Summaries of Selected Research of SSAB Members and Visitors to 2012 NCWIT Summit

May 24-25, Chicago, IL

Members of the Social Science Advisory Board (SSAB) support the National Center for Women & Information Technology (NCWIT) through their research and knowledge about women and information technology. The depth and breadth of perspectives and approaches that SSAB members and visitors bring to the study of women and computing are illustrated in examples of their recent research projects. In the research summaries that follow, we see expertise across social science fields, and theoretical and empirical issues and findings with implications for diversity and the full participation of women in information technology.

For more information about the NCWIT SSAB, see www.ncwit.org/ssab.

Mary Frank Fox
Angela Ginorio
SSAB Co-chairs, 2012/2013

Contents

*May 2012 Visitor

Becoming an IT Worker: A Study of Access to Good Jobs in the Knowledge-based Economy

Sharla Alegria*, University of Massachusetts-Amherst

Topic/research question

What are the consequences of the shift, led by national-level policy, toward a "knowledge-based economy," where American workers ideally produce ideas and innovation rather than tangible goods? Who can be part of the labor force that drives the economy? What is the demographic make-up of this new labor force, and how do these workers become part of it? My study will focus on IT workers to understand who gets these "good jobs" and how they get them.

Overview of research methods

My study will use quantitative data from the Census and National Longitudinal Survey of Youth 1997 to investigate the demographic characteristics of IT workers. I will compare the characteristics of IT workers with the characteristics of manufacturing workers in the 1970s in order to analyze differences between who held the jobs that were key to the industrial economy compared to the knowledge-based economy. Additionally, I will conduct semi-structured interviews with 60-80 IT workers to learn how these workers gained the skill and desire and ultimately jobs in the IT field.

Intended use

This project will comprise my doctoral dissertation in sociology.

COMPUGIRLS Intersectionality Study
Catherine Ashcraft, NCWIT, University of Colorado-Boulder

Topic/research question

We are beginning a three-year research study, in collaboration with Arizona State University and CompuGirls, to examine how girls' intersecting identities (e.g., race, class, gender, sexuality) shape their perceptions of themselves as technologists and their plans to pursue technology education and careers.

Overview of research methods

This is a mixed-method study, combining quantitative and qualitative methods. A stratified sample of 100 adolescent (ages 13-18) girls of color (e.g. African American, Latina, Native American), from high-needs districts will be randomly assigned in one of two conditions (C#1: technology program with cultural relevancy and gendered-identities emphasized; and C#2: technology program without a focus on cultural relevancy or gendered identities). Pre-, mid-, and post-treatment instruments will be administered to girls in both groups. We will also employ qualitative methods including participant observation, interviews, and artifact analysis.

Preliminary findings

Preliminary findings expected in Fall 2013

Intended use

We intend a combination of practical and academic uses and audiences. We will be publishing a report on the NCWIT website and developing practical resources that our members and others can use to implement recommendations coming from these studies. We also plan to submit to academic journals and present at conferences.

Male Influencer Study
Catherine Ashcraft and Wendy DuBow, NCWIT, University of Colorado-Boulder

Topic/research question

This study examines men's experiences with diversity and diversity reform efforts in the technical workplace. We are particularly interested in what motivates or hinders their participation, what they think works and does not work, how they talk about diversity, how they advocate for diversity, and in what ways they feel uncomfortable advocating for diversity.

Overview of research methods

47 semi-structured, in-depth interviews were conducted with corporate men, in-person and by telephone. Interviewees were identified by their NCWIT member representative colleagues as potential interviewees. About half of the interviews were conducted by a male researcher, and about half by one or more female researchers. Interviews lasted approximately 60 minutes and were transcribed.

Preliminary findings

Preliminary findings include some key activities men can do to be more of an advocate for technical women in their organizations, including the following:

- Listen to women's stories
- Talk to other men
- Increase the number and visibility of female leaders
- Correct biases and micro-inequities
- Make discussions of gender less "risky"

Some experiences that led men to be explicit advocates in the workplace include:

- Experience of being a minority of some sort
- Actively sharing in family responsibilities
- Having had a female boss
- Close friendships with female colleagues
- Having a wife in technology
- Having a daughter

Report expected in Fall 2012.

Intended use

Preliminary findings have already been published as an NCWIT "Top 10" resource, intended for use by NCWIT members (and other stakeholders) to help men become advocates: *Top Ten Ways to be a Male Advocate for Technical Women* (www.ncwit.org/resources). Findings and insights from interviewees will be shared at Grace Hopper 2012 in panel format. Complete findings will be written into a white paper shared with NCWIT members, as well as other practical resources to encourage communication and advocacy. The PIs also plan to submit articles from this research to various journals.

Faculty Adoption of Practices to Improve Gender Imbalance in Computing

Lecia Barker, University of Texas at Austin, NCWIT

Topic/research question

Despite widespread dissemination of research-based practices that improve the gender imbalance in computing, typical faculty teaching practices make computing less inviting to women than to men. Most computing faculty members are aware of women's severe under-representation in computing and some act to change the situation. Isolated individual faculty members sponsor courses or integrate teaching methods that make a difference. Most of their colleagues, however, do not adopt practices that lead to gender equity. This study seeks to understand how the nature of teaching practices and individual, local/departmental, and external social influences affect undergraduate computing faculty members' adoption of teaching practices shown by research to increase women's retention in undergraduate computing.

Overview of research methods

The project builds on research and theory into faculty adoption of new pedagogies and curriculum as well as diffusion of innovation. The study triangulates data collection and analysis methods: it begins qualitatively, interviewing and observing 60 computing faculty members at 30 institutions selected for their high or low adoption of effective practices. The interview and observation data will be interpreted and categorized, and then used to develop a model of faculty adoption of teaching practices. This model will be tested via a national survey to determine which factors predict adoption and non-adoption and which variables have the greatest predictive power.

Intended use

Journal articles; presentation at computing education conferences; development of NCWIT practice sheets and talking points/top ten cards; and possibly, faculty adoption in a box.

The Performance vs. Persistence Paradox: Myths about Women in IT

Enobong Hannah Branch, University of Massachusetts-Amherst

Topic/research question

To better understand women who enter IT majors but ultimately leave. When do they leave? After one course or more? And why? Is it "natural selection?" Does poor performance lead to leaving IT? Finally, is there a difference in the pattern observed between 2- and 4-year institutions?

Overview of research methods

The data for this study was collected by SageFox Consulting as a part of the evaluation for Commonwealth Alliance for Information Technology (CAITE-NSF BPC-AE). Variables measured include enrollment status, demographics, test scores, transfer information, course performance, and other academic outcomes (degrees, GPA, etc.) for all students enrolled in IT majors (common undergraduate majors in computing as well as transfer programs to these majors and professional education programs) or taking at least one IT course from six schools (mix of both 4- and 2-year institutions) participating in CAITE. In addition, we collected supplementary institution-specific course data to identify math pre-requisites and other course details. We have only conducted descriptive quantitative analysis thus far but plan to use multivariate methods and incorporate a qualitative component in the future.

Preliminary findings

Women are less likely to enter IT than men. Once women enter they are more likely to stay, but this is only true at 4-year schools. At 2-year schools, both men and women persist at extremely high rates. Math is sometimes thought to be a barrier for women, but we find no significant gender differences in GPA in IT courses requiring math among students who enter IT majors. However, this is only relevant for 4-year schools, because few of the courses at 2-year schools required basic math and none required advanced math. Most women at both 2- and 4-year schools who leave IT majors do so after making considerable investments toward an IT degree. Finally, compared to women who persist in IT, women who leave have comparable or slightly higher grades in their IT classes.

