Spring 2005 Winner

Kimber Lockhart

Instructor's Foreword

"Reading Between the Lines: The Rhetoric of Literacy" participated in the Community Writing Project. In working toward her Research Based Argument, Kimber Lockhart fused the "think globally, write locally" energy of that program with the research and analysis that culminate in PWR 1. Her writing process began with a topic that mattered to her: the causes for and consequences of the under-representation of women in computer science. As she began her research, she recognized that her experience at Stanford accounted in large part for her interest in this broad issue and that it could (and should) inform her research and writing.

As she recounts in her essay, Kimber conducted extensive primary and secondary research and collated anecdotal and statistical data to ground her assertion of Stanford's obligation and opportunity to involve more women undergraduates in its Computer Science program. The result – "Women in Computer Science: A Skill Specific Analysis" – frames the particular case of Stanford's Computer Science major within broader trends in the culture of computing, and frames it to great effect: in a concluding section emboldened by the global breadth and local depth of her research, Kimber makes innovative and practical recommendations as to how the Stanford Computer Science department can welcome more female students. Members of the Computer Science faculty have applauded her work and the department has begun implementing some of her recruitment and curricular suggestions.

Kimber demonstrates exceptional bravery in this essay, for she not only takes theory and puts it into practice in a department of which she is a young member, but she does so in a department in which male students so notoriously outnumber female students that last year's unofficial Computer Science t-shirt made a joke of it. Kimber begins there. By the end of her essay she has, without bitterness, rewritten the punch line.

Claire Bowen

Women in Computer Science: A Skill-Specific Analysis

Kimber Lockhart

The unofficial t-shirt of Stanford University's Computer Science department features seven simplistic white figures on a plain black background with the words "Stanford Computer Science 2004-05" printed below. For such a simple design, the shirt has created a lot of controversy. Why? Six of the figures are male and one is female.

Soon after the t-shirts made their debut, articles began appearing in *The Stanford Daily*. Entitled "Computer Science T-shirts are Offensive," Betty Zhao's May 2 letter to the editor questions the propriety of making gender and enrollment the comic focus of a departmental t-shirt. She asks, "If you were a female student in Computer Science, wouldn't it be troubling to see your minority status being displayed on the chests of your primarily male classmates for the purpose of humor?" Shortly thereafter, Stanford Computer Science course advisor Mike Brzozowski wrote to emphasize that the shirts were not officially affiliated with the department, which is sensitive to the needs of all students. Despite these arguments, the seven person logo graces the chests of many Stanford students, Computer Science majors and non-majors, men and women alike.

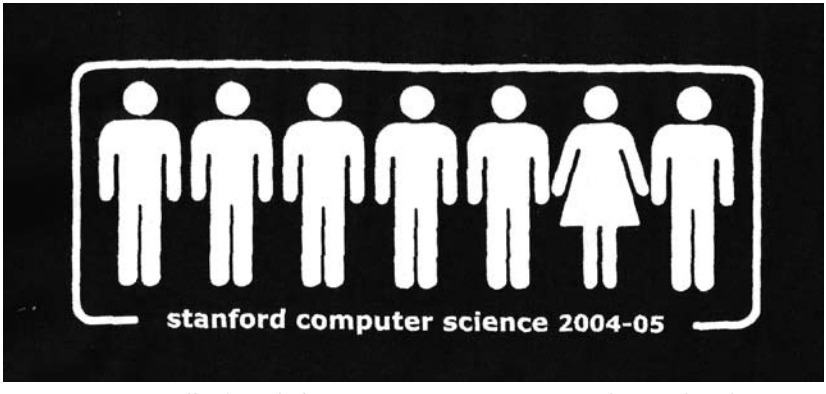

Figure 1. 2005 Unofficial Stanford Computer Science Department T- Shirt (Author Photo).

While the shirt obviously pokes fun at the nearly six to one ratio of men to women in Stanford's Computer Science department, it also points out a rather disturbing trend in computer science around the world. The prevalence of these t-shirts on Stanford's campus is indicative of how the under-representation of women has become an accepted part of the culture of computer science. After all, this culture is built upon the stereotype of a Computer Science major as one-dimensional, antisocial and "geeky." Computer Science departments are making efforts to challenge this culture and bring more women into computing majors. These efforts, however, have met little success. It is easy to blame this phenomenon on a lack of computer science ability or experience in women. I have found, however, that each gender generally possesses distinct skills important to success

in computer science. We need to adopt skill-specific strategies to attract more talented women to computer science.

