Title: Summary of research on gender differences and student interest in STEM

Date: September 2014

Question: >> Could you provide research on gender differences and student interest in STEM (specifically, computer science)?

Response:

This memo includes research reports and articles on gender differences and student interest in STEM.

- Citations include a link to a free online version, when available.
- Citations are accompanied by an abstract, excerpt, or summary written by the author or publisher of the document.

We have not done an evaluation of the rigor of these resources, but provide them for your information only.

References

Aspray, W., & Cohoon, J. M. (Eds.). (2006). *Women in IT: Research on underrepresentation*. Cambridge, MA: MIT Press. Available for purchase at http://www.amazon.com/Women-Information-Technology-Research-Underrepresentation/dp/0262533073

Book description: Computing remains a heavily male-dominated field even after twenty-five years of extensive efforts to promote female participation. The contributors to *Women and Information Technology* look at reasons for the persistent gender imbalance in computing and explore some strategies intended to reverse the downward trend. The studies included are rigorous social science investigations; they rely on empirical evidence—not rhetoric, hunches, folk wisdom, or off-the-cuff speculation about supposed innate differences between men and women. Taking advantage of the recent surge in research in this area, the editors present the latest findings of both qualitative and quantitative studies. Each section begins with an overview of the literature on current research in the field, followed by individual studies. The first section investigates the relationship between gender and information technology among preteens and adolescents, with each study considering what could lead girls' interest in computing to diverge from boys'; the second section, on higher education, includes a nationwide study of computing programs and a cross-national comparison of computing education; the final section, on pathways into the IT workforce, considers both traditional and nontraditional paths to computing careers.

Bleeker, M., Davis-Kean, P., Eccles, J. S., Jacobs, J. E., & Malanchuk, O. (2005). I can, but I don't want to: The impact of parents, interests, and activities on gender differences in math. In A. Gallagher & J. Kaufman (Eds.), *Gender differences in mathematics*. Cambridge, United Kingdom: Cambridge University Press. Retrieved on September 5, 2014, from http://www.rcgd.isr.umich.edu/garp/articles/eccles05a.pdf

Excerpt: The general conclusion that we draw from our work is that, although girls' performance and self-perceptions of ability suggest that they feel competent in math, they are less likely than boys to find it intrinsically interesting and their parents are less likely to create math-supportive or math-promotive environments for them. It appears, instead, that the achievement environment in many homes is a gendered environment and that messages from parents about achievement continue to be sent through gender-typed filters.

Cheong, Y. F., Pajares, F., & Oberman, P. S. (2004). Motivation and academic help-seeking in high school computer science. *Computer Science Education, 14*(1), 3–19.

Abstract: The primary objective of this study was to determine the degree to which academic motivation predicted the executive help-seeking, instrumental help-seeking, perceived benefits of help-seeking, and avoidance of help-seeking of high school students enrolled in computer science (n = 314). Task goals were positively associated with instrumental help-seeking and perceiving the benefits of help-seeking and negatively associated with executive help-seeking; performance-avoid goals were negatively associated with instrumental help-seeking and positively associated with avoiding help-seeking. Controlling for motivation and computer science competence, girls were more likely to seek instrumental help and to perceive the benefits of help-seeking, and African American students were more likely to seek help than were White students or Asian American students. Despite possessing equal computer science skills, girls reported lower self-efficacy, self-concept, self-efficacy for self-regulation, and value than did boys.

Cheryan, S., Plaut, V. C., Handron, C. & Hudson, L. (2013). *The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women*. New York: Springer Science+ Business Media.

Excerpt: The present research examines undergraduates' stereotypes of the people in computer science, and whether changing these stereotypes using the media can influence women's interest in computer science. In Study 1, college students at two U.S. West Coast universities (N = 293) provided descriptions of computer science majors. Coding these descriptions revealed that computer scientists were perceived as having traits that are incompatible with the female gender role, such as lacking interpersonal skills and being singularly focused on computers. In Study 2, college students at two U.S. West Coast universities (N = 54) read fabricated newspaper articles about computer scientists that either described them as fitting the current stereotypes or no longer fitting these stereotypes. Women who read that computer scientists no longer fit the stereotypes expressed more interest in computer science than those who read that computer scientists fit the stereotypes. In contrast, men's interest in computer science did not differ across articles. Taken together, these studies suggest that stereotypes of academic fields influence who chooses to participate in these fields, and that recruiting efforts to draw more women into computer science would benefit from media efforts that alter how computer scientists are depicted.

Davies, A. R., Klawe, M., Ng, M., Nyhus, C., & Sullivan, H. (n.d.). *Gender issues in computer science education*. Vancouver, BC, Canada: Department of Computer Science, University of British Columbia. Retrieved on September 4, 2014, from http://www.wcer.wisc.edu/archive/nise/news_activities/forums/klawepaper.htm

Excerpt: This paper aims to first understand why there is such a significant difference between girls and boys in choosing IT as their careers. A literature review on the important factors influencing gender differences in IT career choice will be presented, as well as a summary of possible actions recommended by various research groups. We will then introduce the SWIFT program, which is an overall program aiming to understand and tackle the issue of low participation of women in the IT field. Under the SWIFT program are various projects that handle different aspects of the problem. These include: (i) an overall career survey to explore the existing gender gap in their perception of science subjects; (ii) the E-GEMS project aiming at developing gender-inclusive computer software to enhance female students' interest in mathematics and educational computer games; (iii) the Virtual Family program focusing on increasing students' programming knowledge by designing gender-inclusive software that provides an easy and enjoyable introduction to Java; (iv) a variety of outreach initiatives, such as the organization of a provincial conference to link practitioners and the design of a new introductory computer course emphasizing computer applications for university programs; and (v), the ARC program which offers retraining for adults who are interested in starting their careers in the IT industry. We will then conclude this paper by highlighting how the above projects address the issue of low participation of females in the IT field, and the new directions our projects generate.