Intended use

Branch, E.H. & Alegria, S. (2012, March 21). *The performance vs. persistence paradox: Myths about women in information technology*. Presented at National Science Foundation Reverse Site Visit for BPC-AE: Commonwealth Alliance for Information Technology Education (CAITE). [Journal articles in preparation]

Application*:* We may need to change our moment of intervention. It is not enough to get girls

interested in IT and enrolled in class at the collegiate level. Particularly at 4-year institutions retention of high-performing women is a critical concern.

Changing the Image of Computing to Increase Female Participation

Sapna Cheryan, University of Washington

Topic/research question

In this research, I propose that current stereotypes of computer scientists interfere with women's ability to see themselves in the field. Accordingly, the proposed research tests the efficacy of transforming social environments to encourage diversity of membership. Several controlled behavioral studies focus on how stereotypes of the field may discourage participation. The proposed work brings together three disparate research areas – the media, environments, and peers – into one theoretical model. Rather than testing a single explanatory path to explain the link between stereotypes and career aspirations, the proposed research examines several mediating processes (e.g., stereotype threat, social fit) to find the strongest one while also allowing for the possibility of multiple mediators. This work is funded by an NSF CAREER award.

Overview of research methods

Several behavioral experiments were conducted at Stanford, the University of Washington, and the University of Georgia to elucidate the relationship between stereotypes of computer science and women's interest in entering the field.

Preliminary findings

We found that women, but not men, were less interested in working in companies and taking classes that contained objects stereotypically associated with computer science (e.g., Star Trek poster, video games) compared to identical companies and classes that had non-stereotypical objects (e.g., nature poster, general interest books). The stereotypical cues evoked a masculinity that made women feel that they did not fit with the people in these environments. These results held even when the proportion of women in the environment was equal across the two types of companies.

Intended use

Cheryan, S., Plaut, V.C., Davies, P., & Steele, C.M. (2009). Ambient belonging: How stereotypical environments impact gender participation in computer science. *Journal of Personality and Social Psychology, 97,* 1045-1060.

Cheryan, S. & Plaut, V.C. (2010). Explaining underrepresentation: A theory of precluded interest. *Sex Roles, 63*(7-8), 475-488.

Thriving Despite Negative Stereotypes: How Ingroup Experts and Peers Act As "Social Vaccines" to Protect the Self

Nilanjana (Buju) Dasgupta*, University of Massachusetts-Amherst

Topic/Research Question

Individuals' choice to pursue one academic or professional path over another may *feel* like a free choice but is often constrained by subtle cues in achievement environments that signal who naturally belongs there and who does not. People gravitate toward achievement domains that feel like a comfortable fit because they are in sync with ingroup stereotypes and away from other domains that feel like an uncomfortable fit because they deviate too far from ingroup stereotypes. Even individuals who are high performers may lack confidence in their ability and withdraw from certain achievement domains—performance and self-efficacy do not always go hand-in-hand. What factors might release these constraints and enhance individuals' freedom to pursue academic and professional paths despite stereotypes to the contrary? I address this research question using a new theoretical lens—the Stereotype Inoculation Model—that reveals how ingroup members (experts and peers in high achievement settings) function as "social vaccines" who increase social belonging and inoculate fellow group members' self-concept against stereotypes. The model integrates insights from several literatures in social psychology and organizational behavior to articulate predictions accompanied by supporting evidence about when ingroup experts and peers serve as social vaccines and the underlying psychological mechanisms.

Overview of research methods

I use a combination of longitudinal field studies conducted in real STEM classes together with controlled cross-sectional laboratory experiments. Each has its advantages and disadvantages. But when the findings from the two types of research methods converge, and they do in this case, the combination is powerful. Moreover, some of my studies use adult college student samples while others use adolescent samples so that I can determine when in the developmental process ingroup experts and peers serve best as social vaccines.

Findings

So far we've conducted six longitudinal and cross-sectional studies of which three are published (Stout, Dasgupta, Hunsinger, & McManus, 2011), two are being written up now, and one is in progress. In these studies we test women and girls' self-concept in academic and professional fields where they are small numeric minorities and negatively stereotyped (e.g., science, engineering, and professional leadership). The data show that contact with same-sex experts enhances girls' and women's positive attitudes toward these fields, their identification with these fields, self-confidence, and motivation to pursue related careers. Contact with same-sex peers produces similar benefits. Female students who are typically small numeric minorities in science and engineering did best when assigned to work groups that had female majorities

rather than groups with female minorities or gender parity. Together, these studies show that same-sex experts and peers act as social vaccines that enhance the recruitment and retention of underrepresented groups in high stakes, high achievement environments.

Intended use

The intended use is three-fold: (1) my goal is to develop new theoretical model about when and how individuals' self-concept can be protected against pernicious stereotypes, test hypotheses derived from this model, and integrate this work with prior research on similar issues; (2) an equally important goal is to disseminate these findings to teachers, administrators, practitioners, and educational policy people; and (3) to translate the findings into concrete interventions that can be tested in the real world.

References

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The Stereotype Inoculation Model. *Psychological Inquiry, 22,* 231-246.

Dasgupta, N., & Stout, J. G. (in press). Contemporary discrimination in the lab and real world: Benefits and obstacles of full-cycle social psychology. *Journal of Social Issues.*

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology, 100*, 255-270.

Aspirations Program Research
Wendy DuBow, NCWIT, University of Colorado-Boulder

Topic

What are the circumstances and experiences that encourage and inhibit girls' pursuit of computing in high school? How, if at all, does their involvement in the Aspirations Program influence their future college and career choices?

Overview of research methods

- Census-style survey of Aspirations Award winners and runners-up. If possible, a control group will be surveyed as well.
- In-depth interviews will also be conducted with program winners and runners-up, as well as with non-winners, if possible.
- Data mining of application and profile data of all Aspirations applicants. Comparisons with other data sources, as possible.

Preliminary findings

- Aspirations Award winners and runners-up are still pursuing 10 of 19 rigorous computing activities after winning the award.
- Among winners/runners-up who are in college…
    - 93% majoring in STEM
    - 88% majoring/minoring in male-dominated STEM field
    - 64% majoring in computing
- Winners and runners-up report increased confidence & increased interest in computing.
- Winners and runners-up report less anxiety about being in computing.

Intended use

Results from this research will influence the implementation of the NCWIT Aspirations Award program. It will also be shared as a white paper via NCWIT, as well as subsets of findings will be shared in journals and magazines that K12 teachers, administrators, and college computing faculty are likely to read and conference/workshop venues they are likely to attend. Results will also be submitted to peer-reviewed journals.

Female Recruits Explore Engineering (FREE Project) and FREE Pathways

Margaret Eisenhart, University of Colorado-Boulder
(Eisenhart's co-PIs: Monica Bruning, Iowa State; Jill Bystydzienski, Ohio State)

Topic/research question

In Fall 2006, our NSF research team identified 132 10th grade girls with strong academic records in mathematics and science at seven high schools in three states (Colorado, Iowa, and Ohio) and invited them to participate in an after-school program to explore career possibilities in engineering. These girls became part of the FREE project ("Female Recruits Explore Engineering"). The girls included Latinas, African-Americans, and Native Americans, with some Asians and Whites; many of the girls lived in families that qualify for free or reduced lunch at school; although they were all strong students in science and math, few had considered engineering as a college or career choice. From early 2007 through August 2008, we met monthly with these girls to explore engineering, meet practicing engineers, visit engineering workplaces, discuss the pros and cons of engineering, and conduct hands-on engineering--all in an effort to increase the girls' knowledge of and interest in engineering. In the years since (2008 to 2012), we have followed the girls on Facebook and in person ("FREE Pathways"). We now have data to analyze their educational and career pathways through high school and into college or work.