In contrast to many other engineering disciplines, women were well-represented in the early days of computer science. Women made up thirty-seven percent of computer science undergraduates during the technology boom of the mid-1980's (National Center for Education Statistics). Since then, the percentage of women undergraduates has been declining. Even the internet boom of the late 1990's, during which technology majors were extremely popular and profitable, the percentage of women majoring in computer science remained stagnant. By 2003 that percentage had fallen below eighteen, and the trend is showing no signs of reversing (Vegso).

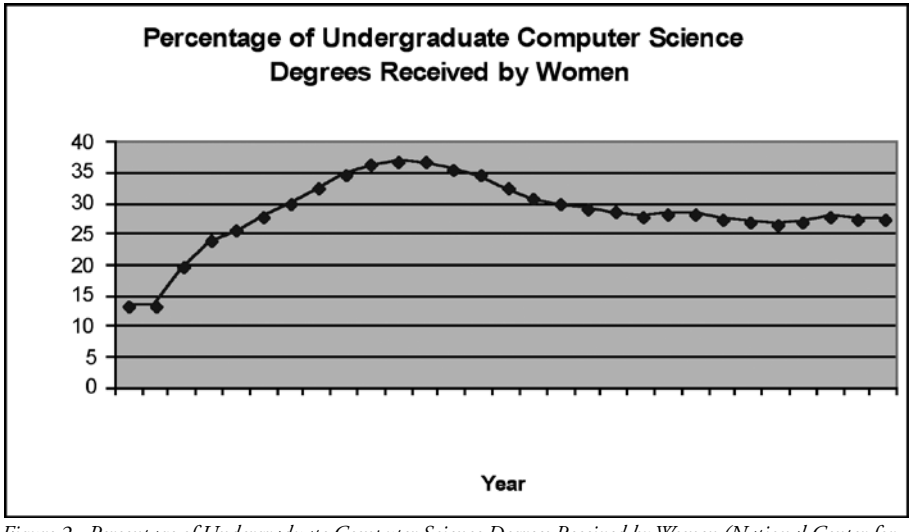

Figure 2. Percentage of Undergraduate Computer Science Degrees Received by Women (National Center for Educational Statistics).

In "Is Diversity in Computing a Moral Matter?" Johnson and Miller assess the claim that women are underrepresented in computer science because they choose not to go into the field (9). It follows from this claim that we should not waste energy and resources trying to encourage women's participation. This is not a convincing argument. While it may be true that there is little overt discrimination against women, there are other ways to make women feel uncomfortable and unwelcome in computer science. Not only is the practice unethical, it is disadvantageous to the discipline to miss out on the potential contribution of women (Johnson and Miller 10).

This contribution is vital to the integration of computing into society. Although "recreational and educational software programs reflect the gender biases and stereotypes of their [mostly male] designers" and much of the software today reflects a subtle bias towards men, women make up a large proportion of software users (Pearl et al. 136). They surf the internet in equal proportion to men and form the majority of internet consumers (Margolis and Fisher 2). For women to feel more comfortable using computers, the gender bias in software towards men must be neutralized. To make this happen, we must address the shortage of women computer scientists.

In addition, the United States faces an impending overall shortage of computer science professionals. Demographic trends suggest a significant decrease in the number of white men entering college during the next decade (Pearl et al. 135). Because white men make up the majority of computing majors, the number of computing majors and qualified computing professionals will also decrease (see figure 3). Coupled with increased demands for technology professionals in the near future, this may result in a critical labor shortage, especially if more women do not enter the field. It is worth our time and resources to encourage women in computer science.

