The Emerging Role of Self-Perception in Student Intentions

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ABSTRACT

Recruitment and retention of women has been a persistent problem in the field of computer science. With a growing number of jobs that require a computer science degree, this problem does not only affect computer science departments with low enrollment, but also impacts industry. There is still no universally accepted explanation for the underrepresentation of women in the computing field. Various solutions have been implemented in an attempt to resolve this problem and yet gender imbalance in fields related to computer science persists.

In this paper we study how perceptions held by students influence their intention to pursue computer science. Through a descriptive study, using a survey given out to first semester students in a computer science class, we measure perceptions, attitudes, self-efficacy, and identity, then we study the correlations between them and students' intentions to further pursue computer science. Our goal is to understand how determinative these constructs are to having students continue in the major.

Interestingly, self-perception, in terms of self-efficacy (does the student feel they are able to use computer science techniques to solve a problem) and identity (does the student see themselves as a computer scientist), emerged as the primary driver for differences in intention. Many other aspects turned out not to exhibit statistically significant gender differences. Understanding at a detailed level what factors influence students to pursue computer science is critical in devising effective interventions that may increase participation in computer science.

Categories and Subject Descriptors

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1. INTRODUCTION

A commonly-stated concern in the field of computer science (CS) education is the low percentage of women entering the computing field. Shortages in the workforce would be greatly reduced if more women majored in CS [2, 6, 13]. Increasing the percentage of women would also provide a more diverse workforce in computing fields, which is critical in order to meet the challenges of the information age, as technology benefits all members of society [3, 4]. For these reasons, among others, there has been a large effort over a decade to increase the enrollment of women in CS.

To devise a means of closing the gender gap, it is important to understand the underlying causes. Many potential causes have been studied. Among the contributing factors, the limited availability of CS courses before the undergraduate level is frequently mentioned [9]. This dearth of K-12 courses leads to large knowledge gaps among students enrolled in introductory CS courses at the undergraduate level, as only a select group of incoming students enters such courses with a solid background in the field. This knowledge gap is also claimed to differ between genders [9]. Ultimately, it can discourage women from entering a computing-based field.

Numerous new programs, recruitment techniques, and workshops have been implemented in hopes of addressing the potential causes of the gender gap in CS. However, the problem persists: few women choose to pursue a degree or a career in computer science.

In this paper, we consider the extent that various perceptions may contribute to the small percentages of women in the field. Rather than starting from a proposed intervention, we instead analyze the perceptions of students concerning CS. Through administering a survey to introductory students we can identify more precisely the discrepancies in perceptions of CS between genders.

2. RELATED WORK

Previous work that identifies perceptions as a cause of the gender gap typically focuses on a few different types of perception. Perceptions related to CS include students' beliefs as to what CS is, who computer scientists are, and if the student has the abilities that computer scientists possess.

Many students do not comprehend the breadth of the CS field. Unlike other scientific fields, students are not typically exposed to CS until they reach the undergraduate level [9]. Hence, a student may enter an introduction to programming class as an undergraduate with incorrect or incomplete notions about CS, computer scientists, or their own abilities to succeed in computing. Often, incoming student's believe that CS is mainly focused on programming and that the skills taught in these classes cannot be used to solve real world problems. For example, a study by Carter [7] examined why students who would statistically flourish in the CS field, instead continued in another. This study determined that a primary contributing factor is that these students do not have a complete understanding of what topics are covered in a computer science degree. In addition, a study undertaken at Georgia Institute of Technology showed that a belief that CS does not have many real-world applications is among the top reasons women end up leaving the field, whereas this idea does not seem to affect men's choice of major [5].

Another deterrent to students entering the field of CS is that they often associate the field with certain stereotypes [1]. Often individuals with an interest in computing are described as being male, and of either Caucasian or Asian descent. In fact, several of the individuals interviewed for the "Stuck in the Shallow End" book gave reasons for not attempting AP CS that included the notion that it was a class for white and Asian males [12]. Also students with limited knowledge of the CS field negatively described it as a very solitary, repetitive activity, discouraging them from enrolling in a class [7]. This narrow image of the CS field and of the individuals involved is often portrayed in the media, making it increasingly difficult to recruit individuals that lie outside this stereotype into the field.

It has also been shown that a student's intention to pursue computer science is correlated with self-efficacy in computer science. Miura found that men rank themselves higher in self-efficacy in comparison to women [14]. Additionally, this survey found that there was a positive relationship between an intention to take a CS class and self-efficacy in CS. In this study we expand the idea of intentions in CS to consider a wider variety of granularities. This includes if a student intends to learn more about CS on their own, as well as if a student plans to pursue a career in CS.