We are addressing the following research questions: What is important for high school girls to know about engineering and how do they find out about it? How does the prospect of a career in engineering fit into the social contexts of the girls' lives? How do the girls' racial, socio-economic, and rural/urban locations influence their perspectives on engineering? And, how and why do young women's interests in engineering change over time?

Overview of research methods

We used multiple methods of data collection: participant observation to record what happened during the monthly meetings; interview questions posted on the website about the girls' developing ideas of engineering; surveys about the girls' previous experiences with engineering and technologies, school performance, future plans, and social networks. In 2007-08, we captured girls' website postings and electronic messages from Blackberries that we distributed to the girls as an incentive for their participation. In 2008-09 we conducted intensive case studies (based on face-to-face interviews) of 24 girls. From 2009-2012, we have captured group and personal Facebook postings and interviewed each girl twice per year.

Preliminary findings

We found that it was not hard to get the girls interested in engineering. A year and a half after the start of FREE, 30% of the original group was considering majoring in engineering in college. This percentage held steady through most of the girls' senior year (i.e., almost 3 years after FREE began). Apparently, high school was not too late to spark both minority and majority girls'

interest in engineering. Hesitant at first, those who stayed in FREE found time, energy, and money to visit college engineering programs, get to know engineering professionals, identify engineering projects of interest to them, and complete their own small-scale engineering projects.

But by the time the girls actually entered college (Fall 2009), only 22% of those who continued in FREE (11% of the original group) chose an engineering major; 35% chose another STEM major[1],[2]; and 33% chose a non-STEM major.[3] What turned out to be a barrier for many of the girls was not the prospect of doing engineering itself but the challenges of *getting into* a college with an engineering program and actually (physically) *getting to* a college with an engineering program. The challenges seemed to come, in large part, from a lack of economic, social, and cultural capital (access to economic, social, and cultural resources) to make the transition from high school to college engineering. The Colorado group, with the least access to capital, had the most trouble (only 4% of the original group actually chose an engineering major); the Iowa group, with somewhat more access to capital, did better (13%); and the Ohio group, with the most access to capital, did best (30%).

Analysis of the post-high school graduation data is continuing.

Intended use

For the most up-to-date information, see our website: http://xploreengineering.org.

[1] For our purposes STEM includes: biological sciences (including medical), physical sciences including physics, chemistry, astronomy and materials sciences; mathematics; computer and information sciences; geosciences; engineering; and technology areas associated with the preceding fields.
[2] Some of these girls began FREE with an interest in science or math, but most did not.
[3] Others were "undeclared" in Fall 09 or did not attend college.

Urban High School Opportunity Structures, Figured Worlds of STEM, and Choice of Major and College Destination

Margaret Eisenhart, University of Colorado-Boulder
(Eisenhart's co-PI: Lois Weis, University at Buffalo)

Topic/research question

The purpose of this project is to investigate the implications of (1) high school opportunity structures (math and science course availability, content and context, sequences and requirements; teacher experience; guidance and counseling services; technology use; extracurricular offerings; and student experience) and (2) "figured worlds of STEM" (cultural models of the kinds of people who pursue science, technology, engineering, or math, and why) for choice of major (STEM vs. non-STEM) and college destination. Longitudinal ethnographic case studies are taking place in four urban non-selective high schools in Denver, Colorado, and four similar schools in Buffalo, NY, with additional ethnographic observations and ethnographic interviews with approximately 12 focal students at each school and their parents/guardians. The schools serve students of similar non-privileged background but vary in the ways they have approached the improvement of math and science education at their schools.

The main research questions are:

1. What are the opportunity structures in which and through which non-privileged students experience STEM in urban high schools?
2. How do opportunity structures for STEM vary across high schools with different approaches to improving math and science education?
3. In what ways do opportunity structures affect non-privileged students' access to selective fields (here operationalized as the decision to pursue a STEM major) and selective colleges (here operationalized as selective or more selective institutions, e.g., HBCU's, state universities/colleges, etc.)?
4. What are the figured worlds of STEM that endow certain experiences in an opportunity structure with special significance such that individuals come to view themselves as "STEM material" or not?
5. How do figured worlds of STEM vary by curricular approach and/or opportunity structure?
6. What is the evidence that STEM-related curricular approaches and/or opportunity structures increase the percentage of non-privileged students who choose to pursue STEM? Who choose to attend a selective college?

Overview of research methods

Research methods include: intensive participant observation in schools and classrooms; in-depth interviews with focal students, parents, teachers, counselors, and principals; surveys of

students in Years 1 and 3 of the project; and collection of historical and demographic data pertaining to the schools, school districts, and regional context.

Preliminary findings

1) Public high schools with similar student populations (70-80% free and/or reduced lunch; upwards of 75% minority) differ substantially in the way they promote and organize STEM opportunities. Some do so in the context of Honors and AP courses; others do it in "academies" (course offerings organized by interest area, e.g., a biotechnology academy) or “tracks” (a forensics track); others do it via required coursework for graduation. Within one school, several different arrangements may be available. In Denver, the following six patterns are salient: (1) In the past ten years, there has been consistent public support for improving Denver-area schools, including renovations and upgrades that support STEM; (2) the schools have expanded their offerings in STEM, adding STEM-focused strands and more advanced courses; (3) during this expansion, status differences across high schools, though present, have been somewhat blunted; (4) changes to STEM opportunity structures have been most evident at the two STEM-focused schools where an academy structure replaced the traditional comprehensive high school model; (5) despite these positive signs, advanced offerings cannot always be sustained; and standardized performance indicators reveal serious student academic weaknesses, especially in math and science; and (6) where changes to STEM opportunities have been the most dramatic (the academy schools), they have produced instability and confusion which leads us to conclude, at least at this time, that college-oriented STEM-oriented curricular opportunities are more consistently available and understood at the traditional high schools.
2) Focal students in Denver and Buffalo share similar and familiar figured worlds of schooling and STEM, but they differ substantially in their outlook on and expectations for both lived-out and articulated high school and college-going opportunities. Students in Denver tend to be more positive about schooling and their future prospects than those in Buffalo.
3) There is intense, broad-based interest in both STEM careers and education more generally among students and parents across the two cities. Focal students work relatively hard compared to other students in the broader school population and make good grades in their courses, including science and math. But these same students exhibit misaligned ambitions when they say, for example, that they want to be doctors but do not know that a medical degree requires more than a four-year college education, or they say they want to be engineers but have no knowledge of the different types of engineering or the higher requirements for admission to an engineering college. This lack of knowledge, coupled with limited school counseling and

guidance, does not promote a direct pathway to expressed goals.

4) Denver appears to exhibit marked expansion in the number of STEM-related opportunities (course offerings; proportion of schools devoted to STEM, etc.) for low-income underrepresented minorities in comparison to available opportunities for the comparable population of students in Buffalo. This is in spite of the fact that both districts assert strongly that expanding STEM opportunities for all students is a primary goal, and district planning has been directed towards that end.

Intended uses

We wrote and delivered four papers at the 2012 American Educational Research Association and will be proposing several more for AERA 2013. Publications to follow.