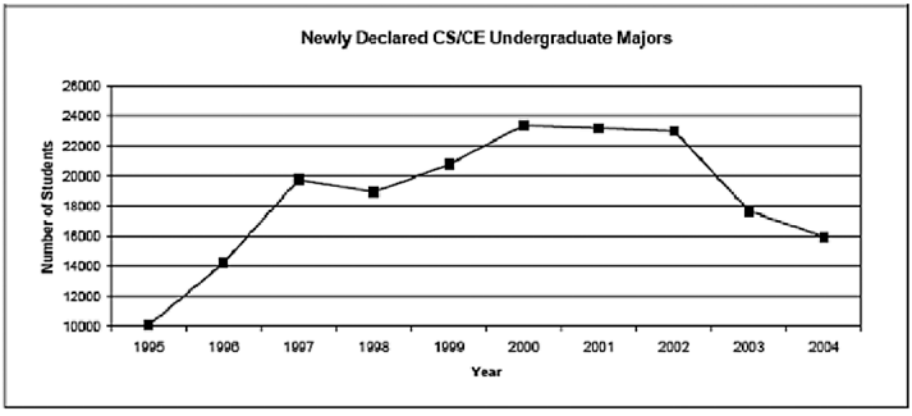

Figure 3. Newly Declared Computing Undergraduate Majors in the United States (Computing Research Association).

To successfully recruit women into computer science, we must first determine what turns them away from the discipline. One theory holds that men are simply better at computer science than women. Perhaps something innate about men or the way men are raised and socialized makes them a better fit for computer science. The evidence, however, suggests that this is not the case. Overall measured intelligence of both genders is the same (Lippa 25). More importantly, men and women achieve nearly identical grades in undergraduate computer science courses (Margolis and Fisher 2). If men were somehow naturally better at computer science they should, on average, perform better than women. Overall, men do not appear to have an advantage over women in the discipline.

Perhaps then, the culture surrounding computing appeals more to men than to women. A stereotypical computer science student loves computers and coding more than anything. He might spend long hours late at night in a dark, antisocial computer lab, with little to show for it except some cryptic code and a "monitor tan." Many women, especially in adolescence, simply do not want to be associated with this image. Although this cultural element is important to address, it cannot be the focus of efforts to increase women's participation in computer science. Attempts to artificially force a friendlier culture on computing have not proven successful. Understanding and tackling the factors that led to the establishment of this culture is the only path to lasting change.

I theorize that the factors creating the gender gap in computer science enrollment are largely based on discrepancies between the genders in specific skills required for success in computer science. Though men and women are equally suited to succeed in the discipline, each group may tend to excel in distinct aspects of computer science. I surveyed Stanford Computer Science professors and examined modern computer science

education literature to determine which skills contribute to success in computer science, primarily at the undergraduate level. I chose to focus on undergraduate education because recruitment strategies must be implemented as early as possible in order to produce a larger number of qualified graduates. Ideally, some changes would take place in junior high and high school. Since many high schools do not have quality computer science programs, and it is very difficult to get pertinent information to teachers in the programs that do exist, high school is not a realistic catalyst for change. In addition, most students choose the field they will study during their first two years as an undergraduate, making undergraduate recruitment the ideal focus for this study.

To compile a computer science skill set, I consulted four professors and five print sources.[1] From these, I identified twenty-nine important traits, with citations ranging in frequency from one to five. I then compiled a list of the top ten traits for success in Computer Science. Table 1 lists each trait along with the number of sources that cited the trait as necessary for success in computer science.

Trait	Number of Sources
Clear Written and Verbal Communication	5
Love for Problem Solving	5
Ability to Decompose Large Problems (Attention to Detail)	4
Logical Thinking Skills	4
Strategic Thinking/Analytical Skills	4
Ability to Work as a Team	3
Organizational Skills	3
Comfort With Abstract Concepts and Symbol Processing	2
Mathematical Skills	2
Self-Confidence	2

Table 1: Top Ten Essential Traits for Success in Computer Science

Next, I consulted scholarly literature in modern psychology to determine if researchers had determined a generalized gender difference in each trait, either innate or ingrained from human socialization patterns. For the purposes of my work, the origin of a trait difference is largely inconsequential – what is important is that the difference exists and could play a role in the different responses of men and women to the modern conception of computer science. Not surprisingly, several traits on the list reveal a gender bias, some towards men and some towards women.

Men's Bias	Neutral	Women's Bias
• Abstract concepts and symbolism	• Strategic thinking and analytical skills	• Written and verbal communication
• Self-esteem	• Logical reasoning	• Ability to work as a team
• Mathematical ability	• Mathematical ability	• Organizational skills
• Problem solving ability	• Problem solving ability	

Figure 4. Results of gender difference analysis.[2]

1 See Appendix 2 for sources included in survey.

2 The ability to decompose large problems was not included due to insufficient sex difference data.

On average, men perform better than women on many kinds of visual-spatial tests, particularly on tests of mental rotation. In these tests, participants are asked to "mentally turn around a sketched three-dimensional object to see if it is the same as an object presented in a different orientation" (Lippa 25). This type of thinking closely resembles the thinking necessary for processing abstract concepts and symbolism. Because of this relationship, men may have a slight advantage over women in this skill area.

