your high school counselor	31	6
College Professors	132	114
Your College Advisor	25	13
Social stereotypes	72	18
Society in general	141	76
Myself	234	131
The media	91	50
Your parents	47	48

Who, if anyone, do you feel is responsible for your lack of knowledge about computer science? (circle all that apply)

Your high school	132	93
Your College	57	32
Social stereotypes	44	33
Society in general	52	33
The media	42	28
Your parents	34	32
I'm just not interested in computer science	173	69

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