Why Guys? How Programming Acquired Its Masculine Identity

Nathan Ensmenger*, Indiana University

Topic/research question

The first computer programmers were women. In fact, the work of "coding" a computer, as it was originally envisioned, was an inherently feminized occupation: low-status, low-paid, and largely invisible. Today, of course, the situation has almost entirely reversed, and computer programmers have adopted a stereotypically masculine identity. The story of the transformation of the "computer girls" of the early electronic computer era into the "IT guys" of the present period is more than a mere historical curiosity: by highlighting the ways in which the professionalization of computing work also involved the masculinization of its practitioners, my research provides insights into the cultural, structural, and organizational reasons why computer work continues to be gendered masculine.

Overview of research methods and findings

My work is primarily historical, and focuses on the early decades (late-1940s to the early 1970s) of electronic computing. I consider this a particularly important period, since it is during these years that computing develops many of its key institutions (professional societies, academic departments, corporate organizational structures) and cultural practices.

The chapter on “Making Programming Masculine,” which appeared in the 2010 collection called *Gender Codes: Why Women are Leaving Computing,* focuses on the experience of women in the early decades of computing, and on the changing opportunities available to them over the course of the critical decade of the 1960s.

In a forthcoming piece in the journal *Osiris*, I am exploring the ways in which masculine identity was mobilized by male computer programmers in their attempts to professionalize and elevate the status of their discipline

References

Ensmenger, N. (2010). Making programming masculine. In T. Misa (Ed.), *Gender Codes: Why Women are Leaving Computing*. Wiley.

Ensmenger, N. (2013, in press). Beards, sandals, and other signs of rugged individualism: Masculine culture within the computing professions. *Osiris.*

Ensmenger, N. (2010). *The computer boys take over: Computers, programmers, and the politics of technical expertise*. Cambridge, MA: MIT Press.

Programs for Undergraduate Women in Science and Engineering: Issues, Problems, and Solutions

Mary Frank Fox, Georgia Institute of Technology

Topic/research question

This study analyzes programs for undergraduate women in science and engineering as strategic research sites for investigating disparities between women and men in scientific fields. The study presents the first conceptually oriented analyses of the universe of programs for undergraduate women in science and engineering in the United States—as they focus on individual women (their attitudes, behavior, and values) compared to the characteristics of the settings in which women are educated.

The research questions are these: 1) What are the programs' operational definitions of the problems facing women undergraduate majors in science and engineering in individual versus structural dimensions? 2) What are major and minor activities undertaken, and do they parallel or diverge from definitions of the problem? 3) What are the programmatic goals, and to what extent do impacts fall short of goals? 4) What are the organizational characteristics of programs and how do they relate to their structural-individual orientations?

Overview of research methods

Data are collected through a mail survey of the directors of the universe of undergraduate-level programs for women in engineering, women in science, and women in science and engineering in higher education institutions in the U.S. The eligible number of programs is 48, and the response rate to the survey was 79 percent (38/48).

Findings and implications

The results identify ways in which programs' structural (compared to individual) orientations to the issues, problems, and solutions of reducing gender disparity will both encounter challenges within organizations and pose potential for redressing gender inequity.

1) Programs lean somewhat more to a structural compared to individual definitions of the problems facing undergraduate women in science and engineering. Among the structural obstacles, "classroom climate" leads in importance.

2) The typical activities programs undertake do not necessarily align with their typical definitions of the problem, particularly insofar as they involve faculty.

3) The discrepancy (or misalignment) between orientations and implementations appears again in reported importance of goals compared to impacts achieved. The disparity is greatest for goals that involve faculty: changing classroom climate and changing faculty attitudes and behavior toward undergraduate women.

4) The strongest structural orientations to issues of women in science and engineering exist among programs that are stronger in their reporting lines, budgets, and faculty participation. At

the same time, such structural (compared to individual) orientations challenge existing institutional arrangements and prevailing gender hierarchies, and thus potentially encounter organizational resistance.

Citation

Fox, M.F., Sonnert, G., & Nikiforova, I. (2011, October). Programs for undergraduate women in science and engineering: Issues, problems, and solutions. *Gender & Society, 25,* 589-615.

Crocheting the Way to Math Equality: The Effects of Teaching Style on Math Performance

Sarah Kuhn, University of Massachusetts-Lowell
(Kuhn's co-investigator: Nellie Tran)

Topic/research question

What are the effects of holding crocheted models of hyperbolic planes on the math recall and learning performance of male and female undergraduates?

Overview of research methods

A preliminary study was conducted this Spring (2012) by undergraduate researchers Alyssa MacInnis, Amy Macdonald, and Maria McSheehy. Under the supervision of Professor Nellie Tran and in consultation with Professor Sarah Kuhn, the students conducted a laboratory study with the following characteristics:

- Students are randomly assigned to one of three conditions
- All watch a 10 minute videotaped lecture about hyperbolic geometry
    - **Control**: Watched videotaped lecture only
    - **Visual Condition**: Watched same video as control but with relevant images inserted into the video as illustration
    - **Visual + Hands on Condition**: Watched same video with images as in visual condition while holding crocheted hyperbolic plane
- Participants completed an online recall test and survey questionnaire immediately after watching the video

Preliminary findings

The test performance of men was the same across all three conditions. The performance of women rose significantly in both the visual and the hands on conditions compared to the control. In terms of women's performance on the math test, there was no significant difference between the visual-only condition and the hands on condition.

On a measure of math anxiety, women's anxiety decreased significantly in the hands on condition compared to the control (while men's anxiety increased.) Women also were more likely to agree with the statement "I like math" in the visual condition as compared to the control, and their tendency to agree increased even more in the hands on condition.

Intended use

We hope to continue this research by replicating the results, adding additional conditions, and trying to understand why we found the effects we did for the hands on condition. We will publish journal articles and present at conferences.

We also plan to present this work and to engage the public in hyperbolic crochet at the USA Science and Engineering Festival in Washington, DC in Spring 2013, and may also bring this work to science festivals and museums in our area.

We are very interested in the practical applications of crocheted hyperbolic planes as a route to engagement with math and STEM, as an antidote to math anxiety, and as a way to encourage positive affect and persistence in STEM. Among the questions we wonder about are:

- Would learning about hyperbolic crochet and having/making hyperbolic planes lessen math anxiety among elementary school teachers, whose attitudes toward math impact their students' attitudes?
- Would parent workshops at school "math nights" that expose parents with math anxiety to hyperbolic crochet positively affect their child's math performance and persistence?
- How can these findings help us to influence the attitudes and persistence of undergraduates?
- Could hyperbolic crochet have a positive effect on underrepresented men?
- Does making math less abstract and individualistic by connecting it to traditional art forms such as crocheting improve the math performance of underrepresented groups, including immigrant and refugee populations?

Second project

Sarah Kuhn is spending the coming year drafting a book on the implications of embodied thinking for how we teach and learn—in higher education and in adult learning in general. The book will synthesize and critically examine relevant theories about learning and embodied cognition. Its major contribution will be to use this synthesis to develop a framework and design requirements for the improvement of learning environments. The project is motivated by this question: *Given the evidence that human thinking involves the body and not just the brain, how can we create learning environments and pedagogy that draw on the power of the thinking body?* This work has strong implications for the inclusion of underrepresented groups in computing because we know that students who are in the minority in a group, and about whom there may be negative stereotypes, are disproportionately negatively affected by poor pedagogy.