Finally, it has been shown that females are less likely to be confident that they have the skills needed to pursue CS [9]. It has been observed that girls at a young age are more motivated to work with computers than their male counterparts. However, as individuals age, the confidence gap between men and women reverses and then grows, even as all students have access to computers and CS classes.

Many of the above factors may contribute to the lack of women in CS. However, it is unlikely that the lack of women in CS can be attributed to one single cause. Most likely the gender gap is created by a combination of factors [8].

3. UNDERSTANDING PERCEPTIONS

To address the problem of low enrollment in CS through effective interventions, it is important that we understand the underlying causes for this low enrollment. We present a descriptive study in which we measure various aspects of each student's perceptions, then examine correlations between those and intention to further pursue CS. We focus on students, primarily freshmen, at the University of Arizona taking the introductory CS course. Our goal is to understand how determinative these other constructs are to having students continue in the major.

We devised six psychological constructs that we feel may play a role in a seventh construct: a student's intention to continue in CS. Those six contributing constructs are (a) perceptions of CS, (b) attitudes about science in general, (c) attitudes about CS specifically, (d) science self-efficacy, (e) CS self-efficacy, and (f) CS identity. We measured these constructs at the very beginning of the course, to ensure that experience in that course is not a factor.

The survey consists of 36 items, each a statement that we asked each student to rank on a seven-point Likert scale of Strongly Disagree, Disagree, Somewhat Disagree, Neither Agree nor Disagree, Somewhat Agree, Agree, and Strongly Agree. This scale allows us to decipher smaller amounts of change between groups than with a coarser scale system. Note, we also included questions that are reverse coded, that is, statements where a student's response should typically be opposite of the rest of the questions within the construct. This allows us to tell when a student is not reading the statements carefully. Where possible, we utilized existing, validated instruments, in some cases modified to apply to computer science, as we describe in the following.

Items were presented in one of three orders to students, with about a half dozen items per page, to reduce the effect of interactions between statements.

Additionally, the survey collects some basic demographic information. This including the student's major, prior classes that the student took, and, most relevant to this analysis, gender.

The entire survey was presented to each student in an electronic form that could be completed at a location and time of the student's choosing. The entire survey took about five minutes.

We studied the following perceptions, each of which may influence a student's decision to continue on in the field of computer science.

- Perception of CS (methodologies it includes),
- Attitude towards science in general (feelings about science),
- Attitude towards CS,
- Self-efficacy in doing science (do they have skill in doing science),
- Self-efficacy in doing CS, and
- Self-concept of the individual (do they see themselves as a computer scientist).

We now examine each of these subjects, addressed by the survey, in turn, briefly summarizing the statements that appear for each topic. The survey attempts to be thorough while presenting a small number of questions. The full survey is available at `www.cs.arizona.edu/projects/focal/ergalics/fieldguide/survey2013.pdf`

3.1 Perception of Computer Science

Often perceptions of the CS field are limited to just programming; however, the field of CS contains many more aspects beyond this narrow view. The survey attempts to investigate if students believe CS is solely based on programming and to what extent their perceptions a limited to only certain areas of the field. To do this, the survey uses a series of statements where each statement described a particular aspect CS.

The statements which appear in the survey were adapted from an AWE (Assessing Women and Men in Engineering) assessment. AWE provides these assessment tools for use in educational settings[1]. We altered some of the statements about scientists (e.g., work on things that help the world, analyze experimental data, gather and analyze data to answer questions) and applied them to computer scientists as well (seven items in all).

The survey asks each student how much they agree or disagree that computer scientists partake in the presented activities. For example, one of the statements used reads "Computer scientists analyze experimental data". Stereotypes of computer scientist do not support this statement because it implies that CS is more than just programming, but many computer scientists do gather or analyze data similar to other related fields.

3.2 Attitudes About Science and CS

Attitudes (i.e., how the student feels about science or about CS, such as do they like it, do they think it's important) may also factor into whether a student plans to pursue CS. Formally, attitudes are defined as "evaluations of objects, of events, or of ideas" [10]. The survey considers attitude in terms of attitudes towards science and more specifically, attitudes towards CS. We measured science attitude with a set of statements which assess whether a student's attitude towards science is generally positive or negative. Statements in this section include the following themes: does a student believes science is important, does the student enjoys science, and does a student enjoys taking science-based classes. We considered attitudes towards CS in a similar manner: we simply substituted the term "computer science" for any instance of "science" in each statement. From the previous research discussed above we expect that attitudes towards CS differ between men and women. With such statements we can discern if a student has a negative or positive attitude toward science and toward CS. Our survey contains three statements pertaining to science and six pertaining to CS.

