AC 2007-2066: VIEWPOINTS FROM THE DOORSTEP: WHAT'S TURNING STUDENTS AWAY FROM COMPUTER SCIENCE AND ENGINEERING?

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computer science and engineering?

Abstract. The current, sharp decline in interest in computer science and engineering (CSE) motivates our investigation of why beginning undergraduates reject CSE as a major. We present a thematic analysis of 14 semi-structured interviews with pre-major undergraduates newly enrolled in the first introductory CSE course (generically referred to as "CS1") at a large, public research university. Our findings illustrate a range of well-formed, negative perceptions about CSE. Many students' concerns had little to do with the intellectual content of the discipline and instead focused on the culture and lifestyle associated with academic and professional life in CSE. Our conclusion discusses the challenge undergraduate CSE education faces in addressing these perceptions and concerns in order to help students make more informed decisions about majoring in CSE.

Introduction

After years of booming interest, enrollment in computer science and engineering (CSE) is now suffering a startling, rapid drop in North America. Between 2000 and 2004, the fraction of incoming undergraduates planning to major in computer science fell by over 60%, and, historically, this statistic has accurately predicted bachelor's degree production.[1] Likely consequences include a shortage of qualified, domestic candidates for computing-related jobs and the downsizing or even elimination of CSE programs and departments.

Having recognized the enrollment problem exists, the broader CSE community is beginning to address the more difficult question of *why* enrollments are dropping and what can be done in response. A small, interdisciplinary community has been doing high-quality research on these questions in the more specific context of the gender gap in CSE. (For an excellent, current overview and sampling of research, see Cohoon & Aspray's edited volume.[2]) Much of the research to date focuses on why students drop out of CSE, commonly around the second year of undergraduate study. The complementary question of why beginning undergraduates reject CSE as a major is relatively less examined. Although reasons for leaving CSE are likely to be related to reasons for entering (or not) in the first place, this is an assumption worth examining. Our study aims to address this need by investigating pre-major undergraduates' perceptions of majoring in CSE and of the career paths they associate with it.

This paper presents a selection of findings from an interview-based, qualitative study of prospective CSE majors at a large research university. This research primarily aims to detail the range of student perceptions about CSE, rather than to make broadly generalizable claims. However, the responses exhibit some patterns in beliefs about and interest in majoring in CSE. We focus here on findings most likely to inform efforts to recruit, support, and retain CSE majors into and through their first year of undergraduate study. Many of the interviewed students' concerns had little to do with the intellectual content of the discipline and instead focused on the culture and lifestyle associated with academic and professional life in CSE. To these students, the CSE life was one of unhealthy competitiveness, high stress, social isolation, and little time for life outside of school or work...and all this for what? Many students admitted

they were not sure; they were uncertain about the content of CSE or perceived the discipline to be narrowly constrained to computer programming and other technical (*vs.* social or interdisciplinary) content.

After a brief overview of the research study, the following three sections of the paper each discuss a theme: unfamiliarity with CSE; perceptions of a narrow, technical focus; and undesirable lifestyle/culture. The concluding section suggests practical implications of the findings.

Study overview

To contribute to a more empirically-based understanding of the decline in interest in CSE, we collected and analyzed detailed, first-hand perspectives on what attracts/repels beginning undergraduates to/from CSE. The perspectives were gathered in 45- to 60-minute, semi-structured interviews conducted with 14 first- and second-year undergraduates who were newly enrolled in the 2006 winter offering of the first introductory CSE course (generically referred to as "CS 1") at a large, public research university. Participants were recruited via the course e-mail list and an announcement by the investigator during the first week of class. All research procedures and instruments were approved by the university's institutional review board.

The university's CS 1 course is a combined pre-major and service course. Accordingly, the majority of enrollees do not intend to major in CSE (at least upon entry into the course), and participants in this study represent the full range of CSE interest level. Although we do not claim our sample to be representative of the university's overall undergraduate enrollment, the students in our sample expressed interest in a wide range of majors. Only half included CSE as one of the majors they were considering, although never as the sole choice and not always as the first choice. Their other interests included both engineering and non-engineering majors, ranging from electrical engineering to psychology and Japanese studies. Of the remaining half of the sample (who were not considering majoring in CSE), some were prospective engineering students and are required to take CS 1. At least three were interested in non-engineering majors (*e.g.*, drama, psychology) and said they were taking the course out of interest in computing.

During the interviews, students discussed aspects of CSE that interested and disinterested them. To obtain some context for interpreting their responses, we followed this discussion with a request for their definitions of computer science, and their beliefs about what makes someone a successful computer scientist. To some extent, this helped us understand how each student conceptualized CSE, rather than impose our own (*i.e.*, the investigator's) assumptions about what CSE is. Indeed, the students' conceptualizations of CSE proved just as informative as their responses to the earlier questions, validating our conservative, exploratory approach. The interview protocol also included questions about CS 1 and academic interests. In general, asking a series of related, open-ended questions about CSE provided a richer, more contextualized, and more complete view of each students' beliefs and attitudes about CSE than would have been possible with a single, more constrained question. We believe this approach is necessary in order to respect and capture the complexity of students' beliefs and decision-making processes.