Preventing Stereotype Threat in Standardized Testing
Elsa Macias, Independent Education Consultant

Topic/research question

Stereotype threat is being at risk of confirming, as self-characteristic, a negative stereotype about one's group. Stereotype threat has been shown to adversely affect students' performance when they worry about reinforcing a negative stereotype. The AP and SAT exams ask students their gender immediately before the exam questions. Researchers have found that female students score lower on standardized tests that measure academic aptitude when their gender is emphasized. Specifically, girls score lower on the AP Calculus exam when they are asked their gender immediately before taking the exam compared with when they are asked their gender after the exam.[4]

Overview of research methods

Background data was collected via a literature review, semi-structured and in-depth interviews, and an analysis of public records.

Preliminary findings

The deleterious effects of stereotype threat have been well-documented and are so potentially harmful that efforts should be made to avoid even the possibility of eliciting stereotype threat in college entrance exams whenever possible. Stereotype threat results in an extra burden for female students whose scores on high-stakes standardized tests may be compromised. Lower AP exam scores can substantially and negatively impact students' admission to selective universities, ability to compete for scholarships, time to graduate, tuition costs, and choice of major or profession.[5] Moving the demographic question about gender to the end of the AP and other standardized tests will avoid the negative effects of stereotype threat.

Intended use

Findings support the need to modify test administration procedures by asking the question about student gender after the exam. This change should lead to substantially increased performance scores on the AP and SAT for girls, and an increase in the number of these students earning advanced university credit.

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[5] Dougherty, C., Mellor, L., & Jian, S. (2005). The relationship between advanced placement and college graduation. *National Center for Educational Accountability.*; Hargrove, L, Godin, D., & Dodd, B. (2008). College outcomes comparisons by AP and non-AP high school experiences. *The College Board.*; and Gupta, V. K., & Bhawe, N.M. (2007). The influence of proactive personality and stereotype threat on women's entrepreneurial intentions. *Journal of Leadership and Organizational Studies, 13,* 73-85.

Leaving Engineering: A Multi-Year Single Institution Study

Rose Marra, University of Missouri

Topic/research question

Our purpose was to identify a set of factors describing the experiences of students' in a college of engineering that are strong influences on decision to leave and study how those factors are related to both predictor variables (e.g. high school preparation) and future behaviors (e.g. new major chosen).

Overview of research methods

We solicited survey data from students who had recently transferred out of a large engineering college. We conducted exploratory factor analysis to determine the main factors for leaving engineering and then used these factors to answer the research questions.

Preliminary findings

Results indicate that both academic (e.g. curriculum difficulty and poor teaching and advising) and a non-academic factor (lack of belonging in engineering) contribute to students' decision to leave engineering. We did find differences for some factors between majority and non-majority students; however there were no gender differences.

Intended use

Marra, R.M., Rodgers, K., Shen, D., Bogue, B. (2012). Leaving engineering: A multi-year single institution study. *Journal of Engineering Education, 101*(1), 6-27.

Rodgers, K., & Marra, R. (2012, January). Why they are leaving. *Prism,* 43.

Diversity, Technology, and Occupational Branding: Examining Efforts to Reconstruct the Identity of Computing and IT Work

Jamie McDonald*, University of Colorado-Boulder

Research overview

My dissertation research is exploring the processes by which certain occupations become discursively associated with individuals who embody particular social identities (e.g., gender and race), as well as how these associations can be broken to promote greater occupational diversity. In particular, I am examining the attempts of the National Center for Women and Information Technology to increase gender diversity in information technology through its Sit With Me marketing campaign, which I conceptualize as an occupational branding endeavor. In particular, I am exploring how the campaign's messages implicate discourses of difference, how these messages are taken up by various actors, and how the material artifacts of the campaign acquire cultural meaning and shape action in organizational settings. The goal of my dissertation is to develop a theory of occupational branding for diversity that attests to the tensions and dilemmas that this process implicates.

More specifically, my dissertation research questions are formulated as such:

RQ1: How does NCWIT's Sit With Me marketing campaign construct the identity of "computing and IT" work, and how does this implicate relations of difference such as gender and race?

RQ2: How do NCWIT's constructions of the identity of "computing and IT" work move across time and space? Who/what are the key actors in this movement, and how do they participate in and/or influence the movement of these identity constructions?

RQ3: How are NCWIT's "target audiences" receiving, appropriating, and/or transforming these identity constructions?

Overview of methodology

I am relying upon qualitative research methodology in general and multi-sited ethnography in particular. I have been "shadowing" the Sit With Me campaign from the beginning, following it in the multiple places where it goes, such as meetings in multiple locations (e.g., NCWIT summits; Pacesetters meetings), telephone conference calls, the Sit With Me website, and red chair events. The more specific methods that I am using to collect data include participant observation, interviews, and document analysis (e.g., examining the publicly posted content about Sit With Me on the website).

Preliminary findings

Not yet available. I anticipate availability preliminary findings being available by August 2012 and I expect my final dissertation to be completed by May 2013.

Intended use of findings

I have been involved in the development of Sit With Me since September 2010 and am collaborating with Wendy DuBow to help evaluate the campaign. I anticipate that my data and analysis will provide very valuable data to NCWIT in terms of the implications of the campaign's messages, how multiple actors are perceiving Sit With Me, and how people are using the campaign to shape (or not) action in organizational settings. As such, I am committed to providing concrete feedback to NCWIT, as well as suggestions for future occupational desegregation campaigns that may be undertaken by either NCWIT or other organizations and individuals.

I anticipate my research also making important contributions to the research literature, as outlined below:

- Developing a communicative theory of occupational branding for *diversity* and comparing this theory with existing research on occupational branding for *exclusion*
- Developing explanations of occupational branding campaigns for diversity and the role that various actors – both human and nonhuman – play in these campaigns
- Accounting for the processes through which artifacts associated with occupational branding campaigns for diversity (e.g., the red chair from Sit With Me) acquire cultural meaning across various sites and among multiple actors, as well as for the role that these artifacts play in the campaign

Turing Award Scientists: Contribution and Recognition in Computer Science

Irina Nikiforova*, Georgia Institute of Technology

Topic/research question

One of the most significant rewards in science is peer recognition, often bestowed in the form of awards. However, little is known about what sets apart award-winning contributions, how award committees determine prize-worthy contributions, and why some scientists are more likely to be recognized than others, particularly in the field of computer science. This study examines the characteristics of award-winning contributions and the education and career factors associated with recipients of the Turing Award, a Nobel equivalent award in computer science. It addresses two key questions: 1) What are the valued characteristics of award-winning contributions to computing and the method of selection of these contributions used by the Turing Committee deciding on the award? 2) Which factors (educational and career-related, including collaboration) are associated with the winners of the Turing Award and differentiate them from the control group of non-winning computer scientists?

Overview of research methods

The study uses a mixed method approach that includes qualitative and quantitative techniques. The first question is addressed with content analysis of award citations and analysis of archival documents of the association giving the award, the Association for Computing Machinery (ACM). The second question is addressed with a mixed method approach that includes a) descriptive statistics and a correlation analysis, b) logistic regression analysis, and c) a method of qualitative comparative analysis (QCA).

Preliminary findings

In regard to award-winning contributions, the study finds that the Turing Committee was just as likely to recognize contributions related to practice ("applied research") as to theory ("basic research"). In regard to education and career factors, the study reveals that neither scientific productivity nor the quality of contributions differentiated winning from non-winning scientists and their contributions. However, early advantages, visibility to the awarding association, prior eminence, and affiliation with a top computer science department distinguished award winners. These findings suggest that excellence in computer science is a quality that has not been defined, explained, or communicated by the award committee to the computing community or to the public. The findings call attention to the limitations of peer reviews and the importance of improving the design of nomination, evaluation, and selection procedures as well as citations accompanying the Turing Award.