It is important to note that CS is the only science that we consider separately. In general any one particular science may influence a students responses to questions about general science. For example, girls take biology at the same rate as boys and go on to become physicians at similar rates as boys [15], though that is not the case for physics and physicists. One of the goals of this survey is to be able to observe the differences between a student's perceptions of computer science and general science in a reasonable number of questions. To account for the fact that a student may have varying attitudes towards biology compared to physics, our survey could be expanded to include multiple versions of these questions to include many specific branches of science. That would have significantly increased the length of the survey and increase the likelihood that students would skim through the survey and not read through the questions carefully.

[1]This assessment was developed by researchers at the Pennsylvania State University and University of Missouri, `http://www.engr.psu.edu/awe/misc/about.aspx`, retrieved September 5, 2014.

3.3 Self-Efficacy, in Science and CS

Self-efficacy is "a person's belief that he of she is capable of the specific behavior required to produce a desired outcome in a given situation" [11]. As before, the survey measures both science self-efficacy (e.g., does the student feel he or she is able to use the scientific method) and CS self-efficacy (e.g., does the student feel that he or she is able to use CS terms to share their results).

The statements that are used to measure self-efficacy in science include the beliefs that each student can effectively communicate a scientific procedure to others, can use models to explain my results, and could become scientists. To generate statements that measure self-efficacy in CS, similar statements were used except any reference to science was replaced with one to CS and the phrasing was adjusted to encourage the student to read each statement carefully. These statements are designed to measure self-efficacy for a student in general science classes and CS classes outside of the typical misconception that CS is only programming.

The statements used to measure both CS and science self-efficacy were based on a Science Process Skills Inventory[2], which was intended to measure skills needed to process information, rather than content knowledge of science. Mary Arnold, one of the authors of that inventory, gave us permission to adapt the statements and the response scale to fit our needs. We chose a subset of the statements from the initial inventory, to maintain a reasonable total length; for self-efficacy pertaining to computer science we replaced "science" with "computer science". We ended up with six questions pertaining to self-efficacy in science and seven concerning self-efficacy in CS.

3.4 Self-Concept

Finally, we consider CS identity, specifically self-concept: does a student see themselves as a computer scientist. Self-concept is defined to be "the sum total of an individual's beliefs about his or her own personal attributes" [11]. To measure a student's self-concept as a computer scientist, the survey includes three items. These statements are designed to measure the importance of CS as part of who they are: "majoring in CS is important to me." Other statements consider different granularities of this concept, such as, being a computer scientist and being able to use CS to solve problems.

The initial questions, "Do you think you could become a scientist?" and "Do you think you could become a computer scientist?" were originally from a survey measuring attitudes towards STEM [16]. The original questions also asked students to explain their answers. Rather than requiring this explanation, we applied the seven-point scale to the items. The explanations may prove useful in future studies, but for our purposes we just wanted to be able to gauge if a student could identify with being a computer scientist or scientist.

3.5 Intention to Continue in CS

A central objective of the survey is to is gauge a student's intention to continue on in the CS field. This intention is considered at the following granularities: enroll in another course, major in CS, pursue a CS career, and plan to learn

[2]My Science Skills (©2010 Oregon State University, Bourdeau, V.D. & Arnold, M.E. (2010) *The Science Process Skills Inventory. Corvalils, OR: 4-H Youth Development Education, Oregon State University.*

more about CS on their own (four items). Our hypothesis is that such CS intentions may be affected by the above listed perceptions, that is, by what a subject understands or feels.

4. SUBJECT POOL

As outlined above, our approach is a descriptive study, in that we measure perceptions, attitudes, self-efficacy, and identity, then look at correlations between those and intentions to further pursue computer science, to understand how determinative these other constructs are retention rates in computer science.

We gave this survey electronically to students in CS 127A for the Fall 2013 and Spring 2014 semesters after receiving permission from the University of Arizona's Institutional Review Board. After following standard practice to obtain consent, a total of 219 students agreed for their answers to be included in this study, though not all answered every question. Approximately one-quarter of the students were female. Note, this class is an introductory class in the CS major, but it also required for several related fields including, but not limited to, mathematics and engineering. Using this type of subject pool could alter our findings as participants have already decided to take a college level course in computer science. The results are still pertinent as problems concerning retention rates in the field of computer science is just as important as issue with recruitment.