Theme: Familiarity breeds…interest?

> Also I don't really know much about computer science. Like, um, what people do really. That's another factor [causing her to be less interested in CSE].

> —female sophomore, not interested in CSE

Many of the interviewed students expressed uncertainty about what majoring in CSE entails, as well as what career paths are available to graduating majors. Of the eight students who expressed unfamiliarity with CSE, most reported low interest in majoring. In some cases, as with the student above, they were explicit about this uncertainty's effect on their lack of interest. Interestingly, even some students intending to major in CSE admitting being unsure of what CSE was about. This was in contrast with students who discussed their interest in other (non-CSE) majors in more certain terms.

One student's account of his recent, strong interest in electrical engineering (EE) illustrates the danger of CSE being left behind as students become more familiar with other majors. He spoke excitedly about the extensive recruitment efforts of the local EE department, including pamphlets, presentations on undergraduate research opportunities, and personal communications. Based on his account, the EE department's efforts helped him connect his longstanding interest in circuits and computing with an academic career as an EE major. In contrast, he admitted that he knew much less about CSE—not enough to "dive in".

In the next two sections, we examine another way in which students respond to their lack of knowledge about CSE: by letting stereotypes, anecdotes, and assumptions fill the gaps. Indeed, with the abundance of negative stereotypes, anecdotes, and assumptions, this appears to be another way in which unfamiliarity depresses interest in CSE.

Theme: Seeing past the programming

> Most [CSE] classes have to do with learning how to program computers and not much else…I don't think I want to have my complete major be just programming. Um, more of a general area of computers or maybe even computer hardware would be more to my interests, um, but I'm interested in taking CSE classes to see if they're all, you know, learning C++ and Java and Visual Basic or if it's other stuff as well.

> —male freshman, unsure about interest in CSE

While most computer scientists agree on computer programming's central importance in their discipline, many would be dismayed at a student passing judgment on CSE without recognizing its wide variety of concepts, theories, methods, applications, and career paths. As in Margolis & Fisher's Carnegie Mellon-based study,[3] programming was the aspect of CSE most frequently mentioned by the students. Only half of the students connected CSE with hardware, and fewer still explicitly recognized the presence of computing in devices other than desktops and laptops, *e.g.*, iPods, security systems.

Tying back to the previous section's theme, the student quoted at the beginning of this section had learned about the informatics (formerly library and information sciences) major from a friend, and he discussed his perception of CSE as differing from informatics for having an overly technical emphasis and lacking a human element. In his view, informatics was about "helping people find and understand information," and his cross-disciplinary interests in psychology and computing seemed more accommodated in informatics than in the programming-focused CSE major.

Although the student quoted above is concerned about narrow focus in CSE studies, similar remarks from other students indicate analogous beliefs about professional life in CSE. Multiple students described their expectations of a workday filled with programming. One student, when asked about what it takes to be a successful computer scientist, responded using the phrase "computer programmer", implying her belief that they are equivalent.

In contrast, students intending to major in CSE discussed the field in broader, arguably more accurate terms. They described applications to real-world problems and the betterment of society, in addition to an intrinsic interest in computing. One student's remarks demonstrated how his view of CSE extended beyond computer programming as an end in itself. He described his participation and interest in the Stanford University's Folding at Home distributed computing effort for analyzing biological data. In another part of this interview, he talked about how he wanted to "see what makes [computers] actually useful for something besides games" and even expressed interest in moving beyond networking for the sake of networking: "It seems like people don't use the Inter—or—computers for anything but the Internet any more. I think it'd be interesting to find some use for computers other than just moving information across a wire."

In this section, we discussed negative perceptions of study and work in CSE in terms of intellectual content and activities. Next, we discuss an equally if not more important set of perceptions about the lifestyle and culture associated with CSE, both academically and professionally.

Theme: It's not just a major. It's a way of life.

> All the people who major in CSE seem very, um, nerdy. To elaborate that I could say they look they're more, I don't know, how to say that, they just look very academically focused...way too focused. Like you can tell when you see them they just got out of their room from coding...scrubby, just wearing a sweater, their hair is all over the place, pants are like all the way up here, glasses, and you can tell that they don't wash their face. They just don't care about their outlook [appearance], because all that matters is like what they did in the room, whatever, their cave, coding.
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> —female freshman, not interested in CSE

Interviewed students made clear that choosing to major in CSE was more than an academic decision; it represented association with (if not acceptance of) an undesirable lifestyle or culture. The "geek" image is nothing new in CSE, and it was a concern common to students who had rejected CSE as a major, as well as those intending to study it. Again, these perceptions were not

limited to academia, with one student describing the ideal computer scientist as someone who could program continuously, not needing to consult with anyone else and only stopping to ingest vitamins (because eating foods would be inefficient). Although this was an extreme example, a stressful work life, sitting alone at the computer, was a frequently invoked image of professional computing. Few students understood the reality that successful computer scientists collaborate with colleagues (often across disciplinary boundaries), consult with clients, and function competently as team members and leaders.

