

Recruitment, Preparation, Retention: A case study of computing culture at the University of Illinois at Urbana-Champaign.

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Computer science is seeing a decline in enrollment at all levels of education, including undergraduate and graduate study. This paper reports on the results of a study conducted at the University of Illinois at Urbana-Champaign which evaluated students attitudes regarding three areas which can contribute to improved enrollment in the Department of Computer Science: Recruitment, preparation and retention. The results of our study saw two themes. First, the department's tight research focus appears to draw significant attention from other activities — such as teaching, service, and other community-building activities — that are necessary for a department's excellence. Yet, as demonstrated by our second theme, one partial solution is to better promote such activities already employed by the department to its students and faculty. Based on our results, we make recommendations for improvements and enhancements based on the current state of practice at peer institutions.

1. INTRODUCTION

The field of Computer Science is experiencing a downward trend in enrollment at the university level [Vegso 2005]. The Department of Computer Science at the University of Illinois of Urbana-Champaign is seeing a similar decline. The authors conducted a study from January to July 2006 which sought to determine through student surveys and interviews how the department can increase these numbers. The study examined three specific areas, recruitment, preparation, and retention. Seeing these three areas through students' eyes, we pinpoint concrete recommendations for improvement for attracting students to computer science, preparing them for industry or research, and keeping them in the field. This paper summarizes the findings of the study and lists a set of recommendations for improvement at both the undergraduate and graduate levels.

The paper is organized as follows. We begin by describing the organization and programs available in the Department of Computer Science. Section 3 summa-

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rizes the related work. In Section 4, we describe the methodology used in the departmental study. Section 5 summarizes our results and Section 6 lists our recommendations.

2. DEPARTMENT OF COMPUTER SCIENCE

The Department of Computer Science at the University of Illinois is frequently listed as one of the top programs in the United States, at both the graduate and the undergraduate level [USN a] [USN b]. To demonstrate the current structural context of the department, we describe the organizations supported by the department and the undergraduate and graduate programs of study.

2.1 Computer Science Organizations at UIUC

The Department of Computer Science at UIUC supports a number of organizations which provide academic, research, and social support and outreach opportunities for students. Throughout this document, these programs are routinely mentioned by the authors and in the participant data. Although other organizations exist, the following briefly describes only those discussed by our participants.

- CSGSO**: The Computer Science Graduate Student Organization, or CSGSO, is a departmental organization whose goal is to improve graduate life. They host a weekly event, called Friday Extravaganza (FE), which provides an informal event for graduate students to socialize, as well as network with various industry representatives whose companies sometimes sponsor the FE. The CSGSO also sponsors seminars on research and graduate life, although specific topics differ annually. Every graduate student is a member of CSGSO by virtue of being in the department.
- ACM**: The department hosts a student chapter of the Association for Computing Machinery, or ACM, which currently has 350 members. The ACM is open to both undergraduate and graduate students, but is primarily populated by undergrads. They organize weekly meetings of special interest groups, or SIGS, on computing related topics. There are also general meetings to welcome new members and inform current members of upcoming events, as well as social events. ACM also sponsors a yearly conference, *Reflections | Projections*, which attracts corporate sponsors, academic and industry speakers, and features a programming competition. The conference is attended by students from multiple universities.
- WCS**: Women in Computer Science, or WCS, is an organization which works towards recruitment and retention of women at all levels of computer science. WCS hosts meetings and social events for both undergraduate and graduate students. In addition, WCS sponsors several outreach and recruitment programs, the largest of which is the ChicTech program. ChicTech organizes teams of students, predominantly undergraduates, to speak at high schools about computer science and UIUC. ChicTech also hosts a competition for high school girls, who pick an organization and design a software program or website for that organization. The teams then visit for a weekend at UIUC to participate in activities and present their project.
- !bang**: !bang is a computer science organization whose goal is to foster more social activities within the Department of Computer Science. They generally

host 2-4 events per year, usually also sponsored by ACM and WCS. The events are large-scale departmental events for students and professors. In recent years, !bang has hosted bi-annual !casino, which most recently was sponsored by Google. Professors from the Department of Computer Science volunteered as dealers for blackjack, poker, and roulette tables. The event allows for interactions between professors, undergraduates, and graduate students.

- WIE:** Women in Engineering, or WIE, is an organization sponsored by the College of Engineering whose goal is to promote recruitment and retention of women in all departments within the college. WIE hosts the Freshman Camp, a weekend retreat at the beginning of the year for all incoming freshmen women. Current CS students, organized through WCS, attend this camp to meet the freshmen and offer encouragement and advice. WIE also organizes a two week program for middle school girls called, G.A.M.E.S., or Girls' Adventures in Mathematics, Engineering, and Science. There are two specialized camps, including one focused on Computer Science. Many students and professors in the Department of Computer Science assist as camp counselors and mentors.

2.2 Undergraduate program

The undergraduate program in the Computer Science department at UIUC is a four year program. All undergraduates take the same core classes in their freshman and sophomore years, including programming, data structures, discrete math, theory of computation, architecture, and computer ethics. For upper level students, there are currently two curricula.

Most current juniors and seniors are on the older track, where students take programming languages, operating systems, analysis of algorithms, an advanced architecture course, and two additional 400-level courses of their choice. The older track also has an application sequence, a set of approved courses in another discipline to which computer science can be applied in a meaningful way. Typical application sequences can be in engineering, mathematics, psychology, music, or business, but students may also design their own application sequence based on their individual interests.

For those students entering after Fall 2005, the course requirements are quite different. The application sequence is no longer a part of the program; instead, students choose a technical track emphasizing a particular area of CS in which they are interested. The three tracks - computer science, scientific computing, and mathematics - have different advanced course requirement appropriate to their specialization. However, since this is such a new program, no students surveyed have progressed far enough on this track to comment on these upper level distinctions.

In addition to majoring in Computer Science, undergraduates can obtain degrees from the College of Liberal Arts and Sciences as a Bachelor of Science in Math and Computer Science, or a Bachelor of Science in Statistics and Computer Science. Moreover, there are other programs available, including a minor in Computer Science that is available campus-wide (except to students majoring in Computer Engineering), as well as the Software Engineering Certificate.

2.3 Graduate program

The graduate program has multiple programs, both for a Ph.D. and a Master's degree. Undergraduates at UIUC can opt for a fifth-year Master's degree, taking 16 hours of additional course work and writing a thesis. Enrolled graduate students can obtain a Master of Science degree, a research-oriented degree requiring 28 hours of graduate course work and a thesis, or a Master of Computer Science, requiring only 36 hours of graduate course work. For either degree, there is a distribution course work requirement in which students must take a course in the areas of Software, Architecture, and Theory and obtain a grade of B- or higher.

For a Ph.D., students must take a total of 48 hours of graduate course work and 32 hours of thesis work to obtain the degree. These requirements are reduced for students entering with a Master's degree. The Ph.D. course work requirements differ for students entering before and after Fall 2005. Before Fall 2005, students have to take one course in the areas of Programming Languages, Operating Systems, and Theory and any other area of their choosing. Students have to achieve a grade of at least A- in three of the courses, and B- in the fourth. After Fall 2005, students have to take one course from Theoretical Computer Science and Formal Methods, and one course from Systems and Architecture. Students must also take two courses in their research area, at least one of which must be a 500-level course. For 400-level courses, students must obtain a B+ or better. For 500-level courses, students must obtain an A- or better. UIUC also offers a Ph.D./M.D. degree, but no students pursuing this degree were surveyed or interviewed.

The distribution requirement for Master's and the foundational requirement and research course work requirement for Ph.D. will be loosely referred to in this document as "core course work."

3. RELATED WORK

The vast majority of research on the decreasing enrollment throughout computer science education repeatedly focuses on two potential "solution" areas: recruitment and retention, which involve getting more students to join and keeping those who have joined [Cohoon 2002] [Margolis and Fisher 2002] [Blum and Frieze 2005]. Recruitment entails attracting K-12 students to computer science and often involves outreach efforts which attempt to make computer science look "cool," exciting, useful, and rewarding. In addition, when recruiting underrepresented students in particular, researchers often recommend opening up admissions criteria without lowering standards, welcoming reentry students, and providing opportunities to bridge educational gaps that students might have between their previous education and the entry-level courses at the university [Margolis and Fisher 2002] [Cuny and Aspray 2002].

The goal of retention is to keep the students and computer scientists already in the field. Retention efforts involve various support structures for the existing students, particularly those who are underrepresented and are more likely to leave. There are several ways in which these support structures can be fostered; providing role models via good teaching, advising, mentoring, and outreach [Ragins 1999] [Gurer and Camp 2002] [Blum and Frieze 2005]. With teaching, students can experience the enthusiasm of the subject through their professor or instructor. Positive

advising relationships can help foster a graduate student's self-confidence and research success. For undergraduates in computer science, advising not only helps the student select courses and fulfill requirements, but also frequently determines the level of interest in pursuing various career options or even a graduate degree. For graduates, positive advising relationships can result in more productive and happier students. With mentoring, students can reach out to their more experienced colleagues and faculty for support. Mentoring is not just about moral support, but also has an impact on whether students finish a program, get good advice, and feel happy about their education [Jaschik 2006]. Finally, with outreach, students can use their expertise in computer science to benefit others, thereby increasing their own self-confidence and obtaining real-world examples of how their computer science skills can be used.

A third, less researched area for solving the problem of decreasing enrollment involves working to create a flexible culture of computing which is open to diversity and allows for students and faculty to define for themselves what it means to be a computer scientist [Margolis and Fisher 2002] [Blum and Frieze 2005]. Margolis explains that "one of the aims of higher education must be to provide students with a broad picture of possibilities and to create an environment where alternate models are valued and respected." One way in which a program can create such a culture is to improve its gender balance. A cross-national study of male overrepresentation in Computer Science [Charles and Bradley 2006] starkly demonstrates the influence that even a nation's culture can have on a woman's entrance into the field. The degree of male overrepresentation in the Czech Republic is three times that of Turkey, the country with the most gender-integrated program. Diversity in race, socioeconomic status also contribute to the environment that Margolis describes, and whether or not students join and stay in the field.

As noted above, the abundance of literature focuses on recruitment, retention, and the newer and broader idea of computing culture. Much of the related work focuses on either the "problems" of computer science culture, or the "solutions" which make computer science look cool, but lacks consideration of students' attitudes regarding the problem areas of computer science enrollment. This paper describes another approach. The study was designed to investigate and understand the attitudes of undergraduate and graduate students in three areas which are well understood to position students for success; recruitment, preparation, and retention. These areas include activities such as departmental culture, teaching, advising, and mentoring. Once their attitudes were understood, our explicit goal was to uncover actual, working solutions which members of the department can cooperatively utilize to reverse the decline in enrollment.