On the other hand, "Gender differences in spatial ability occur in fairly specific skills . . . [they] do not occur on spatial tasks that rely heavily on analytic combination of complex information" (Linn and Petersen 87). In other words, men and women have equal potential in their analytic ability. No difference in strategic thinking and analytical skills exists between the genders. Similarly, studies of deductive logical reasoning find "no or very few differences . . . between the sexes" (Brandon).

Communication skills and ability to work as a team, however, are slightly greater in women than in men. Women consistently score higher than men in measures of verbal ability, especially in verbal fluency, the process of quickly generating words that possess a certain meaning or feature (Lippa 24). This skill is closely related to overall verbal communication ability. Women possess a slight advantage in other modes of communication as well. While men tend to use a more direct, assertive approach to communication, women are better at reading nonverbal cues and carefully choosing the words and tone most appropriate to the situation (LaFrance and Harris 137). Because of their high ability in interpersonal communication and an "interconnected view of the world" (Lippa 28) women tend to be skilled team players as well.

Though not as well documented, some evidence suggests women may have better organizational skills then men. A study of undergraduate students at a metropolitan university revealed that women rank their own organizational skills 13% higher than men rank their skills (Belcheir). This indicates a possible skill difference and a clear organizational confidence difference between women and men.

Perhaps the most notable skill difference between men and women was in measures of self-esteem. While men's and women's self-confidence levels tend to be equal through much of the human life span, a discrepancy develops in late adolescence (Lippa 29). Women tend to experience a "much greater lack of self-esteem during their college years than do men" (Pearl et al. 137).

Sex differences in problem solving and mathematical ability are slightly more controversial. While there is no evidence that men enjoy problem solving any more than women, men tend to score better on tests of mathematical problem solving (Kimura 68). Some studies point to a decrease in this gender gap over the last decade, suggesting that the apparent difference in problem solving ability reflects inadequate measures of these skills. In *Human Sex Differences*, G. Mitchell asserts "Boys are not better at analyzing and selecting elements needed for a solution of a problem" (175). Similarly, men have a slight advantage in overall mathematical ability; "67% of men perform better than the average woman does on math tests" (Lippa 24). Again, this may be inaccurate as "gender differences in math achievement have disappeared in most countries" (Klawe 17) and "girls, if anything, get better marks in math courses than boys do" (Kimura 67). Moreover, mathematical ability is one of the less frequently cited skills for excellence in computer science. Sophisticated mathematical understanding is certainly necessary for some areas of

computer science, but not relevant for other areas, and has a surprisingly low correlation with overall success in computer science (Klawe 17).

Clearly then, neither gender has a distinct advantage in skills important for computer science success. Men tend to excel at some aspects of computer science; women excel at others. The problem keeping women out of computer science is not a lack of ability, but rather different abilities. Effective strategies to draw more women into the discipline should focus on increasing the emphasis on women-dominated aspects of computer science. This does not, however, imply a decrease in emphasis on male-dominated skills. Rather, because "the model of a successful CS student is viewed through a male prism," we need to shift that prism and strike a balance between the sexes to make computer science a friendly field in which all achieve (Marolis and Fisher 75).

Based on the results of my study, I suggest five changes to undergraduate curriculum.

1. Equal emphasis on men's and women's abilities in departmental and disciplinary promotional materials and workshops.
2. Admission policies and course requirements that emphasize underlying traits rather than programming experience.
3. Increased focus on communication skills at all levels of the curriculum.
4. Simulations of real-world teamwork – especially in introductory classes.
5. Advanced course offerings in computer science communication and team development strategies.

Many women initially encounter computer science through flyers, workshops, and other outreach material supplied by university computer science departments. Therefore, it is critical for these materials to emphasize the entire range of skills necessary for computer science achievement. I suggest developing a flyer that features the function of women-dominated traits in computer science. This flyer would target stereotypes of computer science as antisocial and reassure potential students that a great amount of programming experience is not a prerequisite for success in the field. Departmental recruiting workshops should also make use of the entire computer science skill set and teach students about topics in computer science they may look forward to in the future. This way, we would have a chance to dispel myths about computer science before the admission process even begins.