Intended use

Nikiforova, I. (2012). *Turing Award scientists: Contribution and recognition in computer science*. Unpublished doctoral dissertation. Georgia Institute of Technology, Atlanta, GA.

Beyond the Double Bind: Women of Color in Science, Technology, Engineering, and Mathematics

Maria (Mia) Ong, TERC

Topic/research question

The NSF/REESE-funded project "Beyond the Double Bind: Women of Color in Science, Technology, Engineering, and Mathematics" (BDB) is an empirical study co-led by Mia Ong and Apriel Hodari that explores individual, social, and institutional strategies for minority women's persistence in STEM fields. The project is conducted on two tracks: Track I examines written and oral life stories, and Track II examines higher education programs that have a demonstrated record for promoting young women of color in STEM. The study includes women who self-identify as African American, Asian American, Latina, Native American, and mixed race/ethnicity in four STEM fields: physics, astronomy/astrophysics, computer science, and engineering.

The primary research question is: *What strategies work to enable women of color to achieve higher levels of advancement in STEM academia and professions?* Sub-research questions include: *What overarching themes (e.g., faculty-student interactions, mentoring, peers, family and community) appear regularly and consistently in the narratives by and about women of color in STEM across time, discipline, and race? Are there themes that are unique to particular STEM disciplines, races, and stages of life (undergraduate, graduate, career)? Are there specific factors in higher education recruitment and retention programs that influence women of color to pursue STEM degrees and careers? Are there factors that influence them to struggle or consider leaving STEM?*

Overview of research methods

To date, for Track I, the team has collected 481 extant texts, representing 83 women of color, through publicly available means including books, articles, and websites. Track I also includes a total of 28 interviews with 20 women. The team developed a codebook, and these data are currently being coded using NVivo software. They will be analyzed using methods of narrative analysis. For Track II, the team visited two programs, a STEM support program at a suburban public university, and an IT-focused program at an urban HBCU. Researchers made ethnographic observations in classrooms, study sessions, and informal spaces and conducted interviews with students, faculty, and program staff. Field notes were logged, and interviews were transcribed and analyzed using grounded theory methods.

Preliminary findings

We are still in the process of coding and analyzing our full data set, but in our early analysis, we have identified several themes across our Track I data (extant texts and oral interviews) of women of color in physics and astronomy/astrophysics. First, many of these women consider these places to be "chilly" science environments. They often face female and racial stereotypes,

which are manifested via being second-guessed by those in authority and peers compared to their white and male counterparts who are given the benefit of the doubt. These women's abilities are doubted and they are thought to not be able to handle the work compared to their colleagues and peers. As a result, they end up being excluded from peer social circles and professional opportunities. Our participants had to find personal and internal solutions to deal with the sexism and racism they came across. They worked harder than their peers to prove themselves. They worked to find common ground. Ultimately, many of them had to come to terms with the fact that they are trailblazers, and then turn that into a motivating factor for success. As a result, many of them became activists and acted as role models and mentors for underrepresented communities. They joined or started organizations for minorities, women, or women of color. Even those who left bench science still work to promote women and minorities in STEM through education and social science research.

We began coding and analyzing data from Track II (higher education programs) during the Summer of 2011 and now have preliminary results of our analysis of two programs—Bemberton (a pseudonym), a STEM support program at a surburban public university, and Endeavor (a pseudonym), an IT-focused program at an urban HBCU. It was found that program staff at Bemberton explicitly attends to issues of race with *all* students, believing that they are both preparing minority students for success after they leave their university and creating allies of their white and Asian students. Students in both Bemberton and Endeavor displayed strong commitment to caring for their younger peers, and articulated ways in which helping younger peers strengthened their own STEM knowledge and skills.

Intended use

Ong, M. (2011). The Status of Women of Color in Computer Science, *Communications of the ACM, 54*(7), 32-34.

Trends in the Determinants of Gender Segregation Across STEM Majors

Linda J. Sax*, University of California, Los Angeles

Topic/research question

Prior research has identified key factors affecting college women's persistent underrepresentation in STEM fields. These factors include preparation, values, psychological factors, and structural barriers. However, it is unclear whether the determinants of STEM interest have changed over time—and perhaps in different ways—for women and men. Further, there is limited understanding of how determinants of STEM participation differ by the *specific* STEM field, a question of particular importance given that the gender gap in STEM participation ranges from severe (engineering and computer science) to minimal (biological sciences). This study uses national data on entering college students over the past three decades to advance our understanding of the types of women and men who pursue specific STEM majors, and how those characteristics vary across STEM fields and over time. The study is funded by the National Science Foundation (PI Linda Sax, UCLA; co-PI Jerry Jacobs, University of Pennsylvania). Specific research questions include:

1. Over the past three decades, how have the characteristics of STEM majors changed relative to shifts observed across students from all fields? How does this vary between women and men and across five specific STEM fields (biological science, computer science, engineering, math/statistics, and physical science)?
2. Over the past three decades, to what extent are the changes in the gender gap in STEM majors due to: (1) shifts in the distribution of characteristics (e.g. personality, self-confidence, and educational orientations) among undergraduate women and men, or (b) shifts in the predictive power of variables for women and men?
3. How has the salience of the specific student characteristics predicting selection of STEM majors changed over time for women and men?

Overview of research methods

Our research benefits from a massive dataset of more than 10 million college students surveyed via the "Freshman Survey" administered at over 1,000 colleges and universities over the past four decades. The Freshman Survey is a national longitudinal study of entering college students conducted by the Cooperative Institutional Research Program (CIRP) at UCLA's Higher Education Research Institute. The Freshman Survey includes dozens of measures relevant to STEM, including: self-ratings of academic and mathematical abilities, high school academic achievement and preparation, major choice, academic and career goals, life goals, value orientations, and demographic backgrounds. Our study will access data between 1971 and 2010 with the ultimate goal of advancing our understanding of the types of women and men who pursue specific STEM majors, and how those characteristics vary both across STEM fields and over time.

Preliminary findings

We are in the early stages of data analysis, and have begun by focusing on the field of computer science. Trends over time reveal significant fluctuations in the intent to major in computer science, and that these fluctuations have not been parallel for women and men. Notably, the gender gap in computer science interest is larger today than it was decades ago, revealing a trend that is not observed among other STEM fields where the gender gap has remained fairly stable (e.g., engineering, math/statistics) or has diminished (e.g., biological science).

Next we have calculated the proportion of the computer science gender gap that is explained by mean-level differences in the characteristics of women and men, versus gender differences in the predictors of computer science interest. Preliminary analyses reveals that, especially in recent decades, the primary explanation for the gender gap is that women and men differ in the factors that predict interest in computer science. This finding suggests that efforts to close the gender gap in computer science would be unsuccessful if the goal were simply to align women's and men's average levels on characteristics such as math confidence (a positive predictor) or interest in social activism (a negative predictor). Instead, efforts to recruit more women into computer science ought to be sensitive to the fact that women and men differ slightly in their reasons for selecting (or not selecting) computer science as a field of study.

To explore this further, our third research question sheds light on which specific predictors of computer science interest differ for women and men and how this has changed over time. Early results reveal gender differences in the salience of the vast majority of student characteristics examined. That is, either the predictive power is significantly different for women and men or a characteristic predicts computer science interest for one gender only. For example, math self-confidence has become a weaker predictor of computer science interest for both women and men. In addition, we have found that artistic inclinations have become less of a deterrent to majoring in computer science for women, but not for men. This raises the question of whether women increasingly view computer science as a way to express or apply their artistic abilities. These early results provide some evidence that the perception of computer science may have shifted slightly away from a math-focused field, and perhaps more towards a creative vocation, at least for women. As we continue in our research, we will explore this possibility in greater depth.

Intended use

By expanding understanding of who chooses STEM fields, and how that has changed over time, this project will encourage educators and administrators to consider how teaching, recruitment, and outreach practices might be altered to reduce the gender gap across STEM fields in college. In addition to preparing scholarly publications, we will prepare five discipline-specific summary reports (one for each STEM field) that: (a) highlight major trends in the characteristics of women and men pursuing that particular field in college; and (b) propose strategies that practitioners can utilize to recruit more students – especially women – into STEM fields.

An Examination of Perceived Barriers to Higher Education in STEM among High-Achieving High School Students from Underrepresented Backgrounds

Allison Scott, Level Playing Field Institute

Topic/research question

In the context of STEM preparation, racial and socioeconomic inequity is manifested in multiple ways. Structural barriers including disparities in school funding, access to quality instruction, technology, and access to rigorous STEM coursework negatively impact the STEM opportunities and outcomes of low-income students of color in K-12. In addition, research has demonstrated that racial and socioeconomic inequity is linked in complex ways to both conscious and unconscious psychological barriers which impact the motivation, engagement, identity, aspirations, and outcomes of students of color (Steele & Aronson, 1995; Wong, Eccles, & Sameroff, 2005). Further research is needed to identify the relationships between structural barriers within schools, psychological responses to inequity, and future STEM aspirations among students of color.

Psychological theories of responses to racial discrimination and stigmatization (Major & O'Brien, 2005; Steele & Aronson, 1995) and theories of stress and coping (Lazarus & Folkman, 1984) provided the theoretical rationale for this study, which assesses perceived barriers in pursuing STEM studies in higher education among high-performing high school students of color. Specifically, this research examines students' conscious beliefs about comparative preparation, levels of confidence, and anticipated racism/sexism within STEM studies in higher education, and examines differences between groups by demographic characteristics (e.g., gender, first-generation), school quality (e.g., school API), and STEM interventions (e.g. SMASH summer program). Further, this research is focused on examining the complexities in the interactions between race and gender, and assesses how anticipated racial/gender discrimination in STEM varies by race, gender, and psychological variables including self-concept, STEM identification, and attitudes towards math and science. In addition, this research examines coping mechanisms identified by students to alleviate the impact of these barriers and improve outcomes over time.

Overview of research methods

The sample for this study consisted of 152 high school students (10-12 graders) enrolled in a 5-week summer math and science academy in the San Francisco Bay Area. All students are members of ethnic groups underrepresented in the STEM fields (e.g., African American, Latino, Native American, Southeast Asian) and 49% are female. The vast majority of students are both low-income (64%) and first-generation college bound (67%). All students are "high-performing;" students applied to participate in this rigorous summer program and were selected based on criteria including grades, performance in math and science courses and assessments, essays, and teacher recommendations. All students completed surveys at the beginning and the end of the SMASH program, which assessed 25 scales, including perceived barriers, attitudes towards

math and science, identification with math and science, STEM career aspirations, self-concept, among others. The perceived barriers scale (α=.83), adapted from McWhirter's Perceived Barriers Scale (1994), consisted of 8 items assessing beliefs about barriers in preparation, confidence, and anticipated racism/sexism specifically in STEM in higher education. A select group of 15 students participated in focus groups to collect additional qualitative data to expand upon their experiences and perceptions.

Preliminary findings

Preliminary data analyses reveal that there are significant differences in perceived barriers by gender, where male students perceive significantly fewer barriers than their female peers. Additionally, perceived barriers were negatively associated with future STEM aspirations. There were no significant differences in perceived barriers to STEM by first generation status, school quality indicator (API), and race/ethnicity. When further examining the intersection between race and gender, female students of color (e.g., African American and Latino) were more likely to perceive racial discrimination in studying STEM in college than to perceive gender discrimination, and these perceived barriers were negatively related to STEM aspirations. Further analyses will examine: (1) the interaction effects of self-concept, self-efficacy, networks of role models of color to determine any protective factors to buffer the effects of perceived barriers, and (2) the coping responses and resources employed by students to cope with perceived barriers to STEM.

Intended use

The findings will be synthesized into a paper for publication and presentation. The findings will also have real-world applications to inform program delivery of the SMASH program and similar programs aiming to improve STEM outcomes and college-going rates among underrepresented students of color.

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Persistence Research in Science and Engineering
Gerhard Sonnert, Harvard University

Topic/research question

The NSF-funded project "Persistence Research in Science and Engineering" (PRiSE) investigates which high school science experiences contribute to students'—and especially female students'—interest in a STEM career.

Overview of research methods

The main data source of the PRiSE project is a nationally representative sample of college students in English composition classes (N~7,000). The students completed a comprehensive questionnaire about their high school science experiences and other background variables.

Preliminary findings

We examined the development of a physics identity among female students. One of the findings was that female scientist guest speakers in high school physics classes had no effect on the women students' physics identity. By contrast, discussions in class about the underrepresentation of women in science were associated with an elevated physics identity among the female students. We also examined the pathways into and out of STEM career intentions during the course of high school. Already at the beginning of high school, only a very small fraction of females is interested in computer science and engineering, and only a minority among those maintains that interest to the end of high school. We also found females to be less likely than males to participate in certain types of STEM-related out-of-school activities, which in turn predict a career interest in STEM.

Intended use

Sadler, P.M., Sonnert,G., Hazari, Z. & Tai, R.H. (in press). Stability and volatility of STEM career choice in high school: A gender study. *Science Education*.

Dabney, K.P., Tai, R.H., Almarode, J.T., Miller-Friedmann, J.L., Sonnert,G., Sadler, P.M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B 2* (1), 63-79.

Hazari, Z., Sonnert, G., Sadler, P.M., & Shanahan, M. (2010, October). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study." *Journal of Research in Science Teaching, 47*(8), 978-1003.

Lung, F., Potvin, G., Sonnert, G., & Sadler, P.M. (2011). The effect of immigration status on physics identity and physical science career intentions. *Proceedings of the Physics Education Research Conference, Omaha, NE*.

Cass, C.A.P., Hazari, Z., Sadler, P.M., & Sonnert, G. (2011). Engineering persisters and non-persisters: Understanding inflow and outflow trends between middle school and college. *Proceedings of the American Society for Engineering Education (ASEE) Annual International Conference, Vancouver, BC*.

Hazari, Z., Sadler, P.M., & Sonnert, G. (2011). What type of science person are you? Gender & race/ethnicity comparisons. *Proceedings of the National Association for Research in Science Teaching (NARST) Annual Conference, Orlando, FL*.

Orr, M., Hazari, Z., Sadler, P.M., & Sonnert, G. (2009). Career motivations of freshman engineering and non-engineering students: A gender study. *Proceedings of the American Society for Engineering Education annual conference, Austin, TX*.

Gender and Computing: A Case Study of Women in India

Roli Varma, University of New Mexico

Topic/research question

Scholarly literature on the construction of gender in computing in the West has focused on the differences between men's and women's representations in the computer science (CS) and computer engineering (CE) fields and their perceptions of computer technology. Men are seen as mostly interested in the computer technology especially in programming; in contrast, women are seen as mostly interested in the social aspects of computer technology especially its use for the society. The CS/CE themselves are seen as gendered. I question such view of gender and computing fields by using example of women in India. Contrary to the situation in the West, there has been a significant increase in the number of women entering CS/CE fields. This is despite the prevalence of Indian patriarchy—a system of male dominance legitimized within the family and society through superior rights, privileges, authority, and power granted to men.