4. METHODOLOGY

The study took place in two phases from January to July of 2006. In the initial pilot study, four undergraduates and seven graduate students were individually interviewed for a single hour. By no means were the participants selected randomly. Rather, for our pilot study, participants were hand-picked by the researchers to get a breadth of experiences from sophomore undergraduates having just started their computer science courses, to sixth-year graduates about to complete their

Ph.D. work, from males to females, and from parents to non-parents. Among undergraduates, the students interviewed were 100% women. Among the graduate students, the study was approximately 57% female and 43% male.

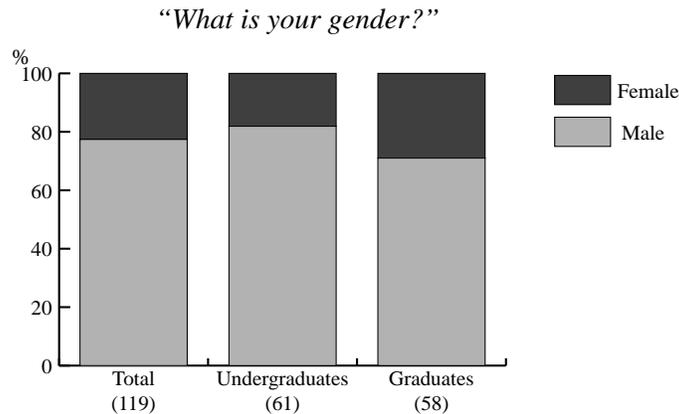


Fig. 1. Overall, in the second-phase, on-line survey, participants were 17% female and 83% male. Female participants were oversampled by announcing the survey to WCS and female graduate students one week before the survey was announced to the general student population of the department. The gender ratio here is not an accurate reflection of the department.

The second phase consisted of an on-line survey developed as a result of the pilot study, combined with nine interviews to supplement the survey data. Participants were recruited randomly through departmental e-mail. Female participants were oversampled by announcing the survey to departmental, female-only groups one week before announcing it to the general student population. For their participation in the survey, students received a three dollar gift certificate to a local coffee shop, and for an interview, students received a five dollar gift certificate.

The participation in the survey is summarized in Figure 1. A total of 119 students participated in the survey, 61 undergraduate students, and 58 graduate students. Overall, the survey participants were 17% female and 83% male. Because the female population was oversampled, this ratio is not an accurate depiction of the actual gender ratio in the Department of Computer Science at UIUC.

All figures which appear throughout the remainder of this document are taken solely from the data obtained through in the on-line study results gathered in the second phase of the study. Where appropriate, quotations from the interviews are used to exemplify the themes of our results.

5. RESULTS

The results of our study have been organized into three areas which impact student success in computer science. The first area is **recruitment**, the means by which participants were initially attracted to and became members of the field of computer science. Recruitment has an obvious impact on a student’s success, for a student cannot be successful in computer science without first entering the field.

We examine how students discovered computer science, and how they discovered the University of Illinois as an institution for study.

The second area, **preparation**, describes the resources a student needs to prepare for his vocation of choice in computer science. These resources are course work, including the quality of teaching, and early research opportunities, each of which has an impact on a student's success. For undergraduates especially, course work allows students to experience the enthusiasm of a particular subject through a professor or instructor. In addition, a curriculum's design, can impact the flexibility a student has to explore her own interests. For undergraduates, early research opportunities allow a student to experience a taste of academia, and encourage her to enter into graduate school. For graduates, early research opportunities allow them to make a faster transition from absorbing knowledge to creating it. We examine students attitudes regarding their access to these resources in the department.

The third area is **retention**. We define retention as a student's feeling of membership both in the department and in the greater computing community. The methods by which this membership can be cultivated are advising and mentoring relationships, as well as the quality of a student's environment and work-life balance. All of these impact a students' success. Advising can help a student to select a career in which they can be productive and fulfilled, or to make better and more significant progress on research. Mentoring gives the student access to a more senior member of the computing community, one who can give good advice or lend moral support. The environment, such as a classroom of peers, can further help or possibly hinder this membership. Finally, allowing students a healthy work-life balance gives them time to participate in the outside activities they value. Again, we examine students' attitudes regarding their access to positive advising and mentoring relationships, as well as their environment and work-life balance.

5.1 Recruitment

Within the theme of recruitment, we investigate three areas: how students discovered computer science, why graduate students in particular selected UIUC as a school for their studies, and how participants take part in recruitment.

5.1.1 Discovery of Computer Science. As summarized in Figure 2, participants varied as to how they were initially attracted to the subject of computer science. The majority of the participants report discovering computer science on their own. Many had parents who were computer scientists and were attracted to the field at an early age. Others report being exposed to it by a teacher or friend. One participant studied Information Systems as an undergraduate, but changed to computer science so he could join his wife at graduate school. Responses for the "Other" category shown in Figure 2 included being exposed to computer science by a brother or via a previous job. It's striking to note that no participant reported being exposed to computer science by a female partner.

5.1.2 Graduates' discovery of UIUC. For the graduates, the method by which students selected UIUC for graduate school is best described by the following interview participants,

“How did you first become interested in computer science?”

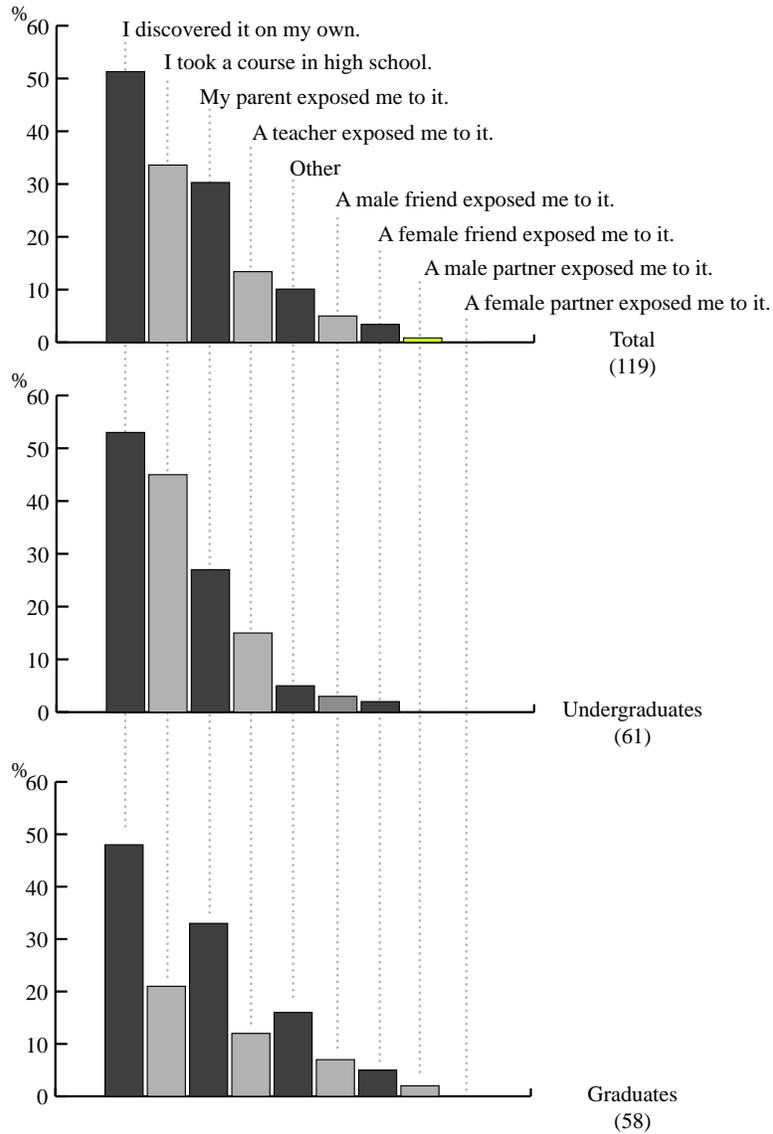


Fig. 2. Participants were asked how they were first exposed to computer science. The top three choices for both undergraduates and graduates were self-discovery, high school course, and parents. More undergraduates than graduates reported taking a course in high school, and understandably so as more high schools have offered computer science courses in recent times. In all cases “Other” referred to being exposed to it via a brother, or via a previous job.

I got the list of—US News or whatever—and I got a list of the top 25 . . . and UIUC was one of those.

UIUC was the highest ranked school I applied to, and I was lucky to get into it. It was a real obvious choice for me.

As everyone else, I looked at US News [and World Report] and I looked at what the rankings were.

As seen in the above, the response for why students selected UIUC for graduate school was generally “It was the highest ranked place I got into.” One participant said of the prospective student visit, “I liked it a lot when I visited it. I felt like I fit in with the people, mostly the students.” Another participant echoed this statement and went on to report that it also helped that a particular faculty member expressed excitement in her attending UIUC during the prospective visit.

5.1.3 *Student attitudes and participation in recruitment.* To determine to what degree participants currently participated in recruiting activities, which we termed “outreach” in the survey, we began by asking participants if they had ever used their expertise in computer science to benefit other people. The examples given in the survey question were helping friends with homework, taking a prospective student to lunch, or volunteering at the local Boys and Girls Club. Of the undergraduates surveyed, 79% said that they had. When asked about details of their schedule, 18% said they spent 1 to 5 hours a week working on outreach activities. Of the graduate participants, 73% replied that they had, and 18% reported spending 1 to 5 hours per week working on outreach activities.

All of the undergraduate interviewees understood outreach to mean “exposing computer science to the outside world.” All undergraduates interviewed felt that outreach was very important, and all but one also thought it was very important to the department. Most of those interviewed had attended or helped with the Freshman Camp, and thought that it was a helpful program. All were aware of or had assisted with G.A.M.E.S.; one had even first been recruited to come to UIUC through that program. Two participants had assisted with recruiting trips to Illinois high schools to talk to juniors about computer science at UIUC. All of them said that they participated in outreach in some fashion, whether through the WCS and WIE activities already described or by helping students not majoring in computer science with their programming projects.

During the graduate interviews, however, the terms “outreach” or “recruitment” were construed two ways. First, as with the undergraduates, “outreach” was understood as a means to expose computer science to the outside world. Second, it was viewed as interactions within and between departments which result in a student support system.

Graduate student interview participants were not very aware of the existing outreach from the first category. Some noted the “G.A.M.E.S. Camp” as one existing outreach program. One participant said of her participation in outreach, “I would if I were asked.” Another participant said simply, “We don’t do it,” pointing to either a lack of good advertising on the department’s part or a lack of attention on the participant’s part. Another simply stated, “I would like to see more active recruitment and retention of underrepresented groups.”

In response to questions about the second type of outreach and recruitment, graduate student interviewees also expressed a desire to see more inter- and intra-departmental interactivity as a way to support the students. In this regard, one participant said,

One of the things that surprised me when I got here was how little interaction there is among students, especially across research groups. It is a large department, and I had very little idea what other students, especially students who had been in the dept long enough to be doing research, were doing. I think I would have benefited a lot from seeing the kinds of projects other students were working on, and talking to them about how to go about getting started with my own research.'

Another echoed this statement with a wish for, "Better introduction to research for new students, faculty involvement in social activities, more interdisciplinary events with the arts and humanities." Yet another echoed it with the suggestion to, "Promote communication among senior and junior phd students." In fact, 31% of the graduate students pointed to a need for some kind of improvement for faculty-student or student-student interaction.

Participants interviewed offered suggestions about how more "outreach" and "recruitment" could be incorporated into the department. One participant said the department should perform outreach to local industry to help teach concepts such as "rapid prototyping which would also help students with networking." This tied to his opinion that the department should be "selling the students more. Other schools have a lot more networking. We don't teach our students how to network." Another participant, who after her preliminary exam had attended only one conference, said this about her advisor's networking for his students,

I haven't seen any evidence that he has, so I assume that he hasn't. I guess that the typical thing that I see is when you go to a conference and you take your student and you start introducing your student to everyone, and that has never happened [to me]. If I was an advisor, and I had any students, I would do this. That one conference that I went to, he wasn't there. I listened to people's talks, but I couldn't make any connections.

The inability to make such connections in the larger community can have serious effects on a student's ability to pursue a career in academia.

Connecting students not only to professors, but also to each other can help them to flourish. One participant wished the department had more group activities for the first-year graduate students to encourage camaraderie, allowing students to "outreach to each other." She said, "The CSGSO is not working adequately or properly" and noted that the Friday Extravaganzas were "not a good way to meet new people." She expected more activities would be offered by the department for the first year students since "there was such a nice program for the prospective students."

The study uncovered a definite disparity between the attitudes of undergraduates and graduates regarding outreach. This disparity seems to be a direct result of the active undergraduate society chapters. All but one of the undergraduates interviewed were active members of WCS and ACM, and most participated in outreach through those organizations. While these organizations are open to graduate

students, they mostly target undergraduates and, as we will discuss later, most graduate students from this study expressed difficulty in finding space within their research, work, and course schedules to participate in such organizations. Though graduate students seemed largely unhappy with the activities organized by CSGSO, most of the undergraduates enjoyed the societies in which they participate, and two even echoed the statement that, “without WCS, I probably would not still be in CS. After all, you can’t go out and promote CS to high school students and then drop out of the program yourself.”

5.2 Preparation

To understand how well the department is preparing its students, we examined students’ future career interests, as well as their attitudes regarding their access to the important resources of teaching, course work, and early research opportunities.

5.2.1 Future Plans. To determine how well UIUC prepares its students for their future vocations, we examined students’ future plans. In the on-line survey, students were asked what kind of job they were considering after graduation. Participants selected any job from the list that they were considering, thereby allowing for multiple answers. Undergraduates and graduates were offered different sets of possible career choices. Figure 3 summarizes the future plans of the undergraduate participants. The top choice of the undergraduate participants was “Obtain a science/engineering related job in industry.” Significantly more male than female undergraduates reported considering applying to graduate school in a science/engineering-related field, with 24% male and 9% female participants reporting they would consider this option. Female undergraduates’ second most popular choice was “Other”; choices included going to law school, and starting a family or a business. Both male and female undergraduates included “I have no idea” as an “Other” option.

Figure 4 summarizes the future plans of the graduate participants in the Ph.D. program. For the total group of participants, an academic job at a research university was the top choice. Female participants predominantly chose this option, with 75% of females reporting that they would consider this choice. Male choices were more distributed across the options. The second most popular choice for males was “A professional job in industry” while the second most popular choice for females was “Research position in a private institution.”

*“What would you like to do after graduating?
(check all that apply)”*

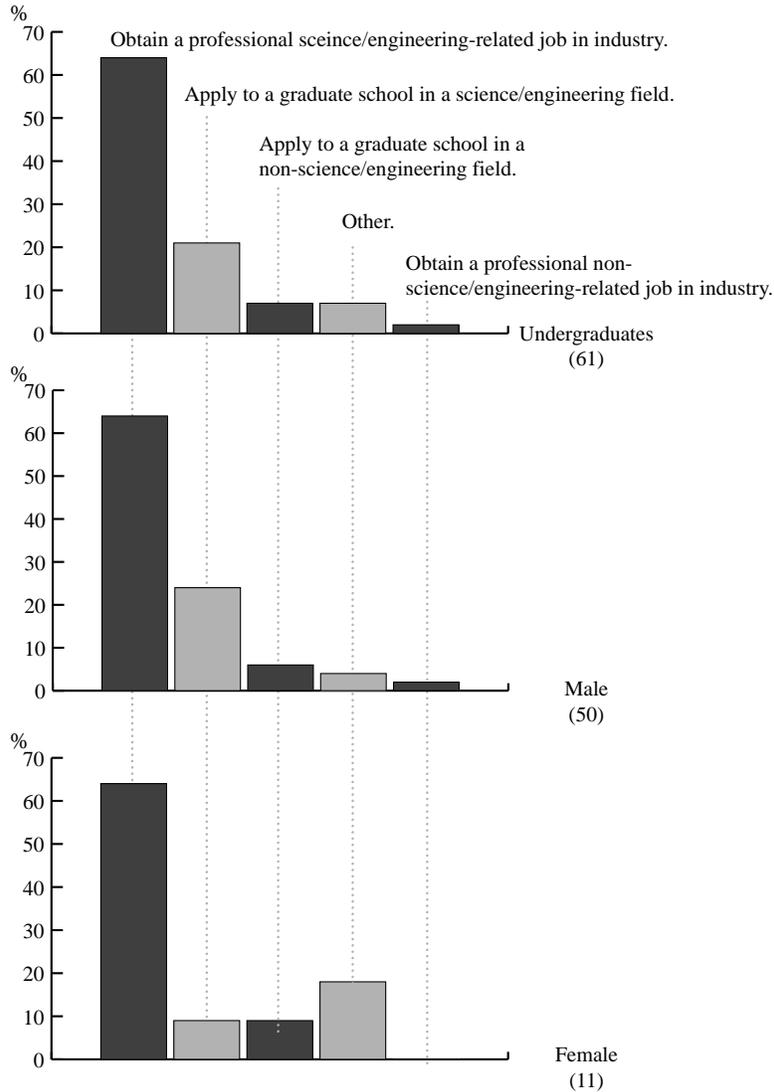


Fig. 3. Undergraduate participants were asked to select multiple choices from a set of possible career options they would consider after graduation. The top option for all participants was “Obtains a science/engineering related job in industry.” Significantly more male than female undergraduates reported considering applying to graduate school in a science/engineering-related field. Female undergraduates second most popular choice was “Other”; choices included going to law school, and starting a family or a business. Both male and female undergraduates included “I have no idea” as an “Other” option.

“What kind of job would you like to get after graduating? (check all that apply)”

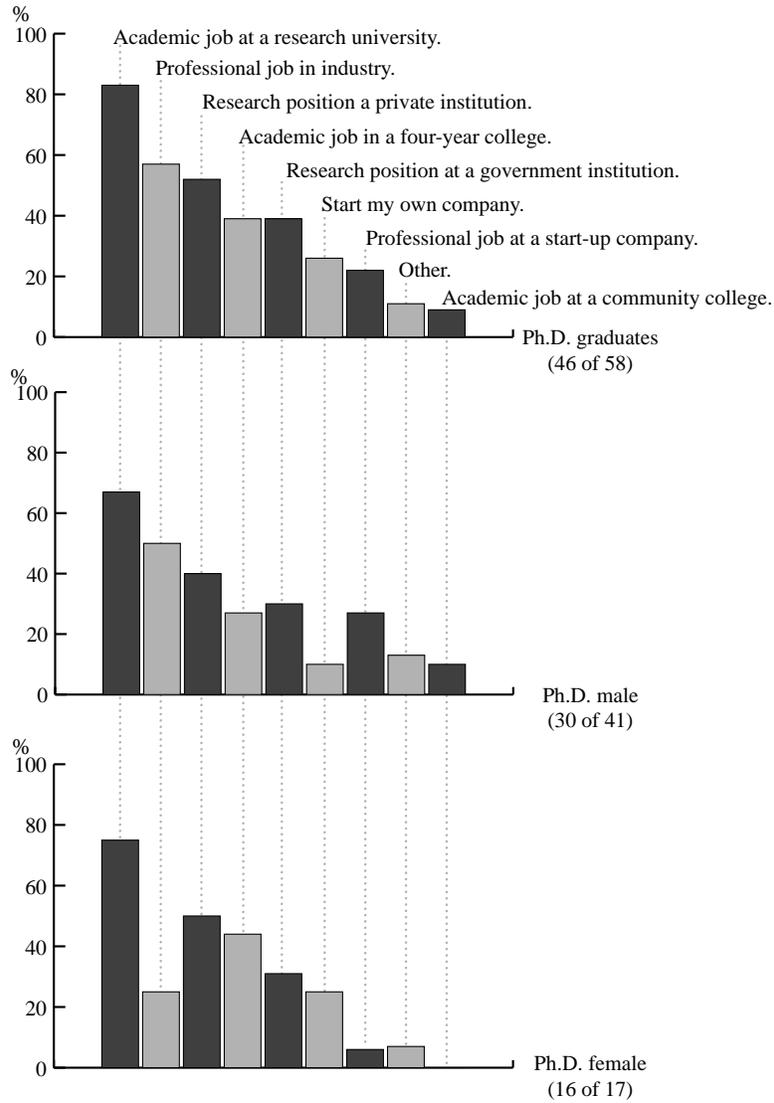


Fig. 4. Graduate participants in the Ph.D. program were asked to select from a set of possible career options they would consider after graduation. Of the 46 of 58 graduate students who were Ph.D. candidates, an academic job at a research university was the top choice. Female participants predominantly chose this option, while male choices were more distributed across the options.

5.2.2 *Teaching.* To determine to what extent teaching prepared the students, we asked undergraduates and graduates about their experiences with teaching in the department. The undergraduate students were asked, “Do you think that the Department of Computer Science values excellent teaching.” Of the participants, 65% replied yes, with more freshman and sophomores replying in the affirmative than juniors and seniors. Undergraduate students also reported on their attendance in lectures as summarized in Figure 5.

“How often do you attend the lectures for your computer science courses?
(this does not include watching video-taped lectures).”

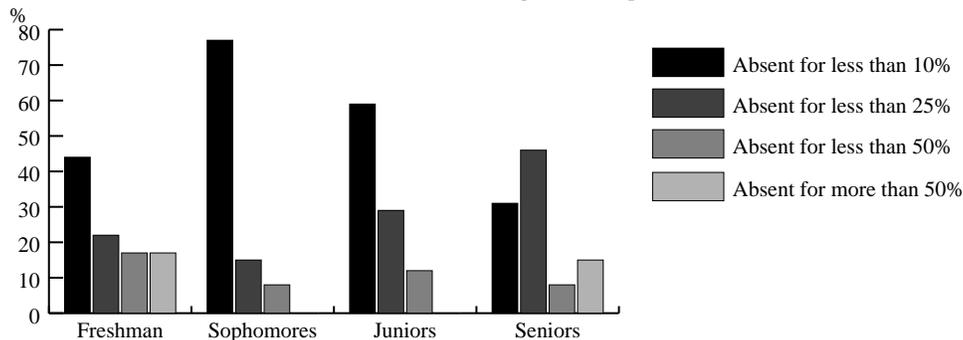


Fig. 5. Undergraduates were asked to report how often they attend their lectures. Sophomores attended their lectures the most and often remarked on the quality of teaching in their CS173, *Discrete Structures*, and CS225, *Data Structures*, courses.

Reasons for not attending lectures included,

- “I do not have time to attend my classes.” (25%)
- “I do not feel that the lectures help me to learn.” (66%)
- “I do not like the teaching style of the lecturers.” (49%)
- “I prefer to watch lecture videos.” (8%)

Many students also selected an “Other” reason for not attending class, 13% of which cited an inability to wake up in time for class, or a preference of sleep over lectures.

For the undergraduates, the teaching quality in the department was one of the most heavily discussed topics during both the interviews and the open-ended questions on the on-line survey. More than half of the suggestions for how to improve the department were related to their courses. In particular, better-trained teaching assistants, more interactive lectures, and more collaborative assignments were the main areas of improvement identified by the undergraduates. Representative comments include:

I know that the department is trying to keep a high ranking, but sometimes I feel that the ranking is the only thing important to the department. The department needs to focus more on the students than on the rankings.

Lots of people feel/act like an island. It would be better if the department cultured more group activities in the classroom.

Fix the teaching, annotate all powerpoints during class, try to move away from powerpoints and towards writing on a tablet/touchscreen so that the students can see the thought process that's going on into the explanations as the professors are doing it. Likewise, for code examples type them up on the fly if possible.

I would like to see T.A.s with more instruction on how to teach a class. The first course a student takes in computer scientist is the most critical, because it is that course that will make a student decide whether to stay in the department. These courses are often considered 'weed-out' courses that get rid of the students who are unsuited to computer science. However, in my experience, they weed out some of the most creative students, simply because the way the course material is presented makes the students feel inadiquet [sic] and dumb.

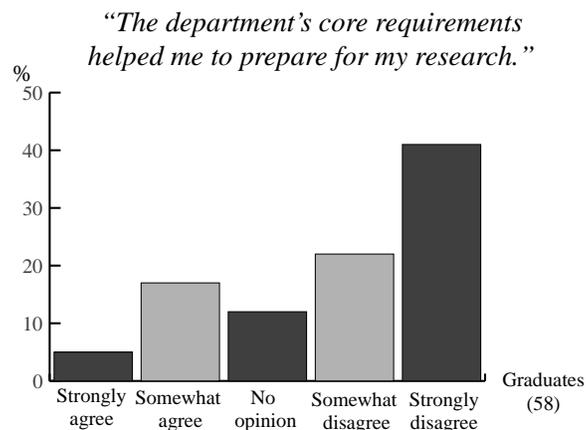


Fig. 6. Participants were asked how much they agreed with the statement, “The department’s core requirements helped me to prepare for my research.” Participants predominantly strongly disagreed.

Graduate students, whose requirements focus around taking certain core courses early in the program, were especially critical of the department’s attitude towards teaching. One participant said,

I think this department has some huge problems that are going to catch up to them. The first is the underlying culture in the faculty that teaching and education are not high priority or important to the image of the school. The second is the high number of young professors which contributes to the first problem because they are so focused on getting tenure.

Another participant said she expected UIUC to have good faculty and courses, but got “badly taught, unorganized courses in which the professors didn’t prepare.” She wished that the department “enforced better instruction” but admitted that not much could be done if a “professor were too famous.” Another said that the

400-level courses are “disorganized, have no textbooks, and there is no feedback.” Another said, “I got a grade in the class, but my teacher didn’t actually give back any homework grades.” When asked about her future plans, one participant said, “I want to go to a university where teaching and research is supported, not like UIUC.”

Most graduate participants were particularly unhappy with the core course work as reflected in Figure 6, with 41% reporting that they “strongly disagreed” with the statement that the “core requirements helped me to prepare for my research.” During the interviews, graduate participants reported a frustration with the delicate balancing act between research and course work in their first two years. Many participants were particularly vehement regarding the demands of the core requirements, expressing frustration with being worried about getting high grades when they would rather be conducting research. The combination of demands of course work, teaching-assistantships, and the core grade requirements were pointed to as reasons for graduate students not having publications until their third or fourth years.

What you are expected to take is asinine. I think it’s an embarrassment to the department that I can get to my qualifying exam without ever having seen [a fundamental concept in my area]¹. The core curriculum is especially frustrating for students because the courses are poorly taught.

They make you take two full years of classes and then [the faculty] get pissed off at you when you don’t have a publication your third year?

Get rid of the core classes altogether or make a significant reduction. I could spend my time preparing for research in my area rather than wasting my time taking classes that are in NO WAY related to my research. If I’m lacking in a needed area, let the qual committee [sic] decide. Let me explore the research areas on my own rather than forcing me to take core classes that professors don’t care to teach and students don’t care to take.

Participants suggested that the core course work be made more flexible. One participant suggested that the core be changed to a series of specialized tracks based on the students’ area of interest. For example, “Someone in architecture should take VLSI, architecture, and compilers.” Another participant thought it would be worthwhile to “take a course not in your area” but thought it was “dumb to have to take a systems course.”

5.3 Retention

We define retention as a student’s feeling of membership in the department and the greater computer science community. We examined whether or not participants felt that they were a member of the community via their attitudes regarding their access to positive advising and mentoring relationships, as well as their environment and work-life balance.

5.3.1 *Advising.* Undergraduates in the CS department are assigned a faculty advisor when they first enter the program. In the past, meetings with this advisor

¹Topic omitted to protect identity.

were not required, but were just encouraged. Today, freshman and juniors are required to meet with their advisor to discuss topics ranging from course work to potential career tracks. There is also an undergraduate advisor available in the main office to meet with students and address their advising needs.

In the second phase of the survey, only 2 undergraduate participants, or 3%, said that their advisor also served as a mentor to them. Most students interviewed did not meet with their advisor, but instead relied on peer advising. In the pilot study interviews, students were asked if and why they had considered leaving the department. Half of the undergraduates interviewed reported that they did not get enough support from their advisor or the faculty they knew. One participant reported that she didn't feel she had anything to discuss with her advisor; that he didn't know enough about the classes to get any help planning her curriculum. A single participant interviewed reported a positive interaction with faculty; it is notable that this participant was also the only undergraduate with any research experience.

For graduate students, an advisor plays quite a different role than for undergraduates. Graduate students must seek out their own research advisors by their third semester and work with them until the end of their degree. Simply obtaining an advisor can be a challenge, as is reflected in Figure 7. Of the graduate participants, 12% of males had a "very difficult" time obtaining an advisor, while 41% of the female participants reported a "somewhat difficult" time.

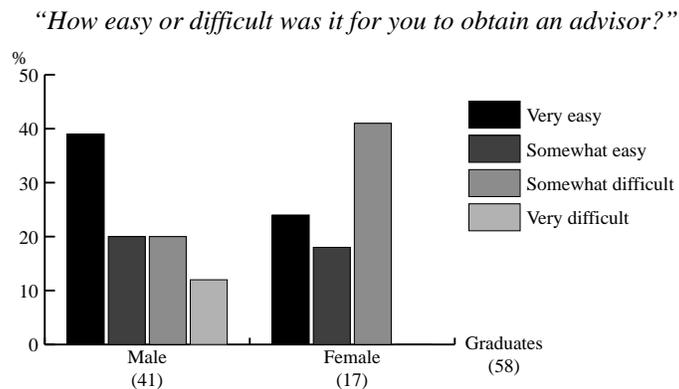


Fig. 7. Graduate participants were asked to rate the ease or difficulty with which they obtained an advisor. Of the participants, 12% of males had a very difficult time, while 41% of female participants had a somewhat difficult time.

During the interviews, many graduate participants echoed the feeling that "there are more students than there are advisors." One participant said that she spoke to "five or six professors before getting an advisor." Another participant reported she was delaying the qualification exam to her fifth semester because she still did not have an advisor. She said, "Professors are not helpful with students gaining a background to be in a particular area of research." She also reported that when she came to UIUC, she expected she could "do any research I wanted" and didn't expect the research opportunities to "be so narrow." Another female participant

said, “Compared to my male counterparts, I need more guidance [from my advisor] as to what I’m doing. I need more constructive criticism and more constructive praise.” A male student said,

I wish someone had told me what I should be looking for in an advisor, what I should be expected to do right away, what the available research areas are, the delicate balance of taking classes and doing research, and the funding problems in the department.

He suggested that the students have a second-year review so that the department can make sure they “understand the process of research from beginning to end. The department thinks this is done by the advisor. This isn’t necessarily true.”

Finding an advisor appeared to be especially difficult for women; a difficulty which is compounded by a lack of female and minority advisors in the department. Female and other minority students are unable to find someone like themselves or an advisor they think will understand them.

5.3.2 Mentoring. Mentoring is one approach to facilitate a student’s feeling of membership in the Computer Science community. Participants were surveyed as to whether or not they had a mentor. For those who did have a mentor, they reported on the sources of their mentoring relationships. For those who did not, they reported on the reasons why.

As summarized in Figure 8, approximately 18% of undergraduate and 53% of graduate students reported having a mentor. For both groups, there was a gap between those participants who reported not having a mentor and those who did not want a mentor, suggesting that approximately 52% of undergraduate participants and 26% of graduate participants who currently do not have a mentor, would like to have one. Of those who reported not having a mentor, approximately 62% of undergraduates and 81% of graduates report being unaware of any mentoring programs available in the department.

During the interviews, we captured some of the attitudes of those participants without mentors. One participant with an advisor said she felt a mentor would be very valuable, but felt uncomfortable seeking out a mentor. She said, “If I had to pick one tomorrow, I know who it would be” but couldn’t bring herself to do it. She said, “There is no formal system, which is unfortunate” and suggested the value of a formal system in which students could option for a mentor. Another participant without an advisor or mentor said, “I did not expect the lack of mentorship” that she found at UIUC and felt that

The last thing the faculty cares about is chatting about my problems. No one would be interested in mentoring me. People here just care about great research, not about mentoring.

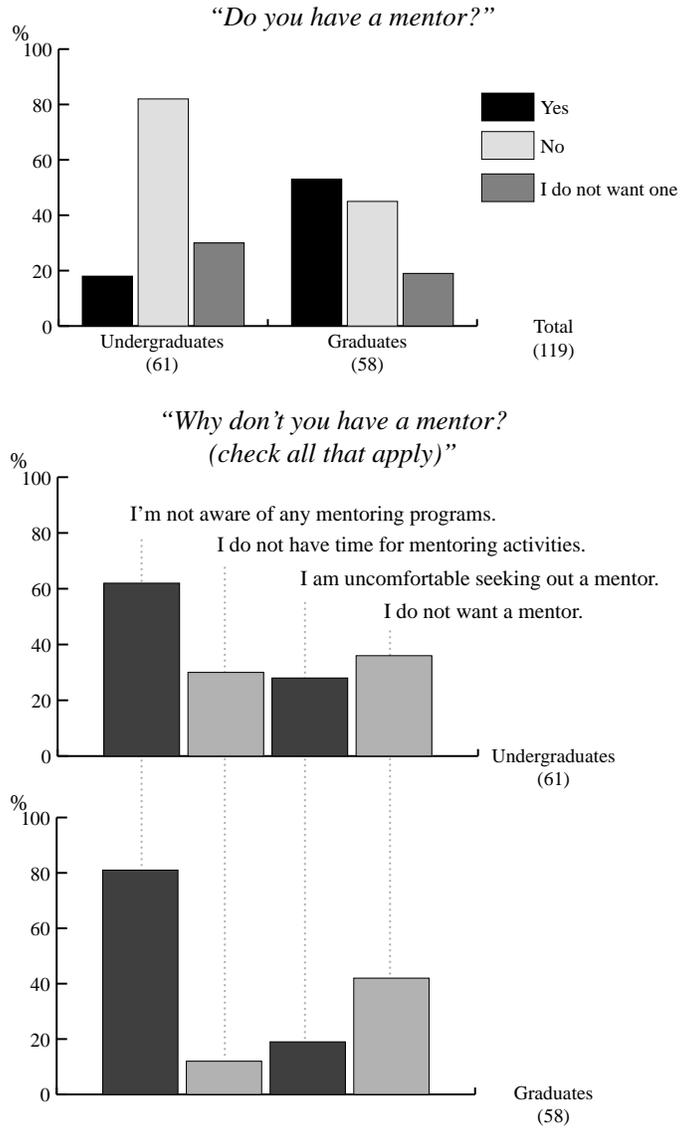


Fig. 8. Participants were asked if they currently had a mentor, either within the department or from another source. Participants without mentors also selected from possible reasons why they do not have a mentor. Many participants were unaware of any mentoring programs within the Department of Computer Science.

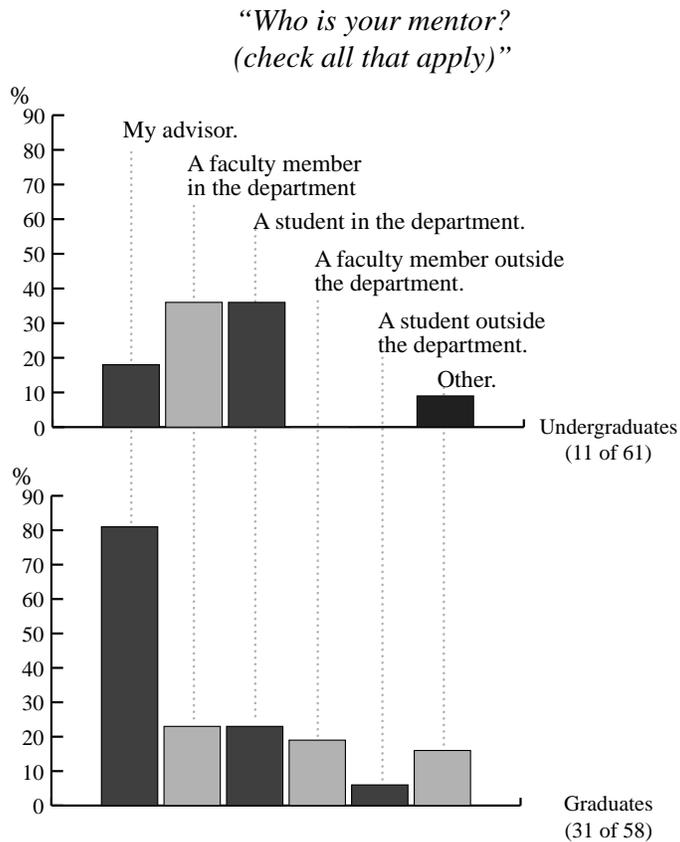


Fig. 9. Those participants who reported having a mentor were asked to report on the source of their mentor. “Other” sources of graduate mentors included those found on programs such as MentorNet, or past employers. For undergraduates, the single “Other” option selected was a family member.

Figure 9 summarizes the actual sources of mentors for students in the department. For the undergraduates, only 11 of whom reported having a mentor, faculty members and students were relied upon most for mentors. WCS appeared to be a major source for mentors for some participants, yet WCS is not the perfect support solution for all of the participants. WCS appears to be an effective social support group for some subset of the female and even male population of undergraduate students. However, other students mentioned having a more diverse set of interests than WCS could address. One participant said of her disinterest in WCS,

They have these coffee hours, but they don't have these ways to break you in . . . for people to introduce you. Most people in it are all very . . . into video games and anime, and so I really don't feel like I feel fit in. When I did try to sophomore year, and I found out that guys are in it, and they were the heads of whatever . . . making projects group. Dude, I deal with enough guys already. Where do the women come in?

While this interviewee in particular expresses a need for a space where she can escape the "guys" that she encounters on a daily basis, many women involved in WCS appreciate the support of the men in the department and welcome them into the group. Striking a balance between single and mixed gender groups is not easy, but research shows that attempting to do so is necessary in order to support women as an underrepresented group and to allow men to be active in creating a climate which is more open to diversity [Chasek 2003].

For graduate students, it was presumed a more natural mentor relationship could be found in the advisor relationship. In some sense, this was the case; the majority of graduate students reported their advisor as their mentor. However, of the 51 graduate participants who reported having an advisor, only 25, or 49%, reported that their advisor was their mentor. This led to our distinction between students who had an advisor relationship and an "Advisor as Mentor" or AAM relationship.

To examine the impact on whether or not a graduate advisor was considered a mentor by his or her student we looked at three areas. First, we looked at how the ease of obtaining an advisor differed between those who reported having an AAM and those who didn't. As reflected in Figure 10, those with an AAM report a slightly easier time of obtaining an advisor than those who do not. Still, this isn't the entire picture. In the interviews, multiple participants discussed the hardships involved in obtaining an advisor which were unrelated to the quality of the relationship with their eventual advisor (see Figure 7).

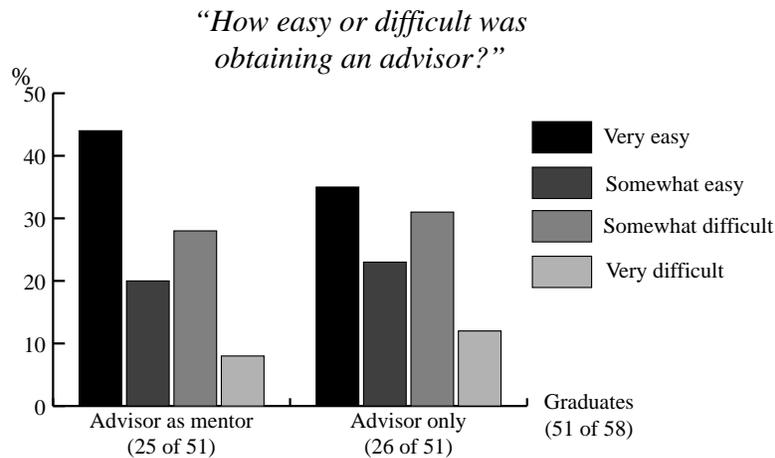


Fig. 10. Participants reported on the ease or difficulty with which they obtained an advisor. Those who reported that their advisor also acted in a mentoring capacity reported a slightly easier time in obtaining an advisor than those who did not.

Second, participants were asked to rate how supportive their advisor is in helping them to become a successful computer scientist. Participants rated their advisor as "1" for least supportive and "5" for most supportive. Participants with an AAM gave an average rating of 4.24 (standard deviation of .65). Participants with only an advisor relationship gave an average rating of 3.65 (standard deviation of 1).

The reasons for which graduate students do not regard their advisors as mentors vary. In the interviews, many participants expressed a reluctance to speak with their advisor regarding personal or even non research-related issues. One female participant with a male advisor said, “There are things I wish I could talk to my advisor about.” She also reported that she felt she would be able to talk to a female advisor regarding issues she was unable to bring up with her male advisor. Other participants reported a disconnect between their preconceived notions about a mentor and their own advisor. One male participant said of his advisor,

It’s not like she’s 60 with lots of experiences. When I think of a mentor, I think of some old guy who can pull strings for you to get a job.

Another male participant echoed this perception. He didn’t consider his male, pre-tenured advisor as a mentor, but instead defined his would-be mentor as, “Someone who is on my side who has some influence.”

5.3.3 Discrimination. Discrimination has the opposite effect of mentoring, in that it alienates students and lessens their sense of membership in the community. In the pilot study, we inquired about participants experiences with discrimination, using the following university definition.

The University of Illinois will not engage in discrimination or harassment against any person because of race, color, religion, sex, national origin, ancestry, age, marital status disability, sexual orientation including gender identity, unfavorable discharge from the military, or status as a protected veteran and will comply with all federal and state nondiscrimination, equal opportunity, and affirmative action laws, orders, and regulations. This nondiscrimination policy applies to admissions, employment, access to and treatment in the University programs and activities.

Among the graduate participants, all interviewed said that they had not been discriminated against by faculty or students in the department. However, many of the participants proceeded to describe situations which the interviewers felt constituted as some form of discrimination. For example, one woman reported that she had been never discriminated against, but later told a story about how she’d been told by a male student in computer science that “women just aren’t as quick as men in computer science.” She reported that this caused her to be more self-conscious. We can only guess at the reasons why graduate students are more hesitant to describe these kinds of events as discriminatory. Because of these initial results, we did not include discrimination questions in the second phase of the graduate student portion of the study.

All four undergraduates interviewed in the pilot study reported that they had been discriminated against by their peers. Three of the four reported that they had been discriminated against only a few times, and that they simply coped with it on their own. One reported frequent instances where she felt discriminated against, but said that “many times, it was unintended or not hurtful to me, but it could definitely be considered discrimination.” She reported dealing with it by speaking to both friends and departmental staff and faculty.

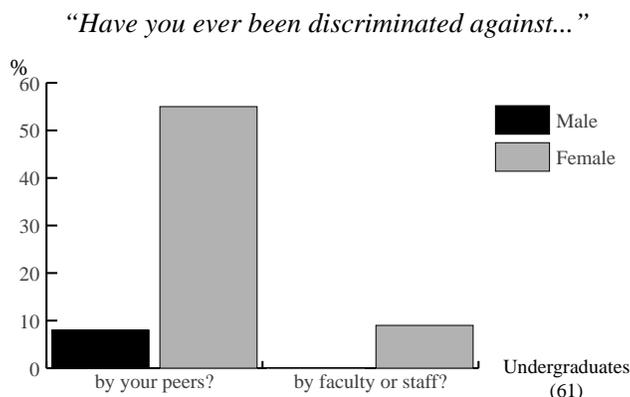


Fig. 11. Undergraduate participants were asked if they had ever been discriminated against by their peers or faculty. Among the men, none reported any discrimination from faculty or staff, and 8% reported being discriminated against by their peers. Among the women, 9% reported instances of discrimination by a professor or staff member, and 55% reported instances of discrimination by their peers.

Given these initial results, we included a section on discrimination in the second phase of the undergraduate portion of the study, summarized in Figure 11. Among the men, none reported any discrimination from faculty or staff, and 8% reported being discriminated against by their peers. Among the women, 9% reported instances of discrimination by a professor or staff member, and 55% reported instances of discrimination by their peers.

It's funny how when I end up working with guys versus girls. Like in [one course] last semester, there was a group of us . . . it was often me and these three guys, but they would always went off on tangents about blah blah blah blah, and they would conveniently finish the homework [later]. Most of them weren't organized, and it always took us forever to get things done. I did feel that they didn't necessarily defer to my opinion as much. If I give an answer then it's not always valued. My opinion should be valued as much as theirs.

Regarding discrimination by faculty, one participant in the second phase described her experience in one of her computer science courses.

My professor . . . all of his jokes are about like, 'oh guys you can tell this to your girlfriend,' and then tells some random joke. That's funny, maybe the first time, but if you do it the whole semester, there are girls in this class. It's not funny at the end of the semester.

While such an experience may not seem overtly discriminatory against women, these kinds of small experiences can result in feelings of alienation for women.

5.3.4 *Work and life balance.* To begin, we asked participants if they felt they were a “typical computer scientist” without offering any definition. This allowed us to gain insight into participants’ own definitions of a “typical computer scientist” and how they compared themselves to their own definition. Not many participants felt they were a typical computer scientist, as seen in Figure 12. Participants

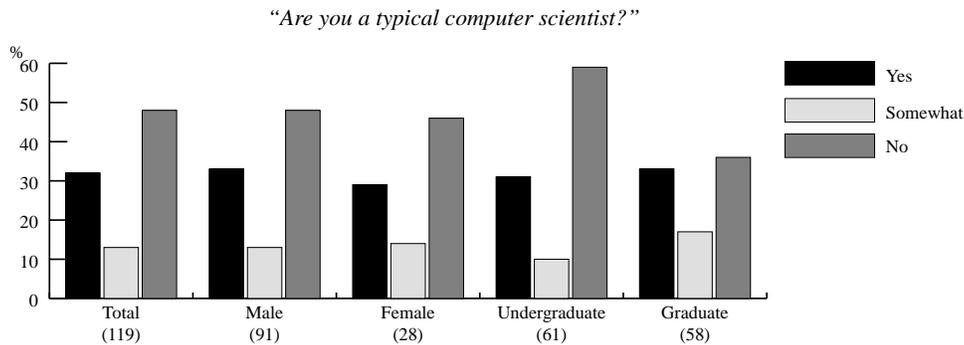


Fig. 12. Participants were asked if they considered themselves a typical computer scientist. The results were uniform across multiple categories (gender, rank), with most students reporting that they did not consider themselves as such.

reasons were incredibly varied, citing their particular research interest, the number of computer languages they know, their race, their gender, their looks and hygiene, their membership in a fraternity, their interests in other topics, and other elements of their lifestyle as reasons why they are not the typical computer scientist. In fact, the reasons for not being a typical computer scientist were so varied that it was infeasible to categorize them. Rather, we list a few here as examples.

No. I've noticed a lot of the people in the major don't look like me and I'm not particularly enjoying the major at that.

No, because I do not enjoy the low level intricacies of computer systems. I am more interested in building computer tools that have a direct impact on human life and for whatever reason, that isn't considered as pure computer science.

No. I think we theoreticians are far too 'math' to be typical.

No. I'm more of a jack of all trades. I like computer science, but my life doesn't completely revolve around it. I write; I read; I make music; I cook. Many of my fellow students appear one-sided.

Many of the graduates interviewed expressed a disinterest in leading the lifestyle lead by the professors in the department. One participant, who was leaving the department this summer, noted a divergence between the values of the department and his own personal values. He said, “[Here] research is the only thing that matters.” This is contrary to his own value which is, “Do I get to spend time with the people I care about?” Another participant pointed out the number of hours professors spent at work, saying,

I think being a professor at a big state school is a very difficult thing. If I'm going to be a professor, I don't think I could hack it here. I don't think I could do what a lot of professors here do. I don't want to work 90 hours a week.

Another participant echoed this statement with, “I don't envy the life of assistant professors at this school; working 100 hours a week when you're 35.”

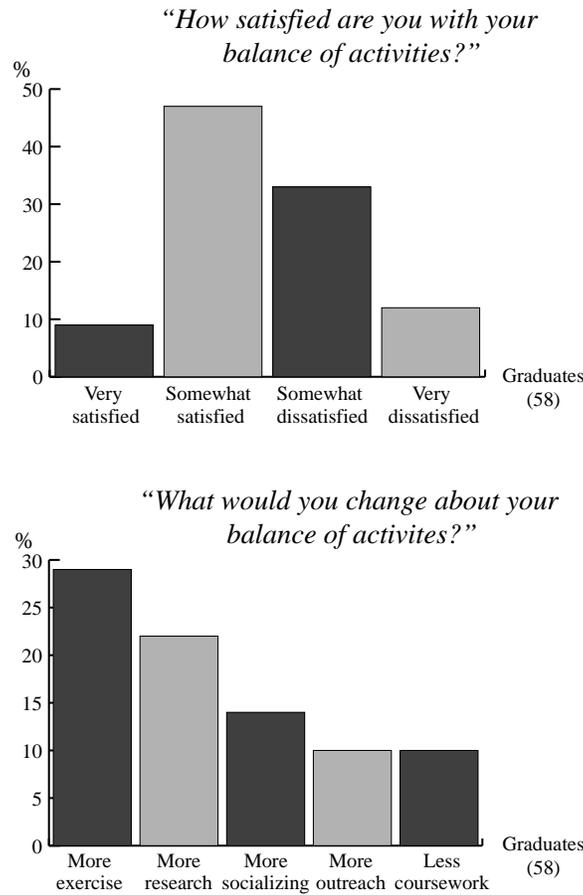


Fig. 13. Participants were asked how satisfied they are with their balance of activities. They were also given the opportunity to express how they would improve the balance if they could in a short answer format. Despite being short-answer, participant responses were easily categorized into the above themes, with most wishing for more time for physical activity.

Given that the graduate school years overlap peak childbearing years, we asked the graduate² participants about their attitudes about parenting while being a computer science graduate student at UIUC. Of the graduate participants, 9% reported that they were a parent and spent “10 to 20” or “30 to 40” hours a week raising children. Of the participants, 35% of the females and 10% of the males said they felt pressure to start a family.

In the interviews, the pressure to have a family was discussed. One participant, who was hopeful about someday starting a family, said this of her pursuit of a Ph.D.

²Undergraduates were not surveyed about family pressure or child-rearing based on the lack of results in the pilot study.

I shouldn't have to give up what I have here. I think that I can have both. The problem is that most people don't think that way. If you are a female then a family should be your priority, not your career . . . I think it's possible to have both. It's difficult. It's not easy.

Another graduate participant said of her reasons on deciding not to have children,

I really don't see it happening, the way that I'm living now. I can take care of a child at the high level in the sense that it won't die, but basically you have to put the child in day care at 8 and take it out at 6 . . . Assume if I have a deadline, I don't even eat properly if I have a deadline . . . Why would I do that to a child, basically. That's why I've given it up altogether.

To test whether the participants were aware of the the department's existing family medical leave policy for graduate students, graduates were asked, "Does the Department of Computer Science at UIUC have a family leave policy?" Only 3% of participants replied "Yes" while 91% replied "I don't know."

The current policy states,

Graduate students in need of a leave of absence due to medical or family emergencies, including the birth of a child, may request a one semester (or in rare cases an academic year) absence from their regular degree programs. Any time constraint on the degree requirements, such as the Master's degree time limit or time limits on Qualifying and Preliminary examinations, will be automatically extended by the length of the leave of absence. However, the Graduate College seven year clock for doctoral studies does not stop by a leave of absence. Any extension to this time limit must requested by petition to the Graduate College.

When shown the policy, graduate participants were asked "How adequate do you consider this policy for your own family plans and needs," the following answers were selected as follows:

- "Very adequate." (16%)
- "Somewhat adequate." (50%)
- "Somewhat inadequate." (26%)
- "Very inadequate." (7%)

All of the parents reported that they felt the policy was "Somewhat adequate." Moreover, the parents interviewed felt that their advisor was supportive of their role as a parent and that it was possible to have a family while in graduate school. Still, some had suggestions for improvements by the department; including a "flexible schedule" and "1-2 month family leave."

6. RECOMMENDATIONS

Given the data presented by our study, we provide a set of recommendations in which the Department of Computer Science may improve in the areas of recruitment, preparation, and retention. These recommendations rely heavily on current practice elsewhere in academia, seeking possible solutions for the particular areas of the Department of Computer Science that need improvement.

6.1 Recruitment

Provide more comprehensive information to prospective graduate students. The study highlighted the naïve algorithm that graduate students used to select a graduate school. This demonstrates a demand to make more information available regarding the choices that graduate students need to make when selecting a graduate school. This information may better attract strong candidates who are informed about the department and graduate life at UIUC, and turn away students who might not succeed in the department's unique environment. One resource, the Survey on Doctoral Education and Career Preparation [Golde and Dore 2001], offers a website [Golde 2001] summarizing the tough questions that prospective graduate students should ask of themselves and their prospective departments and programs of study. Given that prospective students often visit the departmental website, linking cs.uiuc.edu to third-party websites such as these help to provide prospective graduate students with the information they need to make the tough decisions about whether or not to attend graduate school and what graduate school to select.

Facilitate more opportunities for outreach. As noted in Section 2.1, there are a number of existing outreach programs both within the department and the college. The study showed that these are somewhat well-known by the undergraduates, but that the graduate students lack an awareness of these programs. In discussions with faculty after initial publication of our study, it seemed that the same was true of the faculty. Even faculty are not consistently informed about outreach. One simple solution to begin informing the department population of these efforts; include a slide or two about existing outreach efforts in the introductory presentations at the required seminar for all first-year graduate students or faculty meetings.

The Department of Computer Science currently has several strong outreach programs, including ChicTech and CSGSO's prospective student weekend activities, and also participates in college-wide programs such as the G.A.M.E.S. camp. However, there are two areas we feel that the existing outreach system could improve. First, there is no central point of entry into these outreach programs. Individual programs perform their own recruitment via mass e-mail and word-of-mouth. As mentioned in the survey, 18% of participants currently participate in some kind of outreach, not necessarily within the department, for 1-5 hours per week. These and other students who are interested in participating in outreach may simply be unaware of these recruitment efforts, resulting in an untapped though valuable resource. A departmental-run umbrella organization would help students become aware of all outreach opportunities in the department, and might also allow the department to expand outreach to student organizations which currently do not participate.

Second, there is no reward system for students participation in outreach. To exemplify what we mean by reward system, two years ago the College of Engineering offered a course, Engr199, which was designed to allow students to help design a curriculum for Home High, a local school. The course involved some reading and research into current practices, but also had a significant component in which students actually interacted with and taught the middle school students. The Department of Computer Science also offered a similar course under the name-

sake “CS2GO,” whose recent offering yielded the MergeSort DanceTroop, a small band of graduates and undergraduates who perform a choreographed dance of the merge sort algorithm. While schedules are invariably busy for both undergraduate and graduate students, the ability to receive course credit for outreach might allow interested students to participate in outreach activities. This may be more applicable to undergraduates, but also to graduate students who are interested in gaining mentoring experience before becoming faculty themselves. Moreover, these opportunities allow students to participate in outreach who do not feel they fit in with ACM or WCS.

In the undergraduate program, it is somewhat common for students to interact with companies or local organizations, which serves as an additional community outreach service. For example, many students in CS427, *Software Engineering I*, do software engineering projects based on corporate requests from local computer businesses like Motorola or Cisco. The ChicTech program specifies that high school teams participating in the weekend competition should program something for a local non-profit organizations. Projects identified and implemented by the high school students have included tracking software for their high school coach and creating a website and newsletter for a local women’s shelter. These opportunities to use computer science to benefit the real world, whether it is a local business or a non-profit organization, both accomplish community outreach and encourage students to consider the social impact of computer science.

While these outreach efforts are all strong and successful at the undergraduate level, another concern is the lack of awareness of such programs by graduate students. Recall the participants who said of outreach, “I would if I were asked.” or simply that, “We don’t do it.” Given their perception that the department had few outreach activities, multiple graduate student participants offered great ideas for incorporating their research into outreach activities. One participant offered an idea about workshops for people in industry, giving an example of “rapid evaluation and prototyping.” With this idea, the department could forge even more interactive relationships at the graduate level with local companies such as Motorola. The message to industry would be, “The things we are teaching you are the same thing we are teaching our students. You should hire our students.” Another said,

In [a recent conference] there was this talk about how you can bring in the community in your . . . courses. So one professor was talking about how in her class she had students go out into the community and look for problems that were there and come up with a project that would address those problems. Often in Computer Science, we pick problems that no one actually cares about, or no one even actually understands. This is something how you can actually do community outreach. You can go out to schools or Boys and Girls club and see what they are doing and how you can help them do certain things better. It’s also applying what you are learning as a computer scientist.

In the above a graduate student unknowingly describes the ChicTech program, and inserts an opportunity for herself to participate. Both undergraduate and graduate community outreach could be strengthened by encouraging new ideas and expanding existing programs. Given that faculty are often unaware of business connections in the community, and graduates are often unaware of outreach oppor-

tunities, creating a centralized list of industry affiliates could help to foster such outreach, allowing interested students, research groups, or student groups like the CSGSO to organize these types of community ventures.

Facilitate more interaction between students and faculty. In the final question of the survey, students were asked what they think could be improved in the department. Of graduate participants, 31% cited increasing student-professor interactions, and without prompting often cited the recently organized TGIF event as a good example.

I think more informal gatherings between faculty and students would help the atmosphere. For example, the Friday lunches are a good idea. I would like to see more of those around the department.

Another participant echoed this positive response to TGIF and went on to suggest more of these informal events,

One suggestion is to promote some meetings between professors and students who have something in common. For example, meetings between a professor who has some outside interest that matches the interests of some students (e.g. basketball, cooking, kites etc). I believe having something in common with a professor would make students more relaxed and facilitate a first contact and interaction.

Other participants suggested organizing sports teams, bicycle trips, reflecting many participants' interest in increased physical activity. Another participant suggested inviting faculty to the CSGSO FEs.

Both ACM and WCS have regular meetings and seminars, and frequently invite faculty members to serve on panels and meet the students afterwards. For example, WCS hosts a popular annual panel called "Meet Your Professors." CSGSO has a few similar seminars, but they have generally been more limited and dependent on the particular CSGSO officer in charge of seminars. Another suggestion to improve interaction between faculty and graduate students is to put senior graduate students in charge of coordinating talks and seminars, especially local seminars such as CS591, *Advanced Seminar in CS*. For larger seminars such as DCS and the Distinguished Lecture series, graduate students could be added to the committees that choose and arrange speakers. While graduate students cannot be expected to contact and arrange all such activities, they can be allowed to assist in planning and hosting. These activities may help to eliminate some of the "Us" (the graduate students) and "Them" (the faculty) dichotomy that currently takes place at these seminars. In addition, it would place senior graduate students in a more visible, prominent position, which in turn could help graduating PhDs to secure more contacts and better chances in the academic job market.

Among undergraduates, 24% suggested more faculty interaction and social activities to improve the department. Several commented on how great !bang's events such as !Studybreak and !Casino were in terms of encouraging social activities and interactions with professors, and said more events of that type would be nice. Two commented on how great the Powerlunch program was, but noted that most undergraduate students are too intimidated to ask a professor out to lunch themselves. As a solution, one option is to have a weekly lunch sponsored by the department

with limited seating. One or two professors per week would attend as “hosts”, and students could sign up to attend. In this way, more interaction with professors is accomplished, but in a less intimidating setting and where students could meet professors whom they might never have interacted with before.

As another option, it might be beneficial to encourage undergraduates to talk to their advisors and professors during office hours more frequently. However, many undergraduates misunderstand the purpose of the advisor, assuming that faculty advisors are there to assist with course planning. Better informing them of their advisor’s purpose, perhaps during CS100 or other 100- and 200-level required courses, may encourage students to regard their advisors as mentors with regards to career guidance and other professional advice. Resolving this misunderstanding might also help faculty advisors serve their students more effectively.

6.2 Preparation

Improve quality of teaching. While it is understood by the participants that the department’s predominant emphasis is research, the quality of teaching was still raised by both undergraduates and graduates. For the undergraduates, improving the quality of teaching means improving the quality of teaching assistants and to fostering more collaborative course work.

Before discussing how to improve teaching assistants, we summarize the current system for training and assigning TAs in the department. Currently, teaching assistants for the department receive the same two-day training course that all campus-wide teaching assistants receive. International teaching assistants receive an additional two days of training to help them cope with the gap between their own culture and American culture. The Department of Computer Science assigns teaching assistants to courses with the requirement that they’ve taken the course before. However, because of lack of funding, or lack of teaching assistants with a certain expertise, graduate students are sometimes assigned to courses they’ve never taken. Moreover, professors are decoupled from the assignment process, with their assistants sometimes lacking the expertise they expect for the particular course as it’s taught at UIUC. On the other hand, some graduate students are particularly gifted at teaching, consistently lack funding for a research assistantship, or both. This results in career teaching assistants, graduate students who spend two years or more TA-ing courses. One participant was a career TA, and reported leaving the department without completing a PhD this summer.

That said, the current system for training and assigning teaching assistants appears that it could be improved. First, given what little training is available to teaching assistants, it may be worthwhile to provide more resources to them. Currently, the university is host to CTEN, the College Teaching Effectiveness Network. It sponsors events throughout the year, including talks on increasing student motivation, and grading assignments. It may be worthwhile to for the department to better utilize this existing resource by advertising CTEN to its TAs who might opt for additional training. A step further would be for the department to offer more specialized training for its teaching assistants. For example, the University of California at Berkeley offers its own course, CS301, called *Teaching Techniques for Computer Science* which discusses techniques for effective teaching.

In terms of assigning teaching assistants, professors could be given an opportunity

to participate, interviewing the available teaching assistants to determine if a student's expertise is a fit for the course. To increase the available expertise in the pool of teaching assistants, it may be worthwhile to require a year of teaching service of all graduate students, thereby gaining the expertise of third-year students who've never taught while at the same time avoiding career teaching assistants. Incoming first-year graduates do not always have the expertise to TA courses such as CS423, *Operating System Design*, or CS473, *Algorithms*. Distributing the one year service requirement across the entire graduate program could help obtain more expertise. Finally, given that approximately 40% of Ph.D. candidates reported an interest in a career at four-year university, requiring a year of teaching from graduate students may better prepare them for their future career choice.

As previously pointed out, undergraduate participants requested more collaborative course work, whether through discussion sections or group assignments. Several students specifically commented on the new course organizations for the CSx73 sequence. Many liked the new problem sessions in CS273, *Intro to Theory of Computation*, and CS473U, the undergraduate section of *Algorithms*. The discussion sections in CS173, *Discrete Structures* were also mentioned favorably. These interactive learning environments appear to help students who learn more effectively outside of traditional lecture, or for students who might be seeing the topics of CS173 for the very first time. In addition, they provide more social interaction among undergraduates and between graduate students and undergraduates.

For both undergraduates and graduates, improving the quality of teaching means improving teaching styles. One participant said,

I would like the university to help teach professors who are great minds/researchers how to teach and interact with students better. I understand that UIUC is a great research school, and I know the importance of this, but sometimes the people who are best at research are terrible teachers.

That said, one recommendation is to offer a computer science pedagogy course to the department's incoming assistant professors who might lack teaching experience. Currently, the College of Engineering offers such a course, but the approaches to teaching computer science aren't necessarily similar to those for teaching engineering courses. Such a course would be taught by tenured professors of the Department of Computer Science, optional for tenured professors, but required for assistant professors.

Another solution is to adopt the "Assistant Professor of the Practice" position [Fogg 2004] that is seen at universities like Duke and Carnegie Mellon University [Carnegie Mellon University 2001]. With more permanent lecturers who are more focused on teaching than research, students may gain more quality teaching for their foundational 100 and 200 level courses. Such an improvement coincides with the multiple comments from participants who described their excellent experiences with teaching and mentoring as provided by current lecturers of such courses in the department.

Provide more flexibility in core requirements. The attitudes regarding the core curriculum requirements at the university are very disparate among the department and faculty. The department expects graduate students to achieve

“A” grades in many of these courses, while it is understood by the participants that many of the faculty feels that course work is very unimportant compared to research.

Currently, the department allows graduate students to take their qualification exam without meeting one of their core requirements, allowing them to postpone the course until after the exam. This could be extended further, requiring that the core requirements for PhDs be met over three years, rather than two. This way, students may take the courses important for their qualification exam, gain knowledge in foundational areas, and better balance course work and research.

Increase early research opportunities. Given the department’s interest in reducing the time to degree, we recommend offering more opportunities to ease the transition from student to researcher, both for undergraduates and graduates, by making research opportunities available earlier in their programs. In this regard, the department has already offered some opportunities which were met with positive response. These include career panels of faculty during the DCS seminar as well as stand-alone talks such as Professor Sha’s “How to do Research.”

More opportunities, however, could ease this transition further and reduce the current average time to PhD. A good example of such an opportunity is found at The University of Illinois Department of Mathematics. They had a five-year NSF-funded program, starting in June 2000, called the Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE) [VIGRE] program. VIGRE provided for a number of work groups which fostered interaction among undergraduates, graduates, postdoc and faculty. Among them were the Across Level Peers (ALP) group which included undergraduates, graduates, and faculty to discuss a variety of topics, including career plans, and foster mentoring relationships. Also offered was the Research Experience for Graduate Students (REG) work groups, which were organized by a faculty and focused on a single research area. Faculty, postdocs, and graduate students, including first-year students, would meet and take turns presenting problems. As the seminar progressed, the students and faculty would break into smaller groups to conduct original research.

At least one VIGRE group, the Combinatorics REG, continues to meet every summer, fall, and spring semester, despite the funded program’s completion in 2005. Participation has become one successful way to for first-year students in both math and computer science to enter into research in combinatorics as well as find an advisor. Notably, many students in theoretical computer science have also participated in the summer sessions to broaden their research experiences in mathematics. Almost all participants are able to produce a publication with others before the conclusion of the seminar each session.

The NSF has similar grants for Computer Science, including the “Broadening Participation in Computing” program. This kind of program at UIUC could not only help graduate students make the transition to researcher, but it would also give undergraduate students an opportunity to learn more about research career opportunities. Given that only 24% of the male and 9% the female participants reported that they would consider graduate school, this may help to increase the number of University of Illinois undergraduates who continue to graduate school.

For the 41% of female graduate participants who had a “somewhat difficult time” finding an advisor, we recommend programs like the one at the University of Washington [Handelsman et al. 2005]. The Faculty and Graduate Mentorship Program promotes mentoring relationships between female graduate students and faculty in the science, technology, engineering, and mathematics fields. These kinds of specialized mentoring programs between faculty and underrepresented minorities — like women and African Americans — could help to ease their existing frustrations and challenges in finding an advisor.

6.3 Retention

Create multiple and diverse mentoring programs. The study uncovered a notable disparity between the participants who did not want a mentor and the participants who did not have a mentor, suggesting that there is a large population of students who are interested in gaining the benefits of a mentoring relationship. For undergraduate students, aforementioned programs such as the VIGRE All Level Peers groups are designed to foster mentoring relationships between undergraduates and graduates and undergraduates and faculty.

For graduate students, there are currently few mentoring opportunities, the primary of which relies on a student’s single advisor, yet only 49% of graduate students with an advisor regarded their advisor as their mentor. Realistically, no single advisor can be the perfect mentor, so we suggest providing multiple and diverse options for graduate student mentors. For example, the University of Southern California’s Department of Mathematics assigns mentoring triplets at the beginning of the academic year. These triplets consist of a first-year graduate student, an advanced graduate student, and a faculty member. It is the faculty member’s responsibility to schedule approximately monthly meetings with the triplet for informal discussions. Given the recent success of the TGIF program at UIUC, these further informal gatherings may help to foster an improved intellectual community in the department. The triplets could also consist of freshmen, upperclassmen, and advanced graduates. Yet another option may be to simply provide incoming freshmen or first-year graduate students with a list of upperclassmen and advanced graduate students who are interested in being mentors, so that first-year graduates can option for a mentor if they wish. These kinds of programs help mitigate the burden of mentoring on the faculty, improve interaction among undergraduates, first-year graduates, and advanced graduates, and may also help to change the perception that a mentor has to be, as one participant put it, “a wizened old man.”

Provide an adequate family leave policy. Though the peak child birth years overlap graduate school years, there are currently few family leave policies nationwide for graduate students. This is notable for the department’s female students, 35% of whom feel pressure to have a family. Noting other studies, including [Mason and Goulden 2004], which illuminate the need for such policies in order to promote greater female participation in academia, top schools are starting to implement assistance for students who choose to have children in graduate school.

The current leader, MIT, has a Childbirth Accommodation Policy. This policy, administered by the Graduate Students Office, allows up to eight weeks of Childbirth Accommodation. Students who are research and teaching assistants paid by

the university continue to receive their stipend during this time. Teaching assistants are permitted to consider limited duties. MIT doesn't treat this accommodation as a "leave" as that could negatively affect some visa status.

Other universities, such as University of California at Berkeley and Stanford University, have similar policies. Student parents at Berkeley can request "part-time status" meaning that the course requirements are fewer, preliminary and qualification exam clocks are slowed, but full-time benefits are still provided. Pregnant women may also request part-time status. Moreover, for four weeks before and 6 weeks after the birth, research advisors are instructed to expect that the student will be less productive than usual, and that the mother may request a temporary suspension of her research or instructor assistantship.

Graduate students at Stanford also have a Childbirth Policy in which female graduate students are eligible for two-quarter Accommodation Period in which examinations and other academic requirements may be postponed. During this time, they are also eligible for full-time enrollment and keep their health insurance and university housing. Given the university's population of 5500, one-third of which are women, Stanford estimates that 30 of their female graduate students per year will participate, resulting in an annual cost of "less than \$100,000" [Capriccioso 2006].

The existing family leave policy in the Department of Computer Science slows the clock on requirements for the qualification and preliminary exams. Thus, a student could potentially be absent for a semester while recovering from her birth without suffering any penalty for not taking the preliminary exam on time. However, current parents of the department only rated the current policy as "somewhat adequate." To achieve a more adequate policy, we examine how the policy differs from that of MIT, Stanford, and Berkeley. First, it currently relies heavily on a cooperative relationship between an advisor and student. It does not have the same level of protection for students. A student is not guaranteed the ability to return to her research or teaching assistantship after being absent for a period of time. Moreover, an existing university-wide policy only provides graduate students with two weeks of leave for emergency or other health reasons. A student who chooses to be absent for a longer period of time, like the minimal six weeks necessary to recover from a cesarean section, suffers from not having access to health insurance, or partial or full pay. The Federal Family and Medical Leave Act of 1993, as observed by the University of Illinois, provides that its eligible full-time employees, "are eligible for up to 12 workweeks of paid and/or unpaid leave" [University of Illinois at Urbana-Champaign].

7. CONCLUSION

Overall, the study saw two major themes. First the participants described an overall perception of the department placing significant emphasis on research pursuits. These pursuits bring funding to the department and inform the broader computing community of advancements in computer science. Yet, our participants also reported perceiving a negative impact as a result of this emphasis. We spoke with participants who felt that professors sacrificed quality teaching for research and participants who felt that no professor would be interested in mentoring them. We

surveyed graduate participants who disdained the core course work for taking time away from research. Participants turned away from careers at top research institutions because of an unwillingness to pursue the perceived “90 hour” work week exemplified by many professors in the department. Still other participants reported leaving the program without completing their degree.

As a highly ranked department in a large research university, it is understood that the Department of Computer Science at UIUC places a primary emphasis on research. However, as [Serow 2000] and [Baez 2000] show, and our study reveals, this may be at the detriment to other roles — teaching and service — which are also important to a high quality academic environment. Given the results of our study, we argue not that research should be placed secondary to these two other roles, but rather that a greater balance of this triumvirate is necessary to excel as a department.

In a system which places a much higher importance on research, faculty who wish to teach well go unrewarded by the tenure system and even suffer from the public perception that their teaching activities detract too much from a focus on research. Likewise, students may receive poor teaching even at schools which are highly ranked because research takes center stage. For graduate students, mixed messages are received when the need to do research is combined with core requirements that do not necessarily advance the research goal. In this case, pressure to obtain a certain grade in a course unrelated to one’s research area surfaces as concerns that the courses are taking away from research and in advice from advisors that the core requirements “don’t really matter.”

With regards to service, the push to do research may also discourage both faculty and graduate students from acting as mentors and performing outreach and recruitment activities as well as make it difficult to find a healthy work and life balance. Similarly, underrepresented students and faculty tend to be targeted to be active in particular service activities, such as female faculty or graduate students receiving requests to act as mentors for female students or sit on gender-related committees, which do not aid in their promotion or in receiving their graduate degrees [Baez 2000]. These additional expectations further compound the difficulty of being a minority in the department.

Admittedly, our appeal for greater balance among the three roles of research, teaching, and service may seem like too great a challenge with too much a cost for the research pursuit. Yet this triumvirate, when balanced, can lead to a positive environment in which each role informs the other. For example, the encouragement to serve as mentors and perform other service activities frequently provides an opportunity to expand research opportunities. Excellent teaching provides students with a stronger background with which they may do great research. Interaction within the department yields new graduate students and faculty with which to collaborate. The roles do not need to be in competition with each other, but rather can be cultivated to complement each other. As we have seen while talking to both faculty and students, some pieces of this balance puzzle are already thriving within the department. Outreach programs like ChicTech, CS2GO, and the G.A.M.E.S. camp allow undergraduates and graduates to use their computing expertise to impact K-12 education. Courses such as CS427, *Software Engineering I*, make connections to

industry allowing students to network and demonstrate their excellence to outside members of the computing community. Teaching improvements seen in the *x73* sequence foster more interaction among students, paving the way for more research collaboration in the future.

This brings us to our second theme; simply the lack of communication among various entities within the department. This lack of communication has a significant effect on the perception of participants that research is of primary value. There are multiple outreach programs available and improvements in teaching are underway as seen in the *CSx73* sequence, yet many graduates and undergraduates are not exposed to these phenomena. A graduate participant complained that the department doesn't do any outreach, yet we just saw the conclusion of another successful G.A.M.E.S. camp on the local news. Multiple participants complained about certain faculty needing to "sell" the students more, yet many other faculty speak highly of the graduate students, particularly with industry representatives and alumni. Undergraduates complained of a lack of interaction with faculty while faculty complained that students never attend office hours or come to speak with them.

While this dichotomy was especially frustrating during the course of the study, it was also hopeful to observe how many efforts are currently underway. With activities ranging from the TGIF lunch to !Casino, many of the faculty in the department are already involved in improving the student experience at an unprecedented rate. While pieces of the balance do exist, more are needed. It is not simply advertising current activities that is needed, though more diverse footage on the video wall would be welcome by everyone. What is also needed is increased communication between students and faculty regarding everyone's needs and expectations. As one participant said, it is making sure that students "understand the process of research from beginning to end."

The authors of this work were primarily motivated to conduct this study with the belief that its results and recommendations would serve as a list of best approaches to continue this already existing effort. It is our hope that this document and our recommendations will open up channels of communication so that students and faculty can work together to better the department, and in turn, improve the computing culture for everyone.

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