5. ANALYSIS OF SURVEY RESULTS

The goal of this investigation is to gauge (a) whether our specific measures of each of the constructs (described in sections 3.5–3.4) sufficiently hold together (in a statistical sense) to indicate that the construct itself is captured, (b) whether there is a significant difference between genders, and (c) to what extent do the other constructs correlate with CS intentions. We now examine each question in turn.

5.1 Construct Reliability

As discussed above, for each construct we used several items, with the goal that these items "hang together" well, measure the same concept, that is, exhibit construct reliability. A conventional indication of this is Cronbach's Alpha (α), where a value of 0.7–0.8 is considered good.

We consider a construct's answers to be reliable if a student's answers in a single category all fall in the same general area of the seven-point scale, with the exception of questions that are reverse coded, which should have answers on the opposite end of this scale.

Most of the constructs held together quite well: perceptions of CS ($\alpha = 0.837$), science attitudes ($\alpha = 0.779$), CS attitudes ($\alpha = 0.822$), science self-efficacy ($\alpha = 0.855$), CS self-efficacy ($\alpha = 0.837$), and CS identity ($\alpha = 0.814$).

The one construct that did not hold together as well was computer science intentions, with $\alpha = 0.664$. This implies that the individual items are not all testing the same concept, that there are multiple, perhaps overlapping, concepts being tested.

5.2 Gender Differences

We were surprised that for most of the constructs, there were no statistically significant differences (using the t-test) between men and women. In particular, there were no gender differences concerning (a) perceptions of computer science, (b) attitudes of science, (c) attitudes of computer science, or (d) science self-efficacy.

These results have broad implications. As discussed above in Section 2, some of the past research has predicated informally that women perceive CS differently, or that women do not feel that they are good in science. Our results imply that for those we surveyed, those are not significant gender-specific attitudes or perceptions.

There were statistically significant ($p < 0.01$) gender differences in just three constructs: CS self-efficacy (mean $M_f = 4.44$; $M_m = 5.09$) and CS identity ($M_f = 4.44$; $M_m = 5.05$), as well as CS intention ($M_f = 5.00$; $M_m = 5.44$). Note that in all three, females rated themselves lower than males.

These results lead to the initial conclusion that even though CS has "science" in its name and is considered a STEM discipline, computer science seems to be viewed differently than other sciences. It seems that the difference can be attributed broadly to (a) whether the student perceives that he or she can excel in CS (self-efficacy) and (b) whether the student see themselves as a computer scientist (identity). Women to a lesser extent see themselves are being able to *do* computer science and as *being* computer scientists. We again emphasize that here was no difference between men and women on *science* self-efficacy.

Concerning CS intentions, there were significant gender differences on two of the items: "I would like to take another computer science class" ($M_f = 5.16; M_m = 5.63$) and "I plan to major in computer science" ($M_f = 3.82; M_m = 4.68$). For the other two questions ("I would consider a career in computer science" and "I would like to know more about computer science") there were no statistically significant differences. It seems that the distinction in these questions is that women are different than men on *inwardly-oriented* questions but not on the *outwardly-oriented* questions. This also relates to the fact that this construct does not hold together. Interestingly, Cronbach's alpha is higher ($\alpha = .701$) for men if the item "I wouldn't consider a career in computer science" is removed, meaning the construct reliability improves when this item is removed. For women, Cronbach's alpha improves ($\alpha = .731$), if the statement "I would like to know more about computer science," is removed, meaning the other three have a higher construct reliability.

We conclude that it is *not* what women think about CS, but rather how they think about *themselves* within this discipline. The critical challenge is with *identity* and only within CS, not with science in general, which is perhaps why other some sciences are not experiencing problems with participation of women.

5.3 Correlations with Intention

A separate question is, which constructs correlate with CS intentions? We should generally be concerned only with those that do so correlate.

We found that neither science attitudes nor science self-efficacy correlate with CS intentions. This result emphasizes that students do not see computer science as a science.

CS intentions correlate at statistically significant levels with CS perceptions (Pearson's $r = 0.243$), CS self-efficacy (0.256), CS attitudes (0.407), and CS identity (0.646). Unfortunately, in terms of the overarching problem being considered, the strongest correlation, CS identity, exhibits the most gender imbalance. CS self-efficacy seems to also be a factor, but a lesser one.