Implications on the first year of CSE study and beyond

Our findings show that undergraduates harbor a range of negative perceptions of CSE that are well-developed, in the sense that the students are assured enough of these perceptions that they substantially influence interest in majoring. Because we elicited these perceptions during the first weeks of CS 1, we assume that they have not yet been influenced by us (as undergraduate educators), *e.g.*, in a CS 1 course or recruitment effort. In fact, since this study focused on a self-selected population of CS 1 enrollees, we suspect that these negative perceptions might be even more common in the general undergraduate pre-major population. Further study will illuminate the influence of peers, parents, high school teachers, guidance counselors, pop media, and other potential influences on perceptions of CSE, but the challenge remains ours to understand and appropriately respond as students begin their undergraduate careers.

The picture painted by our interviews represents the "start state" of undergraduates with respect to studying CSE. With lack of information and negative perceptions being such serious problems from Day 1 of CS 1, educators must consider how to respond in efforts to recruit, support, and retain CSE majors. Findings from existing studies of reasons why students switch from CSE to other majors mirror this study's; the same issues of unfamiliarity, narrow focus, and lifestyle/culture arise. This suggests that CSE departments have not adequately addressed these issues during the first years of their programs.

The CSE education community has already begun changing the way we regard prospective majors, and this study joins the body of research validating some of the popular interventions. In general, a change in mindset is required; CSE departments must begin actively recruiting prospective majors, which includes informing them about the discipline and its associated career options. (As a recent NSF-funded workshop concluded, "pumps, not filters" is no small change, given the vast numbers of prospective majors most departments had to turn away when they were enrolled to capacity several years ago.[4])

Recruitment can take many forms and reach many audiences. This study suggests that CS 1 represents a critical recruitment opportunity—one full term to pique students' interest, not just prepare them for computer programming. Confirming this, multiple interviewees said they were treating CS 1 as a trial period of sorts, intending to make decisions about proceeding with further CSE study based on the content and experience in the course. To what extent do conventional CS 1 courses address the three main themes discussed above? Most CS 1 courses do very little to educate students about the breadth and applications of CSE, focus primarily on developing programming skill, and are at best neutral with respect to stereotypes about the culture/lifestyle of CSE.

Recognizing that grains of truth often lie at the core of stereotypes, we speculate that subtle aspects of some CS 1 courses in fact perpetuate some of the negative stereotypes discussed in our interviews. Midnight deadlines imply expectations of working until midnight, and late policies with hourly (*vs.* daily) point deductions might encourage students to work on through the night. Staff publicly and proudly exchanging all-nighter "war stories" might further reinforce this unhealthy norm. Individual assignments with strict or ambiguous collaboration policies might induce a culture of competition and isolation. In contrast, high-quality programming assignments with clear success criteria, earlier emphasis on software quality and process, cultivation of good study and time management habits, and knowing when to seek staff assistance might help students better manage the substantial CS 1 workload.

Although there is room for improvement in CS 1, we acknowledge that CS 1 syllabi are already strained, particularly when a single course serves pre-majors and fulfills requirements in non-CSE programs, as in the studied institution. Future work will study the effectiveness and practicality of non-traditional CS 1 courses and "breadth supplements" (*e.g.*, one-credit seminars, one-time information sessions for prospective CSE majors). Outside of CS 1, notable examples of existing interventions directly related to the themes in this paper include the ACM's Computing Careers web site and pamphlet,[5] the University of Washington's series of short videos about CSE and computing careers,[6] and the various efforts of the Computer Science Teachers Association, ACM-W and similar organizations. We might look to friends in the broader engineering education community for guidance, *e.g.*, ASEE's excellent *Engineering Go For It* magazine. These interventions not only help students make more informed decisions, but by clarifying expectations, they might also help CSE departments attract a broader audience of more appropriately prepared and motivated students.

In addition to evaluating interventions, next steps with this work include the inclusion of several additional interviews in a larger analysis and a focused analysis on gender differences. Given the likelihood that perceptions and their influence vary with context and population, we also hope to complement this local, exploratory, qualitative work with larger, multi-institutional studies employing research methods better suited for confirming (*vs.* developing) hypotheses, *e.g.*, focus groups, surveys with closed-ended questions. Such steps would hopefully yield the more general and transferable findings necessary to motivate and inform larger-scale change.

[1] J. Vegso. Interest in CS as a Major Drops Among Incoming Freshmen. *Computing Research News*, 17(3), 2005 May. Available online: http://www.cra.org/CRN/articles/may05/vegso

[2] J. McGrath Cohoon and W. Aspray, eds. *Women and information technology: Research on underrepresentation.* MIT Press, 2006.

[3] J. Margolis and A. Fisher. *Unlocking the Clubhouse: Women in Computing.* MIT Press, 2002.

[4] J. Cushing, E. Roberts, *et al.* Final Report (first draft) of ICER-West, 2006. Available online: http://www.evergreen.edu/icer/documents/icer-northwest-report.pdf

[5] Available online: http://computingcareers.acm.org/

[6] Available online: http://www.cs.washington.edu/WhyCSE/