Goode, J., Estrella, R., & Margolis, J. (2006). Lost in translation: Gender and high school computer science. In W. Aspray & J. M. Cohoon (Eds.), *Women in IT: Research on underrepresentation*. Cambridge, MA: MIT Press. Available for purchase at http://www.amazon.com/Women-Information-Technology-Research-Underrepresentation/dp/0262533073

Summary: This chapter presents four themes that suggest some reasons why and how high school female students are—or are not—drawn into the field of computer science through their high school experiences. First, despite the national and local initiatives to "bring schools into the twenty-first century," researchers discovered that few computer science learning opportunities actually exist at the high school level, especially in schools that serve communities of color. Second, they found that notions of relevance play a key role in influencing females' choices to enroll or not enroll in computer science classes. A limited and narrow presentation of what computer science is as well as what computer scientists actually do impacts students' take on how computer science could further their academic and career endeavors. Third, for the female students who do take computer science, researchers observed an accumulation of negative experiences in classroom settings, where greater male technology experience/expertise and female social isolation and insecurity are part of the cultural landscape. Fourth, all of these experiences are then compounded by the way that computer science is motivated and "interpreted" for the students.

Halpern, D., Aronson, J., Reimer, N., Simpkins, S., Star, J., & Wentzel, K. (2007). *Encouraging girls in math and science* (NCER 2007-2003). Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education. Retrieved on September 5, 2014, from http://ies.ed.gov/ncee/wwc/pdf/practice_guides/20072003.pdf

Excerpt: This practice guide provides five recommendations for encouraging girls in math and science. These recommendations together form a coherent statement: To encourage girls in math and science, we need to begin first with their beliefs about their abilities in these areas, second with sparking and maintaining greater interest in these topics, and finally with building associated skills.

Our specific recommendations cover these three domains in a representative but not exhaustive way. In particular, we have chosen to focus on specific recommendations that have the strongest research backing available. In addition, we limit our focus to recommendations that teachers can carry out in the classroom and that do not require systemic change within a school district. We remind the reader that students' choices to pursue careers in math and science reflect multiple influences that accumulate over time. We have identified practices that elementary, middle, and high school teachers can implement during instruction that we believe would increase the likelihood that girls and women will not prematurely decide that careers in math and science are not for them …

Recommendations:

1. Teach students that academic abilities are expandable and improvable
2. Provide prescriptive, informational feedback
3. Expose girls and young women to female role models who have succeeded in math and science
4. Create a classroom environment that sparks initial curiosity and fosters long-term interest in math and science
5. Provide spatial skills training

Iskander, K., Gore, P. A., Furse, C., & Bergerson, A. (2013). Gender differences in expressed interests in engineering-related fields: ACT 30-year data analysis identified trends and suggested avenues to reverse trends. *Journal of Career Assessment, 21*(4), 599–613.

Abstract: Historically, women have been underrepresented in the Science, Technology, Engineering, and Math (STEM) fields both as college majors and in the professional community. This disturbing trend, observed in many countries, is more serious and evident in American universities and is reflected in the U.S. workforce statistics. In this article, we examine historical students' interest data in order to further the understanding of this discrepancy and to suggest methods to reverse this trend. Thirty years of historical ACT data were analyzed by expressed interest patterns, ACT scores, gender, and intended college major or career aspiration. Statistical package for the social sciences software was used to analyze the data and examine the historical trends of students' expressed interest in STEM-related careers. Results show that there is a significant (although expected) discrepancy between the number of male and female students who expressed interest in engineering majors and careers. Significant changes have also been observed in the interest in engineering fields over time, most likely because of societal influences. These influences are most profound in computer-related fields, causing speculation that both males and females were influenced by the dot com era but that only male interest was piqued due to the rise of computer gaming in the late 1990s. Students are further grouped into three categories—well prepared (ACT ≥ 28), under prepared (27 ≤ ACT ≥ 19), and unprepared (ACT < 19). Of the total number of students who expressed interest in engineering majors, there are many who appear either completely unprepared or relatively under prepared for the demands of these fields. Data show that female students who expressed interest in STEM fields are generally in the well-prepared category; the discrepancy between those who are interested but under prepared is greater in males than females. Results from this analysis demonstrate the importance of earlier interventions to encourage students who still have enough time to get prepared for opportunities that interest them. It is also probable that students are making assumed career choices based on little or no data and may actually find their interest waning very quickly (thus making them a retention risk if they are admitted to an engineering program). This study, therefore, provides a better understanding of gender, societal influences, and ability disparities in high school students who expressed interest in engineering majors and careers. Obtained results suggested some of what needs to be done and

could be used to guide future efforts in order to reverse the current trends of gender disparity and lack of female interest in engineering fields.

Ma, Y. (2011). Gender differences in the paths leading to a STEM baccalaureate. *Social Science Quarterly, 92*(5), 1169–1190.

Abstract: Many have wondered why U.S. women continue to shun certain STEM fields, including science, technology, engineering, and mathematics. This study investigates this question and examines the pathways that women and men follow in attaining their STEM bachelor's degrees. Methods: Using NELS 88-00 and the postsecondary transcript data, the descriptive analysis examines gender differences in the three stages of the STEM pipeline: expected college major, first major, and bachelor degree major. The multivariate analysis examines the outcomes of STEM degree attainment, the subfields attainment and the pathways in a series of logical steps. Results: Drