

**A Different Voice: Women  
Exploring Stanford  
Computer Science**

by Lilly Irani

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## **Abstract**

The shortage of women in computer science is a phenomenon resulting from a wide range of factors that are often entangled or oversimplified in commentary and proposed practitioner solutions. This study uses ethnographic methods and quantitative studies to explore factors influencing students to continue pursuing or to abandon CS in Stanford's introductory computer science pipeline. Sociological and social psychological research sheds light on factors explicated from interviews. CS106A and CS107 are identified as critical junctures in the curriculum and examined in particular detail.

Research identified gender socialization as the greatest force influencing women to discontinue the CS core. The greatest flight occurs after CS106A. Women persist during later courses in the core at rates similar to those of men, but they experience unique struggles in CS107 as they establish a place in a class culture that limits their roles and challenges their confidence.

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## Gender Imbalance: Women's Participation in Computer Science

“Boys invent things. Girls use things that boys invent.”

-- Whitney Darrow,

*I'm Glad I'm a Boy, I'm Glad I'm a Girl*

If this is indeed the case, as claimed by 1970s children's book author Darrow, then the infrastructures of the gender system extend beyond the socialization, stereotypes, interactions, and social structures that shape the roles we play. Technologies themselves, bound by the designers' imagination and experience, are imbued with values and suppositions that further the status quo that produced it.

While many bristle at Darrow's reduction of women's and men's roles in the world, the truth is that most engineers coming out of colleges and universities in the United States are, in fact, men. The most recently available NSF statistics report that in 2000, women comprised 28% of all Bachelor's degrees granted in computer science.

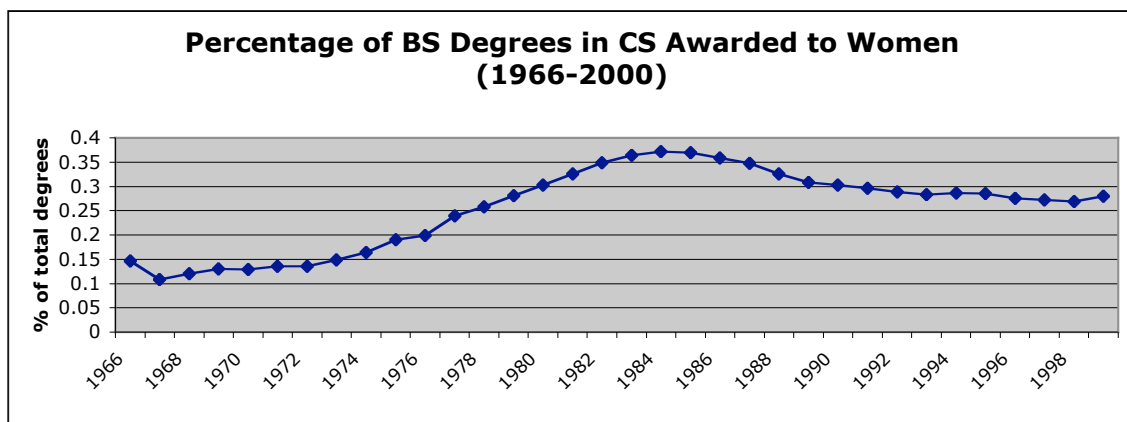


Figure 1 (Source: NSF)

As evident in Figure 1, the magnitude of women's under-representation in computer science is not a historical constant. Nationwide, women achieved peak representation in 1984 as 37.2% of computer science graduates (NSF, 2000).

In 2003, only 18% of declared computer science majors at Stanford University are women, peaking at 20% over the last 12 years, and placing Stanford below the national average (Roberts, et al.).

Enrollment data in high school computer science courses predict women's under-representation at the BS level. The Advanced Placement exam in computer science provides an opportunity for students to learn introductory college-level material while still in high school. In 1999, 17% of students taking the "A"-level exam (covering a semester of material) were women. Only 9% of "AB"-level test takers were women (AAUW, 2000).

Even amongst top math and science students in the nation, the gender gap varies across sciences, with computer science showing, by most measures, one of the largest gender gaps. Figures describing the 2003 Intel Science Talent Search finalists alarmed many, pointing out that the nation's top female scientific minds were staying away from computer science with greater frequency than any of the other disciplines represented in the competition (Figure 2).

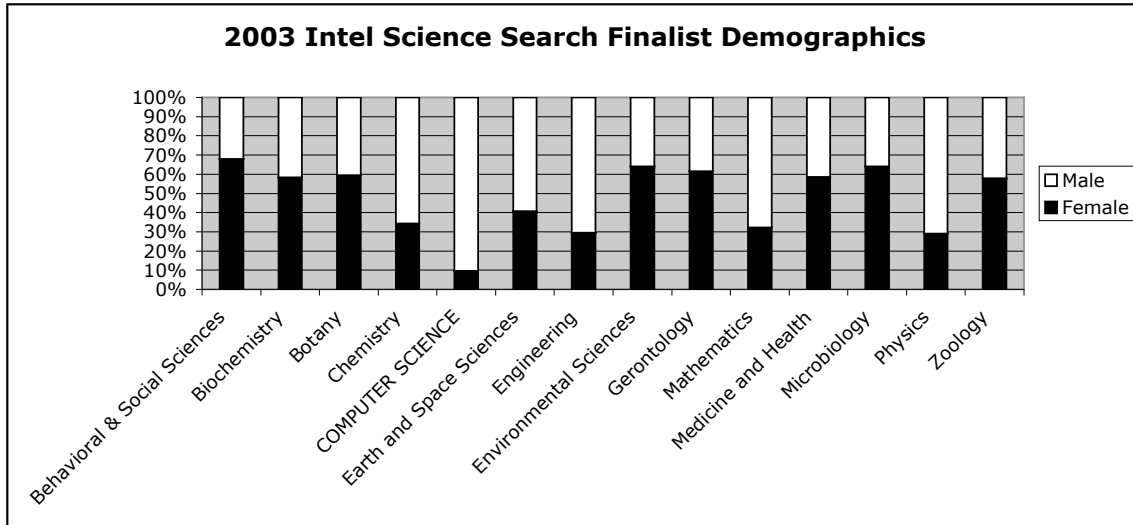


Figure 2

With the increasing prominence of information technology as a critical industry as well as an element of everyday life in the United States, the gender gap in engineering education has attracted greater attention, not only from educators, but also from technologists, researchers, and the news media.

### **A Breadth of Concerns, A Common Focal Point**

Reasons to be concerned with the dearth of women in science and engineering are almost as numerous as the factors influencing the problem.

#### *Social Justice*

For some, the increasing ubiquity of technology in the world means that equal access to technology, as an institution, is essential. The late Anita Borg, a Computer Scientist and founder of the Institute of Women and Technology, explained, “If half the people are left out, it’s impossible to claim that technology is developed democratically” (2002). Women must have equal access to technological literacy and fluency, just as they have the right to basic literacy, as these are the basic prerequisites to making choices and decisions about technologies in their lives. Courses in Microsoft Word and using a web

browser, however, will not suffice. The AAUW defines fluency as “the ability to use technology proactively, understand design issues, and be able to interpret the information that technology makes available” (2000).

In 2000, a U.S. Department of Education survey (Figure 3) found that the only computer-related coursework women complete with frequency equal or greater to that of men are clerical courses, such as computer data-entry. The gap between male and female computer learning in high school has only contracted among men and women taking clerical courses. (In 1994, 25% of graduating women and 16% of graduating men had completed such coursework.) Over four years, the gap between men and women taking computer applications (i.e. graphics and publishing) courses has expanded and the gender gap in computer science course completion has remained constant.

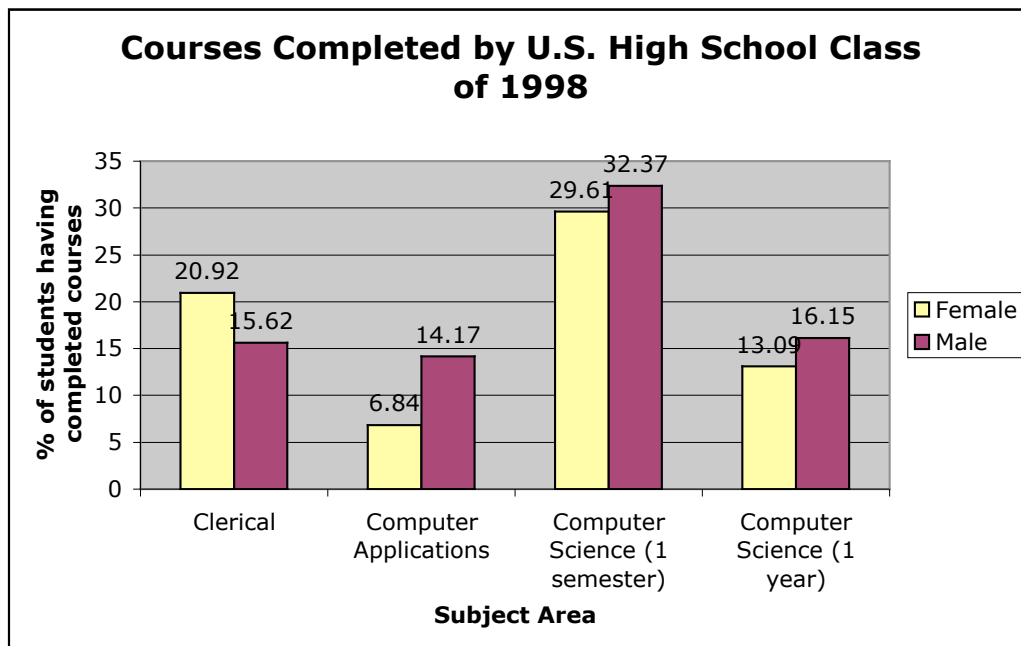


Figure 3 (Source: U.S. Department of Education, 2000)

In a world where technology pushes the boundaries of medical care, privacy rights, and intellectual property claims, women must have access to the education that

will enable them to fully engage as citizens – as individuals, as designers, and as policy makers – in this changing world.

### *Labor Supply*

Especially during “the tech boom” of the late 1990s, some analysts turned their attention to the issue of diversity in the computing professions for a reason more pragmatic than social justice. In the face of labor shortages that justified an expansion of Visas for foreign information technology [IT] workers, priming the pipeline of women and minorities entering the IT sector became a way of expanding the supply of skilled labor in the economy. According to the Computing Research Association, “If [women and minorities] were represented in the IT workforce in proportion to their representation in the U.S. population, this country would have more than an adequate supply of workers to fill even the most dire estimates of a shortage” (Freeman, Aspray).

### *The “Biodiversity” of Engineering*

Pragmatists concerned with the economy are not the only ones who have found reason to puzzle over the gender gap in science and engineering. Engineering practitioners see problem solving as a generative activity, in which a diversity of alternatives must be developed and considered before the most elegant solution can be chosen and fully implemented. Such diversity of solutions is borne of diversity of perspectives, termed “cognitive diversity” by Philosophy of Science scholar Sandra Harding (1998). Just as limiting genetic diversity limits population viability in the long term, limiting cognitive diversity limits a technological solution’s viability.

William Wulf, then serving as President of the National Academy of Engineering, warned, “Every time we approach an engineering problem with a pale, male design team,

we may not find the best solution. We may not understand the design options or know how to evaluate the constraints; we may not even understand the full dimension of the problem” (1998). Darwinian problem solvers, like Wulf, are pragmatists but they look to increase diversity in their ranks as a means of bringing as broad a range of perspectives, experiences, and interests into the process of solution generation. Such cognitive diversity will benefit not only women, or the economy, but also the lives of all consumers of technology.

### **Does the Engineer Really Matter?**

“To bring women in is not just to rectify the inequity...it means to change the conversation.”

-- Psychologist Carol Gilligan

Engineering is a socially centered process, fundamentally engaged in fulfilling human needs. In understanding and fulfilling these needs, engineers make assumptions about the central problem, the user, and the consumer, embedding his or her own limitations of perspectives into the solution produced.

History and Philosophy of Science scholar Londa Schiebinger (1999) describes the extent to which social assumptions are embedded in technology. “While grocery carts and strollers have been designed to fit women’s bodies..., cockpits and artificial hearts have been designed to fit men’s.” While Computer Scientists did not design gender into the technologies Schiebinger describes, they certainly have the opportunity to do so.

The field of Human-Computer Interaction [HCI], a subfield of computer science, is concerned with designing the interface between computer and human, or human and human as facilitated by computers. In mediating people's experiences, HCI designers make assumptions and design decisions that can encode the gender system, as it exists today, into their artifacts and technologies.

The embedding of such values is far from accidental. Methods such as centering solutions around designer-chosen personas deliberately force the designer to make simplifying and sometimes exclusionary assumptions. A speaker to a Stanford interaction design seminar gave the example of designing an interface for monitoring and controlling computer networking. In designing, he chose five personas, based on those he took note of while on site, but made into fictional characters. His personas were two East Asian men and three white men. Based heavily on the designer's own observations made with limited time, those he perceived as being network engineers may have been limited by his own stereotypes. Based on his unchallenged and simplified assumptions, he designed a tool with the interests of the chosen personas in mind.

Persona-based design is a well-accepted user design technique that is only as good as the breadth of perspective possessed by the designer. As Wulf (1998) explains, "One's creativity is limited by one's experiences." If the designers remain pale and male, their designs will maximize their presumed users' empowerment using the technology, and possibly place obstacles in the way of users – women, minorities, or the disabled – they failed to foresee. Beyond serving as an example of bad design, or failing to serve a market, these interfaces mediate and, thus, can unfairly limit access.

Realizing this, Anita Borg founded the Institute of Women and Technology [IWT]. One of IWT's largest projects is coordinating "Virtual Development Centers." These project centers, located on several college campuses, focus on elevating the priorities of women and girls in the development of technology. IWT's ultimate goal is "to create a world in which technology fully and positively serves the world population." To achieve this goal, they focus on a segment of the population underrepresented in technology design and policy. They focus on women.

### **Literature Review**

Like rationalizations for gender differences in general, the gender gap in engineering is typically attributed to "interplanetary" differences between the genders, whether they are claimed to be biological differences or differences in socialization. Both hypotheses, however, focus on the individual and their stable, internal gender attributes, rather than the values imbued in technical cultures and curriculum, and how those structures are experienced differently among individuals of differing social groups.

Are girls simply uninterested in computers? Some analysts hypothesize that girls veer away from computers because they prefer working with people, whether as a result of socialization or genetics. Others theorize that girls get scared away by the mathematics included in typical computer science curricula. Still others argue that if computer science were approached more like Mathematics (DePalma, 2001), the percentage of women in computer science might approach the 45.8% of B.A. recipients in Mathematics who are women (Hill, 1999).

Other explanations focus on extrinsic factors, such as a "chilly climate" for women in engineering (Strenta, Elliot, et al, 1994) that prevents them from benefiting

fully from the network of weak social ties or mentorship. Reports by women in the field have confirmed that uninviting conditions have existed in computer science departments such as MIT and other institutions. In 1983, female researchers at MIT's Artificial Intelligence Lab co-authored the report *Barriers to Women in Academia*. The report's power was rooted in the signatories – every woman in the lab signed her name to the report, which included accounts of sexual harassment, condescending assumptions, and reduced access to social (and in turn, resource) networks, among other obstacles.

Ten years later, then-MIT AI Lab Master's student Ellen Spertus reported that the situation had only marginally improved. However, a study of science and engineering students at highly-selective institutions in 1994 reported that chilly climate was not a salient factor in students' choice of disciplines (Strenta, Elliot, et al., 1994).

Women are entering the pipeline less convinced to pursue computer science than men, but less attention has been paid to this issue. Explanations range from speculations based on practitioner anecdotes to those drawn from related topics (such as gender and mathematics education) in education, sociology, and psychology. An explication of the social and psychological factors influencing women to study CS over another field is so complex that studies attempting to address the issue with any single explanation or solution will necessarily fall short.

Most recently, Jane Margolis, an education researcher, and Fisher, former Dean of Computer Science at Carnegie Mellon, collaborated on an ethnographic, longitudinal study of students entering CMU as CS majors. The study sought to explain why women committed enough to the discipline to come to CMU declared in the major dropped out of the major at such a high rate. The study pointed to a broad range of factors in women's

choice to leave the department, such as differential effects of poor pedagogy on outsider groups, plummeting confidence after some time in the major, and women's sense of being cultural outsiders (Margolis, Fisher, 2001).

Women's exclusion from and novelty in geek culture is frequently cited as a factor in their hesitation to study computer science. Criticism comes not only from outside the culture, but also from inside. Readers of the popular internet news site "Slashdot," which is subtitled "News for nerds," recently expressed concerns over media representations of computer scientists and possible effects of such representations. Even insiders perceived technologist representations in movies such as "TRON" and "Hackers" as deterring those who do not identify as "geeks" from entering the field.

At Stanford University, Department of Psychology, Claude Steele and researchers Sapna Cheryan and Vicky Plaut are applying Steele's theory of "stereotype threat" to gain a better understanding of how geek culture may affect women's performances in computer science. Steele's prior work examined the effects of performance stereotypes on high-ability women and minorities on performance assessments. Steele found that negative performance stereotypes evoked anxiety in students for whom high-ability was a part of their self-concept. Testing conditions that cued relevant, negative performance stereotypes, such as "African-Americans do not do well in math," reliably resulted in poorer performance in assessments of skills related to the cued stereotypes. He explained his findings with the theory of stereotype threat. When presented with a stereotype describing the expectation that a group with which they identify will perform less well on a task, subjects will actually perform less well on a task (Steele, 1997).

Cheryan and Plaut examine the effect of the dominant stereotype that computer science is “geeky” and “male” on subjects’ interest and performance in the field. Preliminary studies examined the variance in subjects’ performances by gender on a webpage design task. In one case, programming was described as an important skill for the task while in another, communication was described as a necessary skill. Even though there was no sex difference in performance, women attributed their performance to ability less than did men ( $p=0.18$ ,  $N=49$ ) in the condition where programming was cited as an important skill. In testing for conditions that predicted higher interest in learning more about web design, Plaut and Cheryan found that the programming condition also predicted the highest male interest while the communications condition predicted the highest female interest ( $p=0.66$ ,  $N=49$ ) (Plaut, et. al. 2002).

A second study probed students’ computer science attitudes after having them read a fabricated news article. One article described CS as “a field dominated by ‘geeks’” while the other directly dispelled the “geek” stereotype, describing CS as “no longer dominated by ‘geeks.’” Women who read the geek-positive article reported that they considered majoring in CS less often than those who read that CS was no longer a “geek” field ( $p = 0.25$ ,  $N=41$ ). Those women also reported greater nervousness surrounding computer use than the “non-geek” women ( $p = 0.017$ ,  $N=41$ ).

These findings promise a better-developed picture of factors influencing women to even consider computer science – something the CMU study sheds less light on, as it examines a pool of women who have already committed to study the discipline. Still, these findings are limited to the psychological level and do not shed light on the socio-

cultural phenomena of how the geek-culture is created and propagated, nor does it help us understand reasons for individual difference within gender categories.

Furthermore, while the CMU study is the most exhaustive study to date of the dynamics of gender in computer science, characteristics that differentiate CMU from other institutions mandate that parallel research be done in differentiated academic environments.

### **Varied Contexts in CS Education: The Situation at Stanford**

This study seeks to build on Margolis and Fisher's study of students at CMU by carrying out a similar study, though smaller in scope, at Stanford. In examining students' experiences in the first four courses in the undergraduate computer science core, we find that socialization experiences prior to college play a major role in students' decisions to pursue computer science. This decision point is typically in the first course, CS106A, though women who have chosen to go on constantly reevaluate the decision as they progress through the later courses in the core, integrating into their more stereotypical computer culture. The differences between Stanford and CMU provide a ground for extending the knowledge of dynamics surrounding the phenomenon of women's relative absence from computer science. This study examines factors influencing high-achieving women to study computer science at Stanford.

#### *The Importance of Context*

In studying the students' decisions to pursue a degree in computer science, researchers must understand the cultural and pedagogical context in which students make those decisions. Context includes the cost of exploring, the availability of alternatives, the cost of switching once decided, and even the local economy.

At Carnegie Mellon, students come in with a declared degree program. Thus, switching at CMU comes much closer to an identity change that Stanford students do not face until late in their sophomore year.

Stanford differentiates itself from CMU in that students come in undeclared. However, introductory CS frequently competes with introductory Economics as the most frequently taken course. Thus those who go on to major, those who fall out, and those who never seriously consider it can be followed beginning in the first CS course, CS106A. Stanford also has few programs targeting those with a declared interest in studying computer science and freshmen are almost always undifferentiated in major. Thus, exploring and “switching” majors can be a weekly undertaking and incur little cost in time or identity.

#### *Stanford's Undergraduate Degree Core*

In contrast to the loosely-sequenced upper division undergraduate CS courses at Stanford, the first year-and-a-half consists of a sequence of four software engineering courses: CS106A, CS106B, CS107, and CS108. CS106A and CS106B form a two-quarter sequence for those with no prior programming experience, but CS106X, an accelerated course covering the CS106A and CS106B material, may be taken instead. In addition to software engineering coursework, students typically take introductions to theory (CS103A/B) in their sophomore year.

(For an extended discussion of the core, see Appendix 3.)

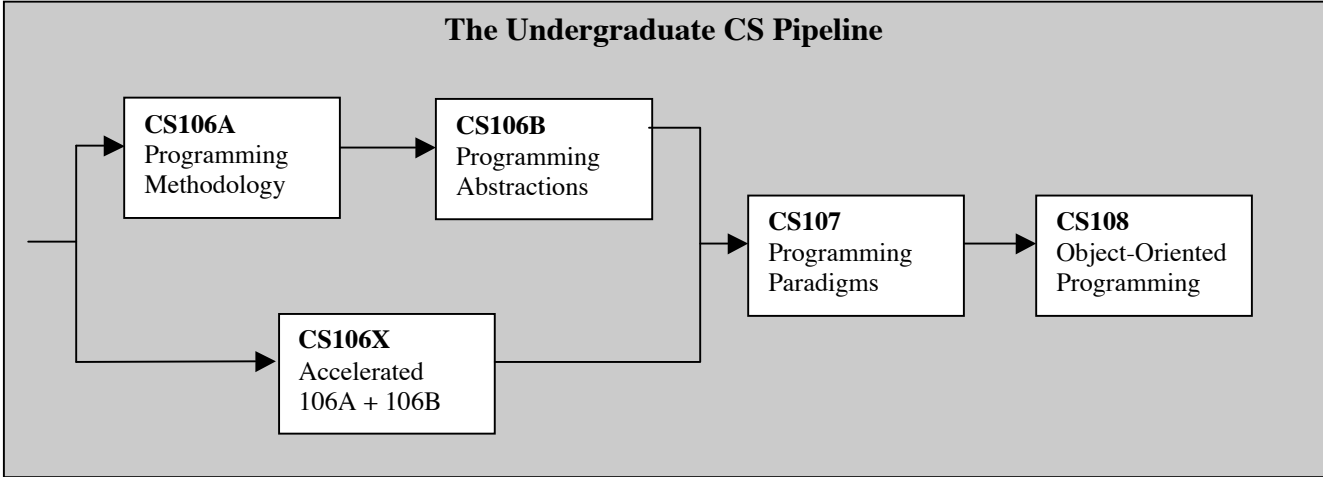


Figure 4

## A Leaky Pipeline: Persistence Among Students Entering the Core during 2000

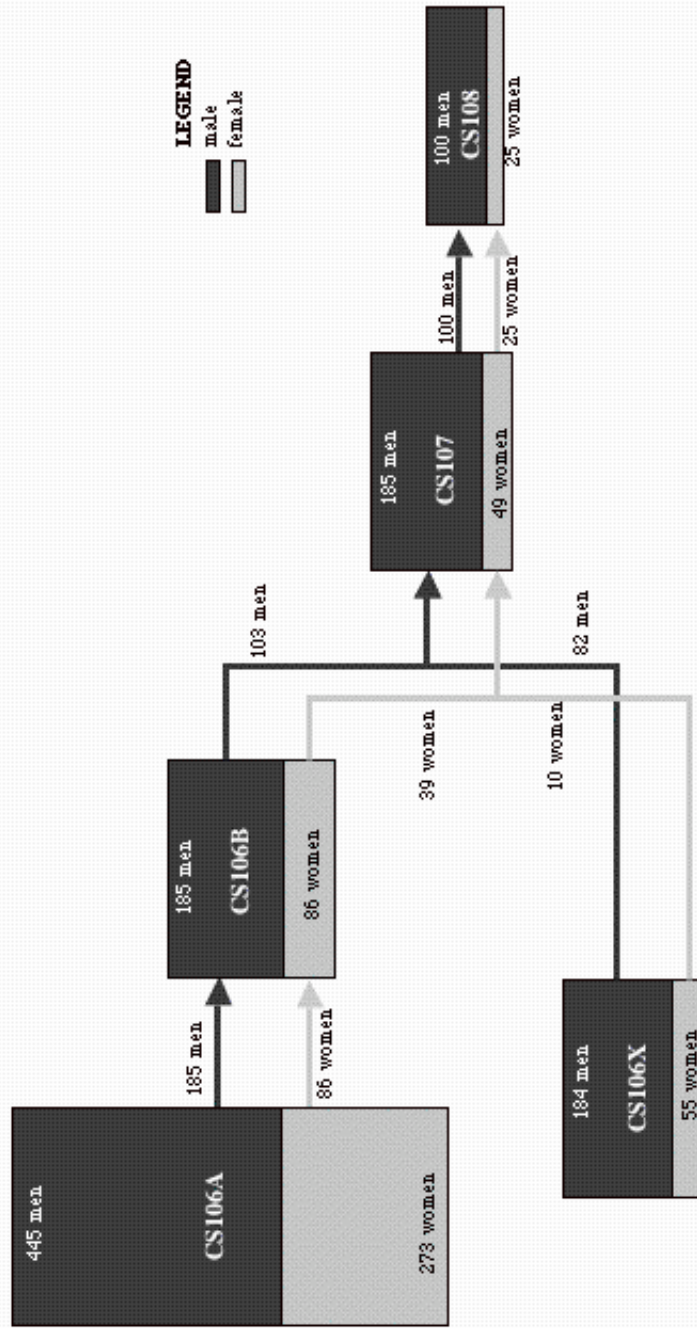


Figure 5: The above describes the persistence of a cohort consisting of students who took CS106A or CS106X during 2000. The ratio of box area to number of individuals is constant so that box sizes accurately relative class size as well as ratio of men to women.

## Research Methodology

### *Overview*

My research consists of a multi-method approach to understanding the dynamics of gender in the introductory CS core. I apply a qualitative, longitudinal study structure to better understand the dynamics of gender in students taking the introductory computer science core at Stanford. Quantitative surveys probing student attitudes towards and confidence in computing fields, as well as analyses of grade and enrollment data in CS106 through CS108 over the last five years, ground ethnographic findings in a broader picture of the population participating in the CS core. Through quantitative analysis, significance of gender differences can be assessed. Qualitative research tells the stories and describes the phenomenon of which the survey numbers are a symptom.

### *Qualitative Methods*

Designed to extend the work of the CMU study, this research follows a cohort of 22 students from CS106A, the time-consuming but popular first course in the introductory series, and five students from CS106X, an accelerated course for students with prior programming experience<sup>1</sup>. The cohort was followed through interviews each quarter that they took a CS course in the undergraduate introductory programming core, consisting of CS106A/B/X, CS107, and CS108.

Subjects were recruited in an effort to obtain a sample representing both genders and a range of ethnicities. The subject pool was roughly 65% female both so that I could focus on the woman's perspective and so that by CS108, the last course in the core,

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<sup>1</sup> The course is designed for the benefit of students *without* prior experience as much as it is for the benefit of the accelerated students. The faster course keeps students who may generate a misleadingly high, daunting expectation if left to participate in the A course, designed to teach CS to anyone regardless of experience.

enough females would remain to provide a well-developed snapshot of students coming out of CS108.

Subjects were interviewed once upon being recruited to the study three weeks into quarter and were interviewed after they had completed the course. Questions in their first quarter of participation covered their prior experiences with computers, their families, their academic priorities, their conceptions of computer science and computer scientists, and their thoughts about the course they were in<sup>2</sup>. As a precaution against receiving guided responses, I chose not to probe explicitly for gender unless the subject raised the issue.

The interview protocol is included in Appendix 1.

### *Quantitative Analyses*

Surveys - I conducted a quantitative survey of students in the undergraduate core to ground my qualitative findings in a broader picture of course phenomena. On their entry into and completion of the course, students were asked to rate themselves in categories commonly thought to be associated with computer science, such as comfort with computers. (See appendix.) The survey was not framed as part of a study on gender and computer science and the only question related to gender was that which asked the subject to specify theirs.

Conclusions were drawn from the surveys only when results were statistically significant at the level  $p=0.05$ . Where response rates were not high enough to make a

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<sup>2</sup> The study follows students through CS106A, CS106B, CS106X, CS107, and CS108. However, only CS106A and CS106X – the first parallel rungs in the core ladder – will be examined in this paper. Other classes present unique social psychological phenomena.

conclusive judgment, yet the numbers suggest interesting possible correlations, I have noted the lack of statistical significance.

Appendix 2 includes the survey instruments.

Grades Data – Grades were obtained for students taking CS106A, CS106B, CS106X, CS107, and CS108. Unique numerical identifiers, course, grade, and gender were provided. I had no access to the student identities – data was provided with names replaced by identifiers not mappable to the original name. However, a student retained a consistent identifier across courses so that analysis could track an individual student’s academic progress over time.

### **CS106A: Socialization Sets the Stage**

Over the last five years, CS106A has attracted between 36% and 25% women. This proportion is significantly greater than the percentage of women enrolled in computer science, which has hovered just above 17% over the last two years. Some argue that women enroll in numbers disproportionately high as compared to subsequent CS courses because CS106A fulfills the University’s applied science general education requirement (GER 2A). However, CS106A is one of many GER 2A courses available to students and is notorious for being amongst the most time consuming, though also famous for being worthwhile and well run. The CS department offers a less time-consuming and more immediately practical course on Internet technologies titled CS105, which enrolled 63% and 64% women during two recent quarters. Considering the high time cost of taking CS106A, as well as the availability of a lower cost alternate, CS106A only makes sense for those at least exploring an interest in computer science – not as a “GER killer.”

The filtering that ultimately causes women to “leak from the pipeline,” resulting in the less than one-fifth of majors ultimately being women, begins to work in CS106A, as evidenced by Figure 6. Figure 6 shows that of the students taking CS106A, women have historically gone on to CS106B less frequently than have men.

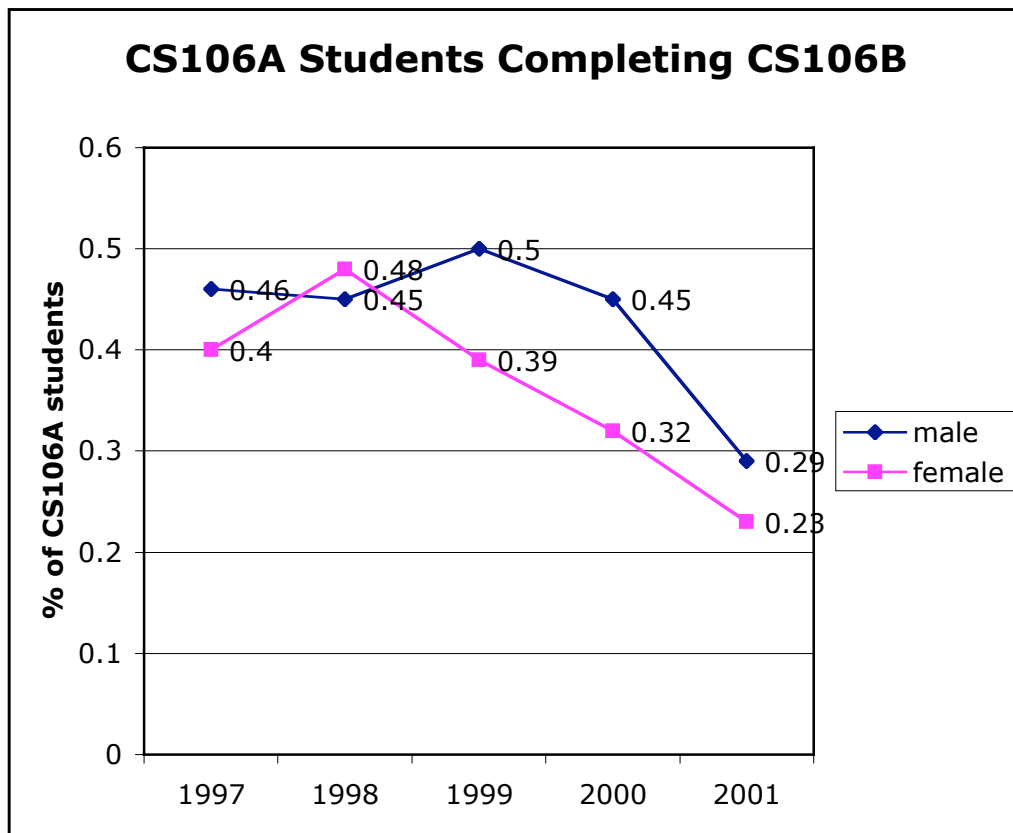


Figure 6

$\chi^2$  tests on showed the difference in frequency at which women and men continue from CS106A to CS106B to be significant in 1999 ( $p < 0.05$ ) and 2000 ( $p < 0.01$ ). By understanding what kind of student takes CS106A and examining their experiences in the course qualitatively, we begin to understand why women are more likely to end their CS experience after CS106A.

### *A Quantitative Snapshot of Students in CS106A*

The results of the survey help us better understand the kind of student who takes CS106A. Table 1 lists means by gender for respondents' self-ratings (on a scale of 1 to

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	Comfort w/ computers	Enjoyment of computers	Mathematical skills	Ability to solve logical problems	Ability to solve problems with the computer
male	7.98	7.87	7.35	7.36	7.05
female	7.44	7.55	7.17	7.55	6.72
p <	0.01	0.25	0.31	0.26	0.23

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Table 1: Entering CS106A student self-ratings by gender

p derived from one tailed t-test assuming equal variance.

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10) in the categories listed in Table 1:

Women's self-ratings upon entering CS106A differed significantly from those of men only in their self-reported comfort with computers. While I know of no comparable metric in other studies, this gender gap seems a natural consequence of findings that show parents perceive and encourage primarily male interest in computers (Margolis, Fisher, 2001).

Respondents were also asked to rate their perception of their classmates and of general Stanford undergraduates in the five categories listed in Table 1. The difference between individuals' ratings of others and their self-ratings gave a measure of how the student felt they compared to their peers. Women and men differed significantly in the way they rated themselves in comparison to classmates and Stanford students in general

in “Comfort with computers.” Women rated themselves higher than men in “Ability to solve logical problems” (this was the only category in which women rated themselves higher than men did). However, women’s self-ratings in this category were, on average, 0.16 below their own rating of other students in the course. Men’s self-ratings exceeded their estimations of their classmates by 0.49. This mean difference was significant ( $p < 0.05$ ). That women perceive themselves as less logically capable than their classmates is especially concerning in CS, where logic, more than math, is a directly used competency from the first day of the introductory course.

Generally, the respondent data paints a picture of CS106A students as fairly confident in mathematical and problem solving skills. While girls’ confidence is of concern to many analysts, psychologist Laraine Zappert reports that men and women often arrive at college equally confident, but it is the woman’s confidence that wanes during the years that follow (1985). Women do come in feeling less comfortable with computers and perceiving that they are behind their peers in logic. Both of these characteristics set the stage for any number of dramatic outcomes. Stories of stress and frustration and stories of struggle and empowerment seem equally viable.

The most dramatic difference in men’s and women’s responses dampens our expectations for persistence. On average, women rated their likeliness to major in Computer Science as 1.6 out of 10 upon entry into CS106A. Men rated their likeliness to major as 4.9 out of 10 ( $p < .001$ ). Similarly, women rate their likeliness to minor in CS (2 out of 10) significantly lower than do men (4.1 out of 10,  $p < 0.05$ ). Women’s ratings of their likeliness to major in CS-related disciplines were in all cases significantly less than those of men at the  $p < 0.01$  level. Disciplines probed in the survey were Mathematics

and Computational Sciences, Computer Systems Engineering, and the interdisciplinary Symbolic Systems (which is commonly thought to be more attractive to women).

Interviews with CS106A students flesh out the stories behind the numbers. What factors lead women to discontinue the series and not pursue computer science? Interviews and survey responses reveal that women's choices cannot simply be attributed to disproportionate lack of interest. In CS106A, socialization, rather than structural and interactional factors, is the primary means of gendering the student experience. I draw on the literature, as well as the words of the women themselves in reaching this conclusion.

Most women I spoke to fell into three categories: women who had interest but chose not to pursue CS, women who took CS too late but reported wishing they had the opportunity to pursue it, and women who have continued to be majors. Of the 13 women in the cohort I interviewed, only three were above junior standing and two of them expressed regret that they had not tried of CS earlier. Another three, all freshmen at the time of the interviews, have, to date, continued on to self-identify as CS majors<sup>3</sup>.

*It's cool, but not really my thing.*

The largest group of women was comprised of ones who enjoyed their CS106A course experience but were unswayed from their prior conceptions of paths they may take in choosing a major. Some students had very planned-out alternatives, such as biology and earth systems, in which they had already invested and with which they had already self-identified. Others, especially freshmen, identified themselves simply as “fuzzy” or

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<sup>3</sup> Because three of 13 exceeds the expected proportion of women to continue on to be CS majors, I must acknowledge a possible role-model effect in my intervention. It's likely that having speaking with an upperclass female CS major on a regular basis changed the gender dynamics of their experience. This is not necessarily a pitfall, however, but a variable to be accounted for.

“social science-y” and saw no compelling reason to switch, despite their enjoyment.

While one of these six women had actually engaged in computer play at home and was a reader of *PC Magazine*, the other five described their use of the computer as having been limited to applications such as word processing and Internet browsing.

After having completed CS106A, these women did not consistently rate themselves as less comfortable with computers, less able to solve logical problems, worse at math, or less enjoying of computers. Like the other women, these women *did* rate themselves as less comfortable with the course material than did the men in the course.

While CS106A typically attracts women as nearly 30% of its students, CS106B’s enrollment ratios drop to about 25% female. An exit survey filled out by the entry survey respondents revealed that those women left CS106A rating their comfort with the course material 7.8 out of 10, where men rated their comfort 8.8 out of 10. The mean difference between the genders was significant ( $p < 0.05$ ). While grades for that particular quarter are unavailable, a grade analysis of a recent five-year window of CS106A grades broken down by gender (Data source: Eric Roberts) revealed no significant difference in mean grades. (Men averaged 3.28353 on a 4-point scale while women averaged 3.26124.)

One student described the confidence mind-game students can undergo during the course of the quarter: “I guess during [the course], I felt myself less techie, but then I went through and felt a bit more techie.” When asked why, she explained, “Compared to my peers, I felt they did it a lot quicker and stuff like not performing as well made me feel inadequate.” She continued, “I just see myself as not completely fuzzy, and I can actually do this, so I should give it a shot...It was the grade. It was better than I expected.

Maybe I got really lucky, or maybe it was the curve, or maybe I'm not completely bad at this stuff."

In the first course, the student had already begun to feel the insecurities of working in a competitive, male-dominated environment. Women begin with an already embattled self-confidence, regardless of male-domination in the field. Eccles finds that "Gifted girls are more likely to underestimate their intellectual skills and their standing in a course whereas gifted boys are prone to overestimate theirs" (Eccles, Barber, et al, 1998). One reason for this difference is that women often grow up hearing that their success is attributable to effort, though boys hear that their accomplishments are rooted in a natural talent (Eccles, 1993). Women have more difficulty regarding their achievements as rooted in stable traits, making it less likely they will extrapolate their CS106A successes into a faith in their CS ability more generally.

The data students use to evaluate one another's performance and understanding is also problematic. Interviews reveal that students judge expertise not by examining the actual work done but by evaluating confident posturing and impressions of the speed at which others work.

Women also face double standards for ability, not only from others but from themselves. Findings show that to be considered in the elite of an occupation, or in this case, a cohort, women in male-dominated groups have to be better than men at the same echelon in order to receive the same legitimacy. Unpublished experimental data also find that women apply these double standards to themselves, making it even more difficult for women in CS to bolster their technical confidence (Ridgeway, 2003). The conciliatory,

communal communication styles typically encouraged in women can also be problematic as men often judge communal speech as less expert.

Even when interested in the course material, women doubted that their interest CS could hold in the long term. While they found the assignments engaging and “fun,” women cited concerns about the single-minded focus the course assignments required and how that would play out in the rest of their college years and their lives.

One then-freshman female with programming experience prior to coming to Stanford explained, “I guess the one drawback that I’ve always considered for myself, personally, was the fact that you have to sit in a cubicle all day and just program. Even if I like it, it’s not very healthy.”

Another student, then a sophomore, expressed reservations about studying CS as well. “I feel, well, reliant on a computer, obviously, whereas if you have a problem [to work out], you can take it anywhere, right?” The student ultimately chose Electrical Engineering.

These concerns are not unique to Stanford women. Several studies have supported the existence of a tendency for women to organize their lives in a multitasking fashion whereas single-mindedness is a more male-typified mentality (Eccles, 1999). Of course, this apparent preference does not imply that either gender is less capable of acting in either fashion, or that they will fail to do so when necessitated by a role they choose to play. However, those that subscribe to non-resistive, hegemonic cultural beliefs do have an interest in acting in a gender-typified way and holding gender “appropriate” values. Having other reasons to have reservations about CS as well, women simply have less of

an interest in resisting hegemonic gender beliefs or resisting the current practice of computer science whose bounds are largely defined by the men who dominate the field.

A freshman female who had never programmed before expressed several times in her exit interview that she “got really interested” in the course material. “I like breaking down problems. I don’t know. I just really enjoy the classes.” She never seriously considered CS, though, instead briefly considering Symbolic Systems for its integration of the humanities, human-computer interaction, and a broad range of other focuses.

Girls are not “Computer People”: Media images of “computer scientists” (read “computer programmers”) contribute to the commonly held image of a computer scientist as a programmer chained to a cubicle. A very recent and popular depiction of life in the computer industry is the film *Office Space*, which tells the story of three software engineers who hate their jobs so much that they hatch a scheme to embezzle from their company using their programming skills. The engineers, two white men and an Indian man, are essentially what is referred to in the CS world as “code monkeys.” Other prominent media depictions of computing include *TRON*, *Wargames*, and *The Net*. Only *The Net* features a female as a programmer, but in all cases, programmers are depicted as pale, video-game obsessed, and extremely isolated. If women are socialized and subsequently rewarded in society for building roots, establishing strong social ties, and acting communally, these films only offer computer science as an option for women who care about the discipline enough to resist hegemonic cultural expectations placed on them based on gender or to resist the cultural norms of the field they perceive they are entering.

For most students, film and television provide the only image of computer scientists that they have. These media depictions are often of individuals who, to some

extent, resist social norms altogether, so that even men may feel uncomfortably resistive in modeling themselves after such figures. A woman attempting to model herself after such a figure would have to resist hegemonic cultural expectations as well. These media depictions are particularly salient to students being introduced to CS, as they typically report that CS106A did not change their ideas of what a computer scientist can do after completing his or her degree.

Seeking Value Along with the Fun: When asked if CS106A gave her impressions of what she can do with CS afterwards, one student answered, “Actually, no. I mean, when I looked at the programs and course descriptions, I can tell what I can take...but reading artificial intelligence, I have an idea of what that is from reading the newspaper, but I don’t actually know what it really is. So no.”

Another student described how someone could do anything with a CS degree: “Frankly, everybody needs a computer scientist. Programming is just all over the place now. There are all sorts of companies that need programmers – you could do any kind of field you wanted to.” So even in her conception of CS as extremely flexible, she still points to the act of programming as the core objective of studying the field.

The Eccles et al. model of achievement-related choices (Eccles, Barber, et al, 1998) gives insight into why, even having established an interest in the course material and assignments, most women choose not to pursue in a career in “computer science” (as they perceive it). In her model, Eccles points out that even where women have interest and current competence in a field, the perceived utility, or value, of a field is critical to justifying its pursuit. The Eccles study points to findings that the perceived value of math

courses mediated gender differences among high-performing students over factors such as expectations for success (1999).

*If only I'd known about CS before...*

Two women in the study – one a junior and one a Ph.D. candidate, both in the life sciences – came out of the CS106A experience with regrets that they had not discovered computer science earlier in their careers. Because they were coming to computer science as after gaining background in biological sciences, both realized the utility of a background in computer science for solving the problems they were interested in unraveling. Gender socialization, rather their behaviors and expectations as actors, created an environment where they never considered a “path to computers.”

The junior female told her story with computers as a story of her father and brother (who is now a CS major) bonding over building computers together. While she was interested in computers as well, she explained, it was “their thing.”

This student’s story is common, both in my interviews and in Margolis’ account. Margolis (2001) described “father-son internships” similar to that my subject reported.

Among the women I interviewed, only one had a “son-daughter-father” internship experience – however she expressed frustration that her father treated her and her younger brother differently. “I found out Dad is a little bit sexist. When we ask him questions, he’ll tell my brother, ‘You know, son...’ and he goes into an explanation of why it’s really cool. With me, ‘It’s like this. Get it?’” She described frustratingly oversimplified explanations, stemming from a general sense that her brother is more suited for technical material. Though she had access to technical information, the interaction was imbued with homophily.

The only other beneficiaries of such “internships” were among the few boys I interviewed – one worked with his father, editing a CS book his dad was authoring. The other worked for his father’s office in a Southern California engineering firm while still in high school.

Even access to the family computer is unequal by gender. The experience of the Stanford students in this study bore great resemblance to that of CMU students in regards to how computers came into the home (Margolis, 21). One study of New York families found that in over half the families studied, computers were located in a part of the home where it was most accessible to fathers and/or sons (Margolis, Fisher 2001). Often, the computer becomes the older boy’s version of the toy cars and science kits that parents offer more readily and frequently to their sons than their daughters (Margolis, 25). To the extent that one’s expectations shape one’s perceptions, many parents consciously or unconsciously guide their sons towards computers and then respond to the son’s budding interest by giving him innocent but preferential access to computer resources. Parents then note that girls just aren’t as interested in computers as boys are (Margolis, 20).

The majority of interviewees described their father bringing the computer into the home. Most also described their mothers as “computer-phobic,” “anti-computers,” or merely apathetic towards the machine. Except in one case, where a male student’s grandmother was the family computer geek, mothers ignored the computer or used it for e-mail and other applications. Since, by Bandura’s findings, children align themselves with role models who have high status and are most similar to them, it comes as no surprise then that girls rate themselves as significantly less comfortable with computers upon entering CS106A.

A lack of technical role models constitutes only one factor in girls' lack of access to information about computing technology and careers. Where people lack role models, they often gain information from their social networks. Moreover, strong evidence indicates that children enforce gender-stereotypic behavior among one another (Lips, 1995), implying that female social groups will be less open to computer play and tinkering than male social groups. Compounding the dilemma for a girl who may have technical interests, Smith-Lovin and MacPherson demonstrate that girls often have smaller, more cliquish social networks than boys, thus making it very unlikely that they will acquire information about male-stereotypic interests through weak ties. Girls who try to cross these gender boundaries are often rebuffed<sup>4</sup> (Lips, 131).

Gender stereotypes shape the guidance women receive beyond the family as well. The post-doctoral student recounted a time during her undergraduate career when she had sought the advice of male CS major friends as to whether the major or minor might be worth exploring.

“I had no idea back then...I find it interesting too. I would ask [my friends] about CS when their final project was due and they were hating life. They just kind of thought that I was good at biology and I should just stick with that and I didn't need computer science,” she explained. Thinking they were acting in her best interest, her friends acted on their gendered conception of computer science, focusing on the hacker side rather than utility to other academic interests questions.

*I like it. I'll stay with it and see what happens...*

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<sup>4</sup> As a high school student, a male friend deliberately and regularly excluded me from his “LAN parties,” or network video game parties. All attendees were male.

The three women in my study who have continued on to become CS majors benefited from alternative cultural beliefs, a more accurate conception of the utility value of CS, and direct encouragement to bolster their confidence.

Two of three women who continued on grew up in immigrant families in the US (from Iran and Taiwan) and the third is a student from Japan. In Iran, CS is actually viewed as an excellent occupation for a woman because it is perceived as entailing less physical danger than other jobs (Irani, 2003). Women constitute nearly half of computer science degree recipients in Iran.

The Taiwanese-American and Iranian-American women both described receiving strong encouragement to pursue CS from their parents. None of the other women described such active encouragement to pursue CS from their parents. The Japanese student described having full support from her parents but did not sense that they preferred her to major in any particular area. While the decision to major is one students face in college, the messages children receive in the family, both subtle and explicit, unintentional and intentional, is of certain impact.

The Iranian-American woman also had a better concept of utility value than most other students. She described sources of information about computing before coming to college:

“People like a lot of my friends’ parents were computer science majors and they were like, ‘Well, it’s way beyond computer programming. There’s a lot of upper level management you can do with it, there’s design of entire structures, beyond the programming so I didn’t get that different a perception after taking the class.’”

This student cited an understanding of options available to a CS major beyond the media stereotype as very important to her decision to major.

The Taiwanese-American cited her uncle as having encouraged her with information about CS after college.

All three women were also uncommon in that they did not battle the lapses of confidence evident among some of the other students in CS106A. All had prior exposure to programming. The Taiwanese-American student and the Iranian-American student actually could have been suited for the accelerated version of CS106 but chose to take CS106A out of a lack of certainty that they could handle the more difficult version of the class. The end result was that they came out of CS106A very confident in their CS skills.

### *Conclusion*

A multitude of factors, centering around gender socialization, influence women's experiences in CS106A and their decision to go on. In particular, women grapple with a search for CS's utility value and reassurance that they can handle future coursework so they can weigh the high costs of CS against the benefits. Some women, finding reason to study CS, find it too late to pursue it. For the few who do go on to major in CS, the stage has been set before college – in technical role models, in alternative cultural beliefs, and in safety nets that support them through or protect them from lapses in confidence.

### **CS106B: A More Focused Extension**

The students that continue from CS106A to CS106B find a very similar course structure and official culture, but subtle differences in student demographics, culture, and student motivations to take the course differentiate CS106B from the course that precedes it. Students enter the course with a conception of CS based heavily on the experience of

coding from CS106A, media representations of programming, and the major’s reputation on campus. In the end, CS106B has little effect on their likeliness to pursue it as a major.

*A Self-Selected Audience*

Differences in CS106B’s feel stem from a course composition very different from that of CS106A. Students willing to invest the time and effort required by CS106B come in more focused on technical fields.

This dramatic shift in focus is reflected in students’ ratings of likeliness to major in a CS-related field at the beginning of CS106B. Where women in CS106A reported a likeliness to major or minor in a CS-related field dramatically lower than did men, by CS106B, the gender gap in aspirations not only narrowed, but in fact flipped in all disciplines except Symbolic Systems.

	F	M	p <
Computer Science	3.3	2.8	.63
Symbolic Systems	1.42	2.08	.26
Computer Systems Engineering	2.75	1.53	.15
Mathematical and Computational Sciences	1.5	1.2	.22

Table 2: Mean reported likeliness to major on entry into CS106B.

While CS106A attracts students from many disciplines, finding a student who takes the CS106B only for fun, having already ruled out a degree program that requires it, is rare. Degree programs that require CS106B include Management Science &

Engineering, Symbolic Systems, Computer Science, Electrical Engineering, and Mathematical & Computational Sciences.

Self-selection of students entering CS106B has implications both in personal characteristics of students and in the culture of the course overall. Table 3 shows that gender gaps in confidence and enjoyment of computers in CS106A narrowed by CS106B. As they did in CS106A, women rated themselves more highly in their ability to

	Comfort w/ computers	Enjoyment of computers	Mathematical skills	Ability to solve logical problems	Ability to solve problems with the computer
Male	8.1	8.2	7	6.8	7.6
Female	7.8	8.1	6.8	7.3	7.4
p <	0.65	0.40	0.80	0.42	0.01

Table 3: Student self-ratings at the juncture between CS106A and CS106B by gender

p derived from two-tailed t-test assuming equal variance. N = 25.

solve logical problems and the magnitude of that gap did not close across courses.

Have women grown more confident or have they self-selected in continuing in the CS core? Comparing CS106A self-ratings of respondents who did take CS106B and those who did not revealed comfort with computers upon entering the core a significant ( $p < 0.05$ ) predictor of women going on to CS106B. Comfort with computers did not significantly differentiate the men who went on from those who did not. Self-ratings of confidence in solving problems with computers at the start of CS106A predicted both men and women who ultimately continued at suggestive though inconclusive confidence

interval. Self-ratings in math and logic were not predictive of persistence through CS106B.

### *Culture Drift*

The shifting demographic of students taking CS106B changed the tone of the course's culture. While the course infrastructure of CS106B clones that of highly-supportive CS106A, students described CS106B's culture as more intense than its predecessor, hinting to students that CS stereotypes had an element of truth.

A sophomore male in CS106B lamented the loss of the more general GER-motivated audience of CS106A, describing his perception (unsupported by survey responses unknown to him) of CS106B students as those committed to continuing in computing. "It seems like an intense crowd, just really competitive, which is true of most majors at Stanford. But still, it just seems like you lost a lot of the kickback people who have to take CS106A," he explained. Another sophomore male described CS106B's course culture as more "hardcore" than CS106A.

Having an similar impression of "hardcore" students in the course, a freshman female described her surprise at winning a coursewide contest for the most innovative solution to an assignment. "I totally didn't expect to win," she explained. "There are some hardcore techies who act like know more CS stuff...Some people know five or six computer languages." While most students in CS106B do not have the level of experience she describes, the power of a few outliers lies in the disproportionate strength of impression they make.

Still, others maintained that CS106B still represented a more diverse cross-section of the Stanford population than do other engineering courses. "[CS106]B still

feels like there are people in it who wouldn't normally be a CS major, which is cool, but you definitely see it's a smaller class and people are into the CS more," one sophomore female said.

Small sections tempered the effects of increased homogeneousness. Citing small section sizes as fueling her sense that CS106B was "pretty diverse," a sophomore female did not perceive prominent subgroups among CS106B students. "A few people liked the fuzzy kinds of things, so it was kind of difficult to get an overall culture," she explained. The small section increased her opportunity to know her peers as individuals, lessening the effects of stereotypes she had of peers.

#### *But What is Computer Science?*

Students entered CS106B with a limited notion of what it means to study Computer Science. Rooted in common cultural representations of technology work and sustained by the focus on software engineering in their first course, CS106A, these students conceived of Computer Science as "coding."

One freshman female, who considered her strengths to be math, computers, Spanish, and economics, decided against CS as a major even though she "really liked programming and CS106." She explained,

I just don't want to be tied down to just having knowledge about computers, I just wanted to have a lot of other interests, too, I don't see myself being a programmer growing up and I know you don't have to, but I just don't really know what all you do if you don't program. Like, I know that I've heard CS doesn't mean you just program, I don't really know what else you do.

She chose to major in Management Science & Engineering instead.

A sophomore female also chose MS&E instead of Computer Science, having entered CS106B with MS&E as her most likely choice major. “CS guys taking this class come home and write the assignment. They have the desire to code. I’m not like that,” she pointed out. “People really good at CS are like that.”

While CS106B’s intended focus is on abstractions such as algorithms and data structures, she perceived assignments as “related to bigger applications done in industry,” rather than stepping stones to solving problems in the discipline, such as AI or graphics. Extremely satisfied with the execution of the course, she complimented the projects as being “easier to relate to the big picture of real computers.” CS106B excelled at teaching CS as she knew the discipline to be. Her perception of “real computers” is intimately tied to software production – only one segment of the opportunities made available by a degree in Computer Science.

#### *Much Learned, Little Changed*

The result of CS106B’s applications-oriented projects is that students find little to change their conception of what a future in CS holds. Entry and exit surveys provide a quantitative snapshot of the course’s effect on students’ propensity to major. When asked to score their likeliness to major in CS at the end of the quarter, half of the students reported no change, roughly half reported a likeliness one point lower than their self-report on entry, and only one reported an increase in likeliness. We could conclude no gender effects in responses.

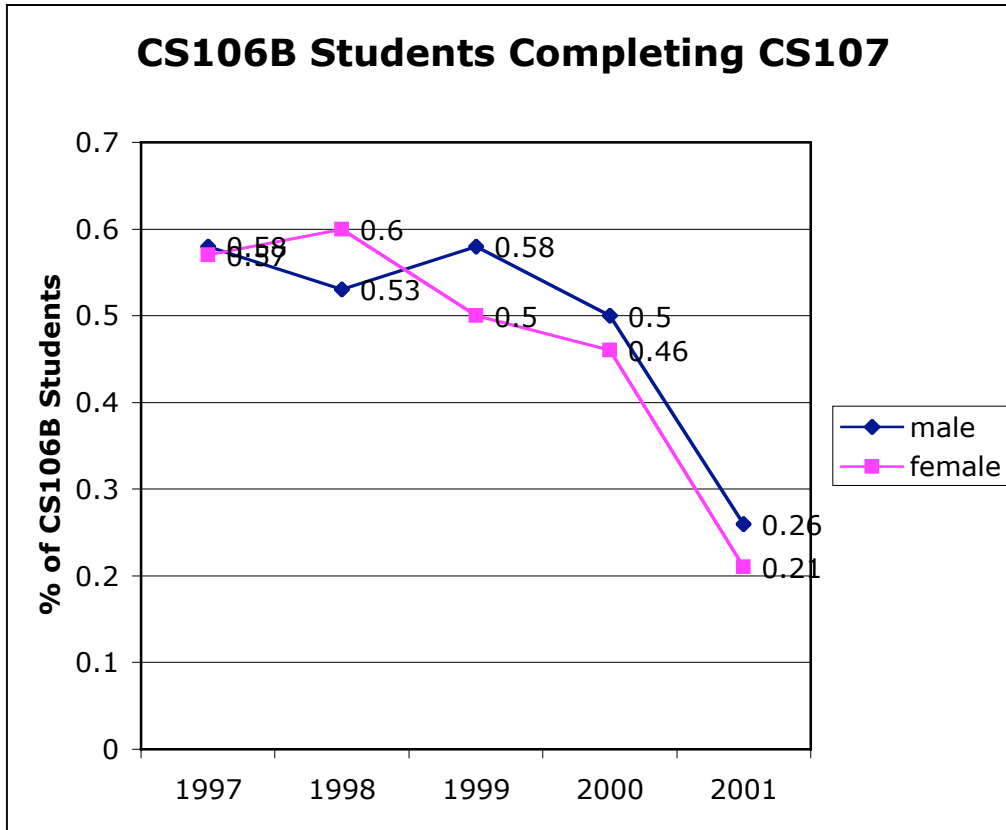


Figure 7: The propensity of students who took CS106B in a given year to go on to complete CS107.

Figure 6 shows a recently stable but small gender gap in the frequency with which male and female CS106B students continue on to take CS107<sup>5</sup>. Of the students in the interview cohort who chose not to go on, none had chosen and then been dissuaded from continuing. Their perceptions of CS as a field left unchanged from entry, they completed

<sup>5</sup> The year 2001 shows a dramatically reduced proportion of CS106B student continuing to take CS107. Easily explained, the enrollment data set includes data only through the end of the 2001-02 academic year. 2001 CS106B students represented in the graph are those who took CS107 within the same academic year. Analysis showed no significant difference in men's and women's likeliness to take CS107 in the same year as CS106B. Thus, while the magnitude of those continuing is not comparable with other years, the gap remains a reliable indicator.

and almost always enjoyed the sequence, but chose to pursue other disciplines in lieu of continuing on to CS107, a course with a reputation for intensity.

### **CS107: Embattled Persistence**

CS107 “Programming Paradigms” marks a distinct shift in the composition and culture of the CS introductory core. Described as “intense” in the official university course catalog, the course is the closest thing that the department has to a “weeder” course. This “weeder” status is recognized both by teaching faculty and students in the study and describes a course made intentionally intense to act as a filter, encouraging only the most committed or talented to continue on. While such courses have been shown to filter women and minorities more aggressively than they do men (Roberts et al., p. 84), analysis of course enrollments from the 1997-98 through the 2001-02 academic years reveal that CS107 *does not* filter women more aggressively than it filters men.

While CS107 does not significantly stem the flow of women continuing in the CS major, qualitative interviews with the cohort, now whittled down to four females and two males, revealed that women did tend to experience the course differently than did the men. Both male and female interviewees described a culture in which technical and intellectual challenges confronted all students. However, increasingly minority status in the course compounded women’s challenges, evoking mental battles not faced by the CS106 students in the study.

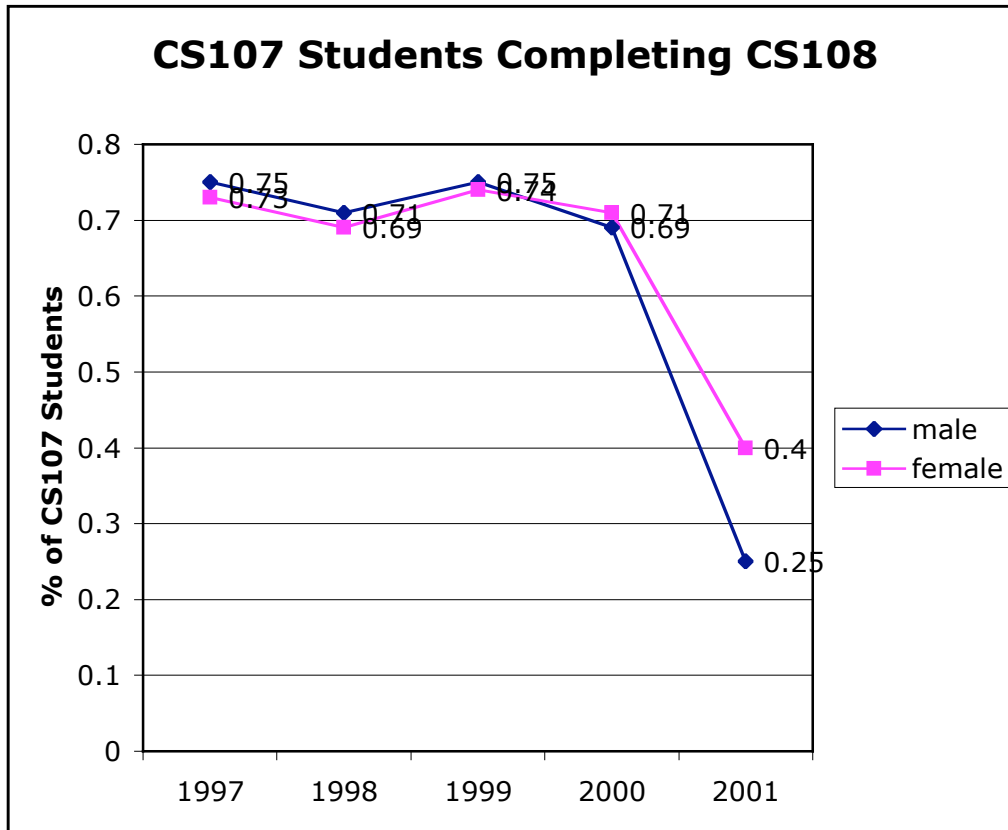


Figure 8: The propensity of students who took CS107 in a given year to go on to complete CS108.

### *A New Kind of Battlefield*

Understanding the dynamics of a battle requires understanding of the battlefield. CS107 has a course staff structure significantly different than that of the CS106 courses. Where CS106A, B, and X all had a course staff consisting of a lecturer, a head TA, and one section leader for roughly every eight students, CS107 has a lecturer, a head TA, and an assistant TA for roughly every 30 students in the course. The one-on-one meetings that provide CS106 students with detailed feedback on each assignment are only scheduled with the handful of low performers on a particular assignment. The learning tools used in CS107 also significantly differentiate it from the courses that came before.

While CS106 is centered around the Mac and IBM-compatible machines common in many households, CS107 students must work in the UNIX environment, familiar only to those with a more sophisticated level of computer experience.

*Students in CS107: A Narrowed Demographic*

CS107 is required of students of computer science, symbolic systems, and some concentrations of electrical engineering – a far more limited audience than CS106B and CS106X. Survey responses shed light on students’ motivations in taking CS107. The students taking CS106B to fulfill their Management Science & Engineering requirements, those taking it in hopes of applying it to other fields of interest, and those simply taking it for enjoyment have left. Left continuing in the core are students focused on computing, many of whom wish “to see how much [they] really enjoy CS.”

Having narrowed its audience to those seriously considering a major or minor in a computing related field, women in CS107 are in the minority, comprising an average of about 20% of the course population in 2000 and 2001. Careful analysis of surveys taken of course entrants reveals that while women and men describe themselves very similarly, the genders diverge in students’ evaluations of their peers.

According to CS107 entrants’ survey responses, the women who do enter the course come in just as enthusiastic as their male peers, reporting their enjoyment of computers an average of 8.4 out of 10 where men self-report it as 8.3 out of 10. The mean difference between men and women was not significant.

The groups begin to diverge, however, in matters of comfort and confidence with computers. While women do not report their own level of comfort in using computers as significantly different than do men entering the course, women *do* assess their peers in

the course as more comfortable with computers than they are, though men assess themselves, on average, as slightly more comfortable than their peers ( $p < 0.001$ ).

More specifically, the groups diverged suggestively, though not significantly, with respect to self-ratings of confidence in solving problems with computers. Women rated their confidence an average of 7.7 out of 10 while men rated it 8.4 out of 10. Significant differences did emerge when students' confidence self-ratings were compared to their evaluations of peer confidence. Women rated themselves an average of a half point less confident than their peers in CS107 while men rated themselves as an average of six tenths of a point *more* confident than their peers in the course ( $p < 0.001$ ).

Despite the divergences, we could not conclude that females entering CS107 report themselves as more or less likely to major in CS than do their male peers. Out of a 10 point scale, males' average likeliness to major exceeded that of women by only 0.15. Though Margolis links confidence to propensity to major,  $\chi^2$  tests showed no correlation between likeliness to major and either self-rated confidence or confidence in comparison to perceived peer confidence *on entry* into this section of the undergraduate core curriculum.

### *A Newly Divided Culture*

While gender socialization played a role in students' value assessments of computer science in CS106, gender grew increasingly salient in differentiating descriptions of experiences among interviewees in CS107 as the proportion of females decreased. The changing gender composition, however, is not the most important cultural distinction described by students in the course. It is in CS107 that course culture significantly diverges from what students consider a normal cross-section of Stanford

culture. While students felt that CS106A was a normal cross-section of Stanford students, and, when pressed, characterized CS106B's culture as Engineer-heavy but not overwhelmingly different CS106A, students strongly felt that CS107 set the stage for a divided culture.

The "tribes" described by students, however, were based not on skill but on personality attributes manifested behaviorally. One sophomore female who chose to major in CS broke her classmates into two groups: those who struggle and those who do well. She went on to explain that students tended to band together with those like themselves in the course. The tribes, however, did not exist in isolation from one another. All students described social contact with students they considered to be at a level disparate from their own.

The main differentiating characteristic between students in the two groups, however, was ability to cope with stress productively, rather than mastery of the material or prior experience. "People who don't do as well start debugging without knowing what's wrong with it. If something bad happens [to me], I don't get stressed. I don't struggle," she explained. For her, the primary distinction between the two groups was not "those who know the material and those who don't," but instead, those who can handle the stress and those who cannot.

A sophomore male who chose to major in Symbolic Systems grouped students in CS107 somewhat differently, though behavioral factors remained most important in classification. To him, the class consisted of "hardcores," "regular people," and those that were "talented."

To this student, to be “hardcore” was to be willing to devote an extreme effort to coding. “Hardcore people are the ones with a dozen diet coke cans lined up empty on their desk. They’ll tell you, ‘I spent a ridiculous amount of time on this program. It’s frickin’ impossible.’ But they have a big smile on their face,” he explained. He noted that “hardcore” was the province of males, not by any inherent gender difference that he could explain, but at least by coincidence. To be hardcore, however, was not necessarily the same as being talented, though there were some who he would designate as both.

Others students shared a consciousness of the word “hardcore” in a way they did not in CS106. “People in 107 are a lot more hardcore than people in the 106es,” commented a sophomore woman mid-quarter.

The word “talented” described students who were perceived as having superior efficiency in completing the requirements of an assignment. Referring to assignments that can typically take 20 hours to complete, the student explained, “Getting it done in 10 hours makes you really talented. There are people who look calm and are going. You don’t see them stop typing. They seem to know what’s going on in class.” The importance of a calm façade recalls the observations of the sophomore female who cited propensity to panic as the primary differentiator among her classmates.

#### *Coding Speed as a Quality Construct*

All students in the cohort described time, or coding speed, as the fundamental measure of ability. While this mapping is not unique to CS107 – students referred to it from the first course in the core – the construct assumes a greater importance in CS107 for two reasons. First, individualized feedback from TAs is reduced to written comments on the assignment. Thus, students have insufficient staff feedback by which to

confidently judge their standing in comparison to the rest of the class. One sophomore male explicitly stated that grades become less important in the face of coding speed as a measure of ability. This measure is especially critical in CS107. Not only are students, according to entry surveys, at a juncture where they are judging whether or not CS is appropriate for them but they are also organizing themselves as members of subgroups in a newly divided course culture.

The topic is a hot one among students. All interviewed described how they compared to various peers. Students establish reputations for relative “talent” amongst themselves. Such status breeds anxiety among many students. “I’ve been feeling like I can’t do CS lately. I don’t think I’m good enough at it. The time I spend in 107 is so much more than other people in 107,” confesses a sophomore female who felt self-identification as a CS major in crisis at the end of CS107.

Though carrying a sheen of objectivity, coding speed, as judged by students in CS107, is a construct open to interpretation, based on self-report and self-display. A sophomore male admits, “I’ll say ‘I’m done’ where it is not *complete* but it’s done,” referring to the fact that he considers himself less “insane about code quality” and will turn in his projects short of completion to specification. The sophomore female frustrated with her coding speed says that she turns in her programs complete to specification and to her “it seems like [others do as well].” If her classmate is to be believed, her assumptions are misguided.

In fact, the recipient of a self-report of coding speed must decode that description as they would any message of social significance. Translating across gender lines, however, is not trivial as linguistic theory suggests that gender differences exist in the

motivations and forms of expressions. Linguist Deborah Tannen suggests that for men, conversations can serve “as arenas for negotiating and maintaining status.” Women, on the other hand, are more focused on establishing commonality and rapport (Talbot).

Research has shown that these cultural differences by gender result in a tendency of women to downplay their certainty while men downplay their doubts (Tannen). These varying self-presentations are both made with similar good intentions. Kimberly Daubman and Harold Sigail found that college-aged men asked to report their performance on an intelligence-related test felt that the person to whom they reported (presumably another student) liked them more when they reported immodestly (“92<sup>nd</sup> percentile” as opposed to “top-half”). Women were opposite in that they felt their companion liked them better when they reported their performance modestly (Daubman, Sigail).

While accepting gender binaries necessarily oversimplifies, such generalizations cannot be ignored for, at very least, they speak to hegemonic cultural beliefs about gendered speech interaction styles. Both men and women acknowledge these beliefs in forming their interpretations of and responses to the statements that others make. While not all choose to play the gender roles prescribed by their sex, people as linguistic agents anticipate that, in general, most will and, in turn, will expect them to.

If hegemonic cultural beliefs about gendered conversational styles enable social actors to decode behavior and speech, we should expect that women in CS107 should successfully modulate reports of prowess in order to consider the possible range of actual abilities that person may have. (For example, a student reporting fast coding speed may truly be a master of the course concepts and their applications, or he can be a hacker who

has forgone clean style and discounted the time needed to debug.) However, for many of the students, this is the first time they have been immersed in a male-dominated environment. For many of these women, translating “male talk” has never been more critical. In a field with a greater number of women, females can establish a sufficient base of comparisons without venturing far into discourse styles less familiar to them. Women refining their identities and roles in the culture of CS107 – an identity that can influence their feelings of validity as CS majors – have few women to look to as reference points in determining their status within a course. Simply comparing their experiences to those of other women does not provide a sufficiently large base on which to build their confidence. Thus, women working to discern feelings of identity, confidence, and competence must translate and incorporate men’s self-reports as well. For many of these women, their interpretations will influence decisions in which their college career and possibly their entire lives are at stake.

By CS107, the realization that perception of coding speed is partially a social construct is not critical for all women. One sophomore female CS major from Japan has excellent grades and is one of the best coders among her friends. She admits, “if my grades were lower, I would rethink. But I like CS and I do well.” Another sophomore female in CS107, an EE major aspiring towards a finance career, denies awareness of a role in any course culture. She insulates herself from contact with peers in the course by seeking support from a sorority sister who has taken the course before. Furthermore, believing that she is cut out for CS is not critical to this student’s self-concept so less is at stake in decoding male peer speech or establishing her role in the peer culture.

The female sophomore at crisis point, however, has plenty at stake. After describing her frustrations of not “coding as quickly as the others” in her CS107 exit interview, she begins to notice the disconnect that sometimes exists between self-report, face value, and reality. “It seems hard to find guys in CS who will willingly admit that they’re not that good at CS. I have friends who are like ‘that program is so easy, blah blah blah’ but I know they spent a lot of time on it. Just a few of them.”

As the above student begins to realize, gauging performance based on evaluations of peers’ confidence can be misleading for women. In the CS107 exit survey, students were asked to rate themselves and their peers in comfort with course materials. While males and females did not rate themselves differently at a significant level, women rated themselves, on average, 0.3 lower than their peers in the course. Men rated themselves 1.15 *higher* than their peers in the course.

This difference in comparative ratings was significant ( $p < 0.05$ ). This difference in confidence, however, is not explained by grades in CS107. In 2000, women attained an average grade of 3.3 out of 4 in CS107, and their male peers attained an average grade of 3.34 out of 4. In 2001, women attained 3.19 and men attained 3.16, both out of 4. Thus women who are unaccustomed to modulating men’s presentations of confidence expertise will likely underestimate their own competence.

Yet when choosing among identities available and valid in CS culture, feelings of competence are critical to women convincing themselves to become domain-identified with the field.

*Being Hardcore: No Girls Allowed*

The role of the “hardcore” is complex, yet well-established in CS student culture. The identity is both admired and scorned, but it is one that is immediately associated with CS student identity. One student who does not consider himself hardcore derided the hardcore lifestyle, decoupled it from true CS ability, and yet he elevated the status of hardcore students, admitting, “There’s actually a lot of it in CS. You want to be ‘hardcore.’”

Another student, a sophomore female, describes hardcore students with awe of their commitment to the course: “People are a lot more hardcore in CS107. It’s getting down to the majors and minors. I knew for a fact that a lot of people would skip 103 and E40 [which they were taking] to sleep and just go to 107 at 9 am. Sweet Hall was so full I couldn’t find a computer sometimes.”

The sophomore male who most carefully defined “hardcore” in his interview cautioned, “Hardcore kids are in danger of seriously burning out...But maybe you do need to be hardcore to get through the CS classes. The old CS kids I know are ones who are hardcore or were hardcore when they were freshmen. They’ve mellowed out a bit.” Interviewees described two primary images of valid CS majors: the calm, talented coder, and the “hardcore kid” who has a hard time but has a good time doing it. Those who perceive themselves as less than “naturally” talented and do not consider themselves to be “fast” enough often relegate themselves to the status of “not being cut out for CS,” as one sophomore girl did.

As one student in CS107 reports, however, the “hardcore kid” is typically male. Hegemonic gender beliefs are far less supportive of women who stay glued to their

computers and act in a single-minded, obsessive manner than they are of men who act that way. These general gender beliefs also expect men to hide strain or difficulty. One explanation of a masculine cult of “hardcore” may be that they are students who may struggle but enjoy it, or at least act like they do. In our gender system, men are incited to spin their struggle into a rite of passage and endurance. No woman in the cohort expressed a desire to be hardcore.

### *Proving One's Self in a Gauntlet*

If women generally do not accept the “hardcore” image of a CS major, then the high-ability alternative is the only one available for them to strive for. The pursuit of this self-concept is complicated with obstacles such as stereotype threat and tokenism faced by minorities subject to stereotypes. The development of a highly competent self-competent, however, is critical. One sophomore female strives for but fears she falls short of that marker. “I just want to make sure I’m making the right decision. I like CS. I can’t see myself doing anything else. I’m not interested in other things. But in terms of ability, I’m not sure I’m there.” Her devotion to CS does not suffice as validation of her choice of major the way it does for some of her male counterparts.

The Latent Threat of Stereotypes - The long-held awareness of stereotypes can depress performance in the students who struggle most for legitimacy. Claude Steele’s work in stereotype threat found that for women who identify themselves with a particular domain – in his study, mathematics – cuing stereotypes of women that threaten their status or expectations of success in mathematics depresses their performance on standardized math tests (Steele).

It is not the case that all women acknowledge Western stereotypes that women are less suited for technical fields. However, all women in the cohort expressed an awareness of the stereotype. The sophomore international student from Japan admitted, “There are much fewer women in CS than men. Maybe in looking for a job, I’ll see the difference. Right now, I don’t.” By “the difference,” she was referring to the potential for women in CS to be treated differently by their male peers. The very fact that she discounts the effect of stereotypes is underpinned by an assumption that she is aware of such stereotypes, at least in the United States.

However, the sophomore female questioning her ability despite her interest cites her desire to overcome the looming presence of stereotypes “that women are more suited towards fuzzy majors and males more suited for techies” as a reason to seek out a mentor through Stanford’s Women in Computer Science organization.

The stereotypical roles hypothesized by Plaut and Cheryan to negatively impact the performance of women in computer science (2003) first become apparent in CS107. While students in CS106A and CS106B describe a course culture largely comparable to other Stanford courses attracting a wide cross section of students, such as Econ 1, CS107 students describe a subculture of “geekiness” previously evident only in CS106X, the accelerated introductory programming course for students with prior experience. This subculture gains an opportunity for visibility because of CS107’s use of the UNIX operating system, only familiar to a very small subset of students. The image of this “geek” subculture is one of male hackers and, thus, its salience implies the stereotype that women *do no* do computers – either because they are too social, too untechnical, too uninterested, or, at worst, too inept.

The mere existence and cueing of the stereotype, rather than any belief in it, is sufficient to hamper performance. While this study provides no means of evaluating the effect of stereotype threat on women, the high likelihood of a depression in performance seems especially threatening to those whose primary means of validating their domain identification *is* ability over interest.

Tokenism and the Minority Experience – As women’s representation among the CS107 student body hovers at roughly 20%, they gain a level of visibility not experienced by males in the class. This visibility is not necessarily accorded as a result of gender, but instead because of their status as “visibly different” from the majority.

This phenomenon, termed “tokenism” by Rosabeth Kanter, most severely affects minority members of groups Kanter terms “skewed” – groups in which the minority comprises less than 15% of the whole. When the minority group comprises closer to 35% of the whole, the effects, such as visibility, are still present, though not as severe. Kanter terms this group composition “tilted” (1977).

While the compositions form different categories, they are by no means discrete differentiators. While Kanter would classify CS107 as a tilted group, its numbers and, thus, its social phenomena, border on becoming those of a skewed culture. Kanter identified four phenomenon faced by women with “token status.” First, as the women in CS107, they are highly visible and memorable because of their difference. Second, in the eyes of the dominant group, they represent the category to which they most visibly belong, giving their actions socially symbolic consequences. Third, attention paid to the characteristics that differentiate the token from the majority, such as appearance, distracted the majority from recognizing less discrepant characteristics such as

performance. Fourth, the token group felt pressure to keep the dominant group from looking bad for fear of retaliation (1977b).

All four risks described above are ones that may be faced by women studying computer science at Stanford. By CS107, however, the politics of appearance had already surfaced as a topic on the minds of students. An open-ended conversation themed “Why does being a woman in computer science matter?” observed at a meeting of Stanford’s Women in Computer Science [WICS] organization quickly evolved into a discussion of how appearance affected women’s reception among their peers.

Two women who had just completed CS107 complained of the pressure they felt to dress down. The pressure was not explicit or externally applied, but instead implicit – a consequence of the women’s perception that more feminine clothing both increased visibility and distracted peers from their technical skills. The laid-back style that some CS106 women in the group viewed as a liberation from pressure to appear fashionable grew into a burden just as constraining as the style being escaped as women’s numbers dwindled and their token status increased.

Even if women reduce the femininity of their clothing, Kanter predicts that other social skills stereotypically ascribed to women, such as emotional nurturing, overshadow and distract from their domain relevant skills and traits. The end result, according to both Kanter and the upper-division women in the WICS forum, is that women felt they had to work harder to have their traits and talents recognized. Kanter’s work, however, implies that in struggling to have their competence recognized, the minority already has confidence in their competence. For women developing their self-concept at this critical

juncture, there exists a feedback loop in which technical interaction and acknowledgement are affected by and can affect an individual's confidence in turn.

Kanter's findings do not, however, superficially describe all aspects of CS107 course culture. In particular, Kanter's boundary heightening seems to fall short of capturing the stressed camaraderie evident among students CS107. Boundary heightening occurs between token and dominant group members in skewed groups when the existence of tokens sharpens and galvanizes the cultural commonalities among the dominant group. This serves to further isolate tokens, often reducing their access to support and resources. Evidence of boundary heightening in CS107 was more subdued than examples described of group rifts in a particular American corporation that was the focus of her study (1977).

Examining the social dynamic of CS107 students through the lens of intergroup relation theory casts a shadow of doubt on assessments of peer merit as seen through the eyes of women in CS107. Women entering CS107 rated themselves, on average, 0.5 out of 10 lower than their peers in ability to solve problems using computers, though men rated themselves 0.5 out of 10 higher than their peers ( $p < 0.01$ <sup>6</sup>). If ability to solve problems with computers is the core competency of CS domain, women and men enter agreeing that women are lower status citizens. According to Gilbert, et al., members of higher-status groups tend show strong favorable bias in assessing the creativity and competence of their own group members. These biases only serve to further cement the status gap among students in CS107. The gap in status, as measured by confidence in ability to solve problems with computers in comparison to peers, did in fact shift but stay constant in magnitude among students between CS107 and CS108. Women rated

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<sup>6</sup> Significant both under t-test and Mann-Whitney rank sum test.

themselves, on average, 0.7 out of 10 lower than their peers while men rated themselves, on average, 0.25 out of 10 higher than their peers on leaving the course.

Several factors may combine to reduce and disperse the effects of boundary heightening and status-weak group identity among students CS107. First, men and women do not form the only distinct cultural groups – the “hardcores” are also a highly visible, though less superficially so, subgroup. Over the course of the quarter, students feel that they can reliably identify this subgroup and interviewees frequently described themselves in contrast to these students. The presence of such a subgroup provides grounds for a cultural unity between women and a subset of the men by providing them with a common reference point from which to differentiate themselves, temporarily reducing the salience of gendered cultural differences.

Other aspects of CS107 and Stanford culture circumvent the consequences of increased social barriers, at least in part. In particular, the importance of dorm social groups and the presence of Sweet Hall, a central 24-hour UNIX workstation lab where many CS107 students work, as a home base provide compelling reasons for students in CS107 to positively interact across token and dominant status groups.

One sophomore female, self-described as being at “a crisis point,” cited her dorm companions in the course, both males, as her primary source of support during the course. While Kanter would predict that this woman should experience heightened social boundaries separating her from her male peers, she and her companions developed their rapport in the dormitory – a gender balanced environment. Their rapport overwhelms the boundary heightening that comes from uncertainty about others.

The presence of Sweet Hall provided a site for CS107 students to become bonded through “common fate,” a term used by sociologists to describe conditions in which the outcomes of individuals are interlinked (Gilbert, et al.).

A sophomore female contrasted her experiences programming in her own dorm room in CS106 with programming in Sweet Hall during CS107. "I programmed in Sweet Hall and I'd meet a lot of people," she explained. "Sometimes I'd help people find bugs and it was a chance to learn that I was on the same level as others."

Perceptions of common fate, perceived interdependence, and actual interdependence, as well as distinctive shared experiences, have been shown to lead to collective identities (Gilbert, et al.). The helping student's experiences in Sweet Hall engaged her and others in a shared identity as CS107 students. While that collective identity was always available to her, Turner's self-categorization theory (SCT) explains identities, both personal and social, as “different levels of...inclusiveness” mutually exclusive from one another (Gilbert, et al.). A shift from an identity as a woman in CS106 to that of a student in CS107, triggered by interdependent experiences, accentuates similarities the student shares with others in the CS107 group as a whole and deemphasizes differences that define the subgroup identity from which she has temporarily moved away.

According to Schopler and Insko, individuals sharing a group identity more often engage in cooperative rather than competitive social behavior. The student who helped others in Sweet Hall serves as one example. However, the climate in the CS core does not always encourage such beneficial interactions. One sophomore female cited fears of inadvertently violating the honor code as an impediment to feeling comfortable helping

and being helped by her peers.

For a group of sophomore females in CS107, a base for cooperation came by strengthening their “ingroup identity” as women in CS107. Typically working in a group in Sweet Hall, they formed a support network. However, establishing strong ingroup identity does not make any headway towards breaking down barriers dividing their ingroup from their classmates. Gilbert points out that “groups rate their ingroup more positively than they rate the outgroup.” The women’s identification with the ingroup fueled a continued sense of isolation from other students.

### *Climbing Over the Obstacles*

That CS107 does not filter women more aggressively than it filters men is surprising, given the cultural frustrations, as well as the obstacles to self-confidence and domain identification, experienced by women taking the course. In fact, of the female survey respondents between CS107 and CS108, all women reported likeliness to major in CS equal to their likeliness to major when they entered CS107. Most men also reported no change in their likeliness to major, though 25% reported a one point decrease in their likeliness. Confidence bruised among both men and women, most students cited the level of time investment already put into the core as their main reason for taking the next step after CS107, giving CS a final shot.

### **CS108: Hope on the Brink**

Students come through CS107 tattered and worn, but they have invested a large amount of time in pursuing the major, preventing them from giving up on the discipline right away. The course, vastly different from CS107 in both content and culture, comes in time to bolster those who found CS107 unencouraging.

### *On Equal Platforms*

One student cited the Java programming language – the language used in CS108 – as an equalizing force in the class. The same sophomore female who experienced a crisis of confidence in CS107 described finding validation in CS108.

This one guy I knew in CS107 – he got the top score in the class. He’s a sophomore and this quarter he’s *TA*. He also had never done Java, so I felt like in CS108 it was more even. I’d ask him how long it took him to do a program and he’d say “blah blah hours.” I’d feel like, “Oh my god! It’s going to take me triple the amount of time.” But he said, “I’ve never done Java either!” And it actually took me about the same amount of time to code. Before, in 107, it was very different.

For the cohort interviewed in this study, the Advanced Placement courses taught in high school used C++. As the AP Exam recently switched to Java, Java’s equalizing effect may not persist as a new generation will enter with Java experience.

The content of the course varied not only in programming language but also in the skills valued and rewarded. Students were charged with the task of implementing a large-scale software in teams. Superior projects required not only coding knowledge, but also engineering competence in team-problem solving and project management – skills unnecessary in prior courses in the core.

The new nature of these CS projects excited the students interviewed. A female student excitedly described the experience of working with two male friends who had helped her through CS107. “When we got together to work on the assignment, they weren’t very aggressive so I had to take that role. I had a lot of fun doing that – integrating, getting on people to work...I loved it!” she exclaimed.

Not all students had such positive group work experiences. Another student described her group as having worked together ineffectively as one of the members produced unreliable, untested code. Whether successful or a challenge, the small team work process added a new dimension to students' picture of software engineering – a dimension less in conflict with hegemonic cultural beliefs of femininity.