Table 1: **Survey results for men in computer science; 1 is strongly disagree and 7 is strongly agree.**

Construct	Number of Participants	Mean	Standard Deviation
Intentions in CS	158	**5.4351**	1.01234
Perceptions of CS	150	5.5124	.81960
Attitudes towards CS	153	5.8420	.69716
Attitudes towards Science	148	5.7523	.91359
Self-efficacy in CS	148	**5.2181**	.86399
Self-efficacy in Science	146	5.5297	.80817
Self-Concept as Computer Scientist	149	**5.0582**	1.18849

Table 2: **Survey results for women in computer science; 1 is strongly disagree and 7 is strongly agree.**

Construct	Number of Participants	Mean	Standard Deviation
Intentions in CS	61	**4.9918**	1.09541
Perceptions of CS	55	5.6909	.62437
Attitudes towards CS	57	5.7105	.81742
Attitudes towards Science	57	5.5205	1.20023
Self-efficacy in CS	55	**4.6104**	1.19094
Self-efficacy in Science	55	5.3455	.89515
Self-Concept as Computer Scientist	58	**4.4425**	1.20023

(We emphasize that correlation is not causality. We hypothesize that it is the gender differences in CS identity and self-efficacy that are causing the differences observed in CS intensions, but cannot rule out that the causality doesn't go the other way.)

5.4 Summary of Analysis

The final results from the survey are listed in Tables 1 and 2 for men and women, respectively. For most of the constructs listed in these tables there are no statistically significant differences between genders. However, significant gender differences (shown in **bold**) can be observed for both self-efficacy in CS and self-concept as a computer scientist. Additionally, significant differences between men and women were observed concerning intentions to pursue computer science.

6. CONCLUSIONS

Females report having lower computer science self-efficacy and computer science identity. Note, females and males did not differ in science self-efficacy, indicating that this is specific to computer science. In addition, another interesting finding is that women and men did not significantly differ in attitudes of either CS nor science nor perceptions of CS. Lastly, the strongest correlation occurs between intentions to pursue CS and identity as a computer scientist. Identity also happens to be the construct that has the greatest discrepancy between men and women. These results suggest that computer science self-efficacy and computer science identity might play a role in the underrepresentation of women in computer science careers.

From these findings we can conclude that solutions to close the gender gap in CS might be more effective if they also focus on changing women's perceptions of themselves in the computer science field.

7. FUTURE WORK

Our study leaves two distinct areas for future work in terms of determining the role of perceptions on students' intentions to pursue CS. First altering the subject pool for this survey or distributing the survey to the same subject pool multiple times may provide us with more generalizable information. Secondly, the constructs that were created for this survey could be polished to increase construct reliability and to better capture the most important aspects.

7.1 Broadening the Subject Pool

The finding described about leave several opportunities for future work. Among these is to determine if student's perceptions alter after completing an introductory course in CS. Many introductory courses focus on teaching basic programming constructs and could even support common misconceptions about the computer science field. In the introductory course at the University of Arizona, we will be attempting to expose students to a different method of framing CS lessons in a similar manner to other science classes, in addition to the material that emphasizes programming. This approach might allow students to perceive CS as being more closely related to other science courses. The survey data presented in this paper suggests that being able to convince women that CS is a science could positively influence their intentions to pursue computer science. Ultimately, we could observe this change through a survey given at different times throughout the offering of the introductory course.

Additionally, this survey could be applied to students taking a more general CS course that is not part of the major. This would open up our survey to individuals that had not initially intended to pursue a computer science degree. In the Spring of 2015 the University of Arizona is offering another CS course (CSc 170) as a general elective that will focus more on the theories behind CS, rather than just on basic programming concepts. Students in this type of class will typically be interested in learning more about CS but who do not necessarily intend to pursue a degree or career in the field.

Another area of future research could involve tracking how a student's perceptions change as they continue on while pursuing an undergraduate degree in CS. Administering our survey multiple times throughout the career of undergraduate students could give us an opportunity to observe how changes in perceptions can factor in to the retention rates in CS departments.

Lastly, we have made our survey available with the hope of collecting data from other universities in a wider variety of fields and potentially from students at the high school level.

7.2 Changes to the Survey

Our survey could be refined based on the results reported here to better capture differences in perceptions between genders. To begin with, it would be helpful to separate intentions in CS into two separate constructs, one considering intention to pursue a career or other long term goals in the field and the other to gauge intention to pursue CS as an interest or as a tool to support a career in a related field. We believe that this approach may produce two constructs with better construct reliability than our original construct for CS intentions.