Overview of research methods

I conducted in-depth interviews with 60 female undergraduates majoring in CS in 2007–2008. The study took place in two engineering institutes and two universities that granted four-year undergraduate degrees in CS. Random sampling was used to select 15 subjects who were in their second and later years of studies at each institution. The interviews were structured in the sense that only certain issues were covered, and they were also unstructured in the sense that they resembled private conversations with the subjects. Each interview lasted anywhere from less than an hour to an hour and a half. Interviews were recorded, transcribed, and inserted in the Nvivo program for data analysis. Two independent coders coded the same data to ensure reliability. Once all interviews were coded, I analyzed the data for possible relationships between concepts and variations in the patterns observed.

Preliminary findings

This study found that very few female students in India knew word processing, email, and internet before enrolling in a university. Most of them began using a computer on a regular basis after they were admitted to a university. Even though they had less prior computer experience, they were confident to handle CS because they considered themselves very strong in mathematics. They never entertained the idea of changing their major from CS to some other field. It is mostly because the image of CS in India is of a lucrative and woman-friendly field. People who join the field are seen as smart and intelligent, without being anti-social. Women in India have practical reasons (e.g., economic benefits), educational reasons (e.g., strong background in mathematics and sciences), and social reasons (e.g., higher status in the society and support from family) to enroll and do well in computing.

Intended use

Varma, R. (2011). Indian women and mathematics for computer science. *IEEE Technology and Society Magazine, 30*(1), 39-46.

Varma, R. (2010). Computing self-efficacy among women in India. *Journal of Women and Minorities in Science and Engineering*, *16*(3), 257-274.

Varma, R. (2011, June 28). *Women in computing education in the USA and India: A western problem or a global one?* Saarbrücken, Germany: Max Planck Institute.

Varma, R. (2011, June 16). *Women in ICT education: A western problem or a global one? Lessons from USA and India.* Uppsala, Sweden: Centre for Gender Studies, Uppsala University

Varma, R. & Kapur, D. (2011, June 23-24). Educating women in computer science in India. Presented at HELENA International Conference: Gender and Interdisciplinary Education for Engineers (GIEE), Paris, France.

The STEM Agency Initiative for STEM Learning Among Marginalized Youth: From Fractal Village to Global Village

Sneha Veeragoudar Harrell, TERC

Topic/research question

The research problem I seek to address is the underrepresentation of marginalized groups in STEM professions in the United States of America. The standard paradigm of research on computer science education focuses almost exclusively on cognitive challenges apparently inherent to particular computational concepts (e.g., Ben Ari, 2001). Yet developments in the learning sciences have suggested that computer science curriculum should embrace a broader conceptualization of learning: human reasoning, it is proposed, is embodied, distributed, and situated, and learning is accordingly perceived as inherently collaborative, contextualized, and instrumented (cf. Dourish, 2001; Greeno, Collins, & Resnick, 1996; Hutchins, 1996, 2000; Kosslyn, 2005; Lakoff & Johnson, 1999; Lave & Wenger, 1991; Lemke, 2002; Ramachandran, 2007). One result of this broader view of human reasoning and learning within the STEM disciplines is the emergence of research on relations between student identity and learning (Gresalfi, 2009; Lave & Wenger, 1991; Nasir, 2002).

My research program, too, embarks from the assumption that student disposition toward STEM disciplines plays an important factor in learning (see also Kilpatrick, Swafford, & Findell, 2001). A central conjecture herein is that for students to learn STEM content, they should perceive disciplinary participation as a vehicle of self-progress.

To pursue this conjecture, I conducted two studies. In one, entitled Fractal Village, I implemented a computer science instructional intervention at an alternative high school serving underrepresented students evicted from mainstream education in an urban California context. In the second, entitled Global Village, I implemented an after school program for computational literacy development at a small independent school for refugee girls in the southern state of Georgia. In each of these studies I evaluated the conjecture in the form of three case studies of individual participants. This research has resulted in: (1) a theoretical model of computational agency; (2) a design framework for creating an ecology that fosters agency: (3) a design for marginalized youth; and (4) transformative outcomes in terms of the intervention's affect on the participants' lives. In summary, the research questions addressed in my research straddle both theory and practice. The theory-oriented research question is: What are the relations amongst cognitive, affective, material, technological, and social factors apparently contributing to computational agency? The practice-oriented research question is: What are the design principles that help foster computational agency development?

Overview of research methods

Oriented by my initial set of research questions, while remaining open to emerging questions, I perform microgenetic, qualitative analysis (Schoenfeld, Smith, & Arcavi, 1991; Siegler & Crowley, 1991) so as to reconstruct data episodes identified as particularly informing of the ways in which computational agency factors interacted in the learning environment. Using

grounded theory techniques (Glaser & Strauss, 1967), I detected patterns and articulated constructs emerging through this iterative scrutiny of the data. These techniques were useful so as to explain how the design supports student construction of a computational identity, thus informing future design (cf. Clement, 2000; Goldin, 2000).

Preliminary findings

Through the lens of case studies, I argue that to build agency, students must develop both skills and dispositions—a spiraling inter-constructive growth. Findings demonstrate that students' successful participation was contingent on their growth along both cognitive and affective dimensions of the computational agency framework. The cognitive and affective supports offered by the intervention respectively impacted participants' cognitive and affective growth. Moreover, these parallel growths are co-dependent: as their skills grow, students are motivated to face further challenges, and the affective supports help them overcome these challenges, and so on.

With respect to the theory-oriented research question (understanding the growth of computational agency), a claim emerging from these findings is that cognitive and affective factors are co-dependent variables, reciprocally related, in contributing to computational agency development. I came to realize that whereas the disciplinary content has a value in terms of computer science, the content was predominantly a vehicle for disposition building. That is, the content served as context in through which the instructors' caring, modeling, and achievement could be experienced, effecting development of an affirming self-image as a computational learner and doer. In this sense, the work of my research can be seen as expanding on Constructionism, by demonstrating that not only is content learned through building in the public space—values, friendship, community, and identity are built too, and these, in turn, fuel content learning.

With respect to the practice-oriented research question (delineating design principles), the emerging claim is that computational agency development can be fostered through implementing *pedagogical commitments* through *discursive and applied mixed-media technological supports*. The pedagogical commitments reflect critical and constructionist views framing the intellectual orientation of my research and, specifically, the design that was created in anticipation of the intervention that constituted the empirical setting of the central study. The discursive supports—cognitive and affective—reflect aspects of teacher–student interactions. These discursive supports had not been specified, let alone labeled or articulated explicitly, prior to the implementation and were only identified retroactively during analysis in the Fractal Village Project. Yet these supports were essential for realizing the design, and hence realizing the contributing pedagogical commitments.

Intended use

Harrell, D. F. & Veeragoudar Harrell, S. (2012). *Imagination, computation, and self-expression: Situated character and avatar mediated identity*. Leonardo Electronic Almanac.

Veeragoudar Harrell, S., & Abrahamson, D. (2010). Second Life Unplugged: A Design for At-Risk Students' STEM Agency. In Gazit, H. (Ed.), The metaverse assembled [Special Issue]. *Journal of Virtual Worlds Research.*