#### *Families, not Tribes – Course Culture*

The final project's small teams impacted course culture as well. The cultural divides characterized by the multiple “tribes” of CS107 – the “hardcores,” “the talented ones,” and the mainstream students – were initially diluted and ultimately superceded in CS108. Dilution came as a result of simpler initial assignments that did not differentiate students as CS107 assignments did. Rather than a curve-like distribution, grades on the assignments tended to cluster in high ranges. Because students were less differentiated by grades early on the course, group divisions were less likely to form. Ingroup identity requires the accentuation of difference from some outgroup (Gilbert, et al.). Thus as differences become less obvious, so do divides.

When groups did form in CS108, they reduced the importance of behavioral divides like those that formed in CS107. Bunnyworld, a large-scale group project at the end of the course, required teams of two or three individuals. Working together intensely and bound by a very obvious “common fate,” students formed strong group identity in these small “families.” In keeping with self-categorization theory's premise that group identities are somewhat mutually exclusive at a given point in time (Gilbert, et al.), the formation and importance of the small groups diminished the importance of other group

identities, such as males and females, or “hardcores,” “the talented ones,” and the mainstream.

One sophomore female – the same who described getting through CS107 depending on her drawmate – experienced a flattening of what was once a cultural hierarchy in her mind. In CS107, she categorized students as dividing into three levels, ascending in ability and in comfort with the course material. She placed herself at the lowest rung and her drawmate a rung above. In CS108, however, she felt that these levels were far less relevant. In a Bunnyworld group with her drawmate, she found him to be “unaggressive,” leading her to take a leadership role. Those who she had once placed in a higher-status outgroup in CS107 became her ingroup in CS108, setting a social stage in which her competence could thrive into a sense of confidence.

### *Affirmation*

CS108 served as a stage in which students who had an unsure relationship with their chosen major could validate their decision to continue. Students were more equal than in prior courses in being unfamiliar with the tools and techniques of CS108 and Java, despite prior experience with programming. A less-alienating, small-group culture encouraged collaborative learning and diminished the importance of the cultural divides that trapped some women in CS107. Perhaps most importantly, in the long run, the skills required for success in CS108 extended notions of what it means to be a good software engineer, including a broader range of students in that identity along the way.

“After CS107, it became a question not of whether I could pull it off but of how well I could pull it off,” a sophomore woman explained. “After 108, I was sure that CS was for me.”

## Stanford's Responsibility and Future Action

When women at Stanford never seriously consider majoring in CS, set on viewing Computer Science as an enjoyable activity at best, what role does the Computer Science Department play? If the major root of Stanford's leaky pipeline is gender socialization, some argue that this problem must be addressed earlier on – that the University can have no impact on the fundamental problem.

While the University cannot change how its students are socialized, nor should it necessarily change its admissions to select for those who are socialized differently, the CS Department can guide its student culture to be one inclusive of a broader range of values. Many students, particularly those later in the core and older undergraduates not in the study, desire such a shift towards a more diverse, cooperative learning community in Computer Science. Men and women are both among these ranks. Telling is the small contingent of men involved in Women in Computer Science, explaining that they seek a community of technical-minded individuals outside the context of classroom competition.

In their report entitled *Tech Savvy: Educating Girls in the New Computer Age*, the American Association of University Women observed that computer science places a “cultural emphasis on technical capacity, speed, and efficiency” (2000), a value evident as early as CS106, though countered in part by the course's emphasis on problem solving style and elegance<sup>7</sup>. Recognizing that the culture of computing extends beyond Stanford's CS Department, this institution's hands are still not tied.

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<sup>7</sup> This emphasis on style did not go unappreciated by one student who commented that it gave her a better impression of CS. “That I really appreciated, because it did take into account the human side of things and the aesthetic side of computer science,” she

CS106 and CS107 serve as examples of the effect that explicitly controlling a culture can have. The departments that produce members of this computing culture, such as Stanford's Department of Computer Science, have an opportunity to choose the values that are important to the production of knowledge in the field. They have the power to embed those in their pedagogy, countering social artifacts that may artificially and unproductively marginalize talented students. This commitment to emphasizing those values must continue beyond the CS106 courses, supported by faculty in courses across the discipline, lest those values should degenerate into a nicety.

Organizations like WICS are just one step in this direction. The CS106 program has been successful in eliminating the "chilly climate" in the classroom described by researchers Hall and Sandler (1982) as a pattern of gender bias that can affect women in nontraditional fields, though work remains to be done in finding a place to introduce students to the breadth of CS beyond just software engineering earlier on. Great potential also remains partially untapped in the CS Department's residential summer program, the Computer Science Research Internship [CURIS]. The program can be an opportunity to foster a "common fate" community of enthusiasm, shared resources, and technical creativity, though factors such as competitiveness and tokenism must also be accounted for in program design.

Creating an inclusive Computer Science program is not synonymous with compromising the rigor of education or the quality of research output. It means enriching the creativity influencing the field and telling the truth about the excitement of the field so that the next potential Turing does not walk away uninspired. And, as the late Anita

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continued. "It's not just getting it done but it's how you do it, and how elegant you are in doing it, and that really means a lot to me.

Borg – a systems engineer and founder of the Institute for Women and Technology – believed,

In this century, we have the responsibility to learn, be involved in, and have an opinion about technology, and to ensure that women and girls are actively involved in creating the future... We will cast our votes by deciding what we want, by becoming technically literate, and by applying our genius to build the technology for a positive future.

## Appendix 1: Interview Protocol

Before the interview begins, have the student sign the consent form and fill out a short form with their identification and contact information (name, year at Stanford, e-mail, phone number).

While these questions are meant as a guide for conversation to ensure certain topics are covered in the interview, the interviewer is free to add investigatory questions as issues arise during the interview, or eliminate questions that will result in redundancy.

Student background:

We will ask this set of questions once, the first time we meet an applicant.

Can you tell me the story about you and computers? (How and when did you get interested? How do you typically use them?)

Purpose: Get a sense of specific experiences and exposure that shaped their interest in computers, if they are interested. If they don't have a strong interest, learn what experience of lack thereof contributed to that.

In your opinion, what are positive and negative aspects of computers?

Purpose: Probe student's attitude towards computers.

How does your family use computers?

Purpose: Was there a computer expert in the family? Who was it? How did parents use it? What is parents' occupation? Brothers and sisters attitude towards computing?

Academic interests:

We will ask this set of questions once, the first time we meet an applicant.

What do you consider to be your academic strengths? Other interests?

What are you considering majoring in at Stanford? What about minors or other academic interests? Would your answer to that question have been different if I'd asked when you arrived on campus?

Perceptions of Computer Science:

We will ask this set of questions once, the first time we meet an applicant.

What strengths do you think a successful computer science major should have?

What do you think someone can do with a degree in CS?

What do you perceive as benefits to studying CS? What do you perceive as problems in studying CS?

Entrance Interview

This set of questions is for the interview to be conducted at the beginning of the quarter when the student first enrolls in a CS course. Before the student begins, have him or her fill out a short quantitative survey.

Survey:

One a scale of 1 through 10 (with 10 being best), how would \_\_\_ rate yourself in the following areas in relation to your peers in the following characteristics?

	you	your peers
math		
ability to solve logical problems		
ability to use computer to solve problems		
comfort with computers		
enjoyment of computers		

What first brought this course to your attention?

Purpose: what factors in? GER? academic advising? prior interest? prior courses in the sequence (if applicable)?

Why are you taking this course? Any other reasons?

Purpose: probe for place of course and material in terms of students goals? perceptions of course? course reputation?

Did you have any reservations about taking this class?

Purpose: What influences the student’s decision to take the course? How does reputation affect girls’ decision to take the class? Look for contrasts in female/male responses.

What do you expect get out of this course?

Purpose: Do students expectations match results (to be determined at exit interview)? What do students find to be attractive objectives in a course? practical knowledge? conceptual understanding? literacy? idea of CS as a field?

What CS courses do you plan to take?

Purpose: Gives sense of a change over time if these plans change.

Exit Interview

This set of questions is for the interview to be conducted within two weeks of the end of the quarter in which the student was enrolled in a CS course. Before the student begins, have him or her fill out a short quantitative survey.

Survey:

On a scale of 1 through 10 (with 10 being best), how would \_\_\_ rate yourself in the following in relation to your peers in the following characteristics?

	you	your peers
math		
ability to solve logical problems		
ability to use computer to solve problems		
comfort with computers		
enjoyment of computers		

Did you enjoy taking CS\_\_\_ this quarter?

What aspects of your experience did you find particularly fun or rewarding?

Anything else?

What aspects of your experience did you find unfavorable or frustrating?

Anything else?

Listen for: support network? opinion of assignments? culture frustrations? self-confidence issues?

Did you feel respected by the instructor? the course staff? your peers? What gives you those impressions?

Purpose: does reduction of course staff take away one of the few sources of support encouragement students have? does this affect girls' unduly harshly? are there subtly (or unsubtly) biased comments coloring girls' experiences?

How would you define course culture of CS\_\_\_? Did you feel as if you fit in?

Purpose: how does culture change from course to course? how does this affect girls' sense of belonging?

Did taking this course change your thoughts on what you might want to take while here at Stanford? How? Why?

Listen for: modified perceptions of CS and CS majors? what altered interest? change in intent to major or minor?

Do you think you'll take any other CS courses? Why or not? What course?

Did you find that your perceptions of what it is to study CS changed this quarter?

Did you find that your perceptions of what it is to be a computer scientist changed this quarter?

## **Appendix 2: Survey Instrument**



### **Appendix 3: Stanford's Undergraduate CS Core**

This study focuses primarily on Stanford's undergraduate programming core.

#### CS106A – Programming Methodologies

The course “Programming Methodologies” has been designed as an introduction suitable for students continuing on to pursue a CS major but specifically designed for those with no prior programming experience. As one lecturer put it on the first day of lecture, “Do you know how to turn on the computer? Or could you ask someone if you couldn't? That's all you need to take this class.”

CS106A is an introduction to problem solving by breaking into subproblems. The course's tools are a programming language, its syntax, and techniques for writing and fixing code. Though the course is currently taught in the C programming language, it was once in Pascal and will move to Java in 2004.

Elements of the courses design reflect the department's awareness that prior experience in computers is not equally distributed among students. Thus, the course aims to attract a wide range of students (Roberts, et al., 86) by avoiding the presumption that students take the course because of an interest in programming for its own sake.

Assignments from the course are designed to be gender neutral and include graphical screensavers and word games like Hangman.

The course's most distinctive feature, shared with CS106B and CS106, is the grouping of students into sections of about six to eight, taught by an undergraduate course TA, called a “section leader.” These section leaders teach section once a week and meet with each student to review and give feedback on each assignment. Section leaders

also staff all-day drop in office hours so students have course help during most waking hours. The utilization of extensive course staff enables the CS department to set a high bar and enable each student to reach it by providing extensive resources.

#### CS106B – Programming Abstractions

“Programming Abstractions” is a continuation of CS106A. With the programming language under their belt, students are led to focus on algorithms and data structures as higher-level entities. The course staff structure is identical to that of CS106A. This course is widely regarded as more abstract – less syntactical – than CS106A. Some students find the increased abstraction conceptually difficult, but others comment that they find learning the concepts easier than mastering syntax as they did in CS106A.

#### CS106X – Programming Methodologies & Abstractions (Accelerated)

CS106X compresses CS106A and CS106B into one quarter for students who have prior programming experience. Students completing CS106X tend to be viewed as “hardcore,” which can translate into a misconception that they have better command of the material than students who go through the conventional track. However, CS106X covers roughly 90% of what is covered in the A/B track and conceptually difficult concepts most students with prior programming experience do not already know are covered an accelerated rate.

Rather than a shortcut through the introductory core, CS106X is indented to make the mainstream A/B sequence a friendlier learning environment. The vocal, self-styled hackers who may put off average students or further perpetuate negative stereotypes of CS students are attracted to X, away from A/B.

### CS107 – Programming Paradigms

Marking a major shift from the controlled, supportive culture of the CS106 courses, CS107 abruptly weans students off of the personal teaching interaction and inducts them into upper-division CS department culture. While the course has a TA for roughly every 30 students – most upper-division CS courses have a ratio of roughly one TA for every 50 students – the TAs only have individual feedback meetings with the most troubled students.

The course provides students with an intense introduction to two new programming languages, teaches them very low level C programming, and introduces them to how computer languages are translated into lower level machine languages. Students commonly describe this course as the most difficult and stressful of the core.

### CS108 – Object-Oriented Programming

Usually taken after CS107, CS108 comes as a break to taxed students. The course teaches Java, a newer programming language commonly thought to be easier to program in. CS108's provides large project experience and allows students to explore a Java and its capabilities in a way that seems unstructured compared to the rigor of CS107. The final project, titled "Bunnyworld," is commonly considered an initiation into computer science, though its focus is exclusively on software engineering.

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