Also our survey treats all other sciences in a single general category. In order to get a more accurate comparison between CS and other sciences, the survey could be altered to specify a specific science, such as biology or physics, rather than using general science questions.

Additionally, we did not observe any effects of the common perception that CS mainly involves coding. To better determine if the perception of CS as programming impacts intentions toward CS, it would be useful to create another construct for perception of the CS field that focuses on computer programming. We feel that this is important to study due to the sheer amount of prior research that speculates that this perception is a part of the reason why enrollment in CS courses is low. This new construct would measure student beliefs about the amount of coding ability and creativity needed to be a computer scientist. This construct may also bear light on why some women do not see themselves as computer scientist, while having high self-efficacy in science.

7.3 Potential Interventions

The data from this survey implies that interventions should not focus primarily on perceptions or attitudes of CS. Rather, the problem appears to lie primarily in self-perception and only with reference to CS, not with reference generally to science, and within that, how women think about themselves (inwardly-facing) within their discipline.

Interventions that change self-perception vis-a-vis CS, specifically identity, may be effective. However, the simple fact that there are few women in CS is a daunting situation.

Another potential approach would be to do a better job in framing CS as a science. As noted above, there are not significant gender differences in attitudes or self-efficacy concerning science. If women see CS as more similar to other sciences rather than just programming (CS perceptions), their CS self-efficacy may improve, so as to eliminate this gender difference. This may then contribute to resolving the gender differences in CS identity. Our data also provides support for efforts that moderate the effects of certain stereotypes that may be a cause of gender differences in science self-efficacy.

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8. REFERENCES

[1] M. Adya and K. Kaiser. Early determinants of women in the IT workforce: a model of girls' career choices. *Information Technology & People*, 18(3):230–259, 2005.

[2] D. E. Agosto, S. Gasson, and M. Atwood. Changing Mental Models of the IT Professions : A Theoretical Framework. *Journal of Information Technology Education*, 7:205–221, 2008.

[3] A. M. Balcita, D. L. Carver, and M. L. Soffa. Shortchanging the future of information technology: the untapped resource. *ACM SIGCSE Bulletin*, 34(2):32–35, 2002.

[4] S. Beyer, K. Rynes, and S. Haller. Deterrents to Women taking computer science courses. *Technology and Society Magazine, IEEE*, 23(1):21–28, 2004.

[5] M. Biggers, A. Brauer, and T. Yilmaz. Student perceptions of computer science: a retention study comparing graduating seniors with CS leavers. *ACM SIGCSE Bulletin*, 40(1):402–406, 2008.

[6] T. Camp. The incredible shrinking pipeline. *Communications of the ACM*, 34(2):129, June 1997.

[7] L. Carter. Why students with an apparent aptitude for computer science don't choose to major in computer science. *ACM SIGCSE Bulletin*, 38(1):27–31, 2006.

[8] S. J. Ceci, D. K. Ginther, S. Kahn, and W. M. Williams. Women in academic science: A changing landscape. *Psychological Science in the Public Interest*, 15(3):75–141, 2014.

[9] J. Cohoon, McGrath, and W. Aspray. *Women and Information Technology: Research on Underrepresentation*, volume 1. The MIT Press, 2006.

[10] M. Gazzaniga, T. Heatherton, and D. Halpern. *Psychological Science*. W. W. Norton & Company, New York, 3 edition, 2010.

[11] S. Kassin, S. Fein, and H. Markus. *Social Psychology*. Wadsworth Cengage Learning, Mason, OH, 8 edition, 2008.

[12] J. Margolis. *Stuck in the shallow end: Education, race, and computing*. MIT Press, 2008.

[13] C. McCullough. Attracting under-represented groups to engineering and computer science. *Population*, 20:1–11, 2002.

[14] I. T. Miura. The relationship of computer self-efficacy expectations to computer interest and course enrollment in college. *Sex Roles*, 16(5-6):303–311, 1987.

[15] R. T. Snodgrass. Broadening cs enrollments: An interview with Jan Cuny. *Ubiquity*, 2013(February):1:1–1:8, Feb. 2013.

[16] S. H. Wingenbach, G. J. Degenhart, K. E. Lindner, J. R. Dooley, D. L. Mowen, and L. Johnson. Middle school students' attitudes toward pursuing careers in science, technology, engineering, and math. *NACTA Journal*, 51(1):52–59, 2007.