Admission policy reform is an important method of recruiting more women to computer science, especially in universities with departmentally-based admission procedures. It is critical, however, that these reforms do not just ease the admission standards for women. This will result in women (and men) questioning whether they deserve to even be in the department. Instead, we need a more holistic approach. Because "prior experience [does] not predict eventual success," admissions decisions should consider traits and skills important for success in computer science rather than an applicant's programming experience (Margolis and Fisher 130). Officials at Carnegie Mellon University have adopted this policy over the last decade. These changes in admissions policies look promising, but could be further improved by compiling a more extensive list of necessary traits and skills.

For universities without departmental admissions, introductory classes can implement the same strategies. Assignments and exercises could be developed that emphasize the skill set behind computer science success rather than actual coding. While these assignments

should be supplementary to programming practice, they would give all experience levels an equal chance to excel in computer science from the beginning.

As part of these supplemental exercises, communication skills – especially verbal – should be implemented into the computer science curriculum. I suggest required dialogue and presentations in small, non-threatening situations. Every student should be expected to participate. Informal essays or exercises in commenting pre-written programming code would help develop written communication skills.[3] An increased emphasis on communication in the computer science curriculum would not only attract more women to the discipline, but also challenge the stereotype that computer science majors are antisocial, and improve communication skills for all students, a necessary factor for success in many fields.

Teamwork is another real-world skill underemphasized in introductory computer science classes. While independent programming experience is a necessary part of any undergraduate curriculum, there are many more opportunities for collaboration. These cooperative projects, however, will do little good unless they are structured similarly to collaboration in academia and industry. I suggest projects in groups of five or six where each member takes on a different role in completing the project. For example, one member could write the client code while others write necessary classes and/or libraries to complete the project.[4] This type of assignment would allow for social interaction and team building, skills that generally attract women, and teach computer science students how computer development functions outside of academia.

This emphasis on communication and teamwork could be developed into an upper-level series for computer science majors. Courses could examine the role communication and teamwork play in computer science while building student's skills in these areas. To offer this option would remind women that the aspects of computer science in which they tend to excel are important and valuable for success in the discipline.

While both men and women are equally suited for success in computer science, each group brings a slightly different skill set to the discipline. Computer science needs the diverse prospectives of both groups. We can achieve a more balanced gender ratio by employing strategies suggested by the different skill sets. The increased participation of women would relax the unfavorable culture that currently surrounds computing and ease the stereotypes of what it is to be a computer scientist. A population of computer scientists that accurately reflects the user demographic will allow for better software development and integration, helping to bridge the gap between technology and everyday society. Perhaps one day women will be so prevalent in computer science, the novel joke told by the 2005-2006 Stanford Computer Science t-shirt will no longer be funny.

3 Commenting code refers to placing comments, or notes to human programmers, between lines of computer language code. Comments are critical to good programming style because they allow other programmers to determine, at a glance, what the code does.

4 Modern computer programs make use of libraries and classes to simplify the programming process. Libraries and classes are essentially collections of frequently used code encapsulated for simplicity and easy access.

Appendix 1

I emailed ten Stanford Computer Science faculty with the following request:

> *The first step in my research process is to compile a list of specific skills required for success in computer science. I want to try to break down the list into two (overlapping) lists – one for success at the undergraduate level (i.e. in a computer science education program) and the other for success after school.*
>
> *In order to compile these lists, I need your help. Would you please create a list of 5-15 specific traits (interests and/or experience could be included as well) that you consider essential to computer science at each level? I will then compile the lists to create specific skill sets and begin the next phase of my research.*

Four professors returned usable responses. Though the response rate was below 50%, the professors that responded were lecturers who routinely interact with undergraduates and are interested in Computer Science education. The professors who did not respond were generally researchers in the Computer Science department.

Appendix 2

Sources consulted to build essential computer science skill set. See Works Cited for complete citations.

Email to Author:
Johnson
Roberts
Sahami
Weiderhold

Print Sources

Klawe
Lee, Trauth, and Farwell
Prey and Treu
Taylor and Mounfield
United States Bureau of Labor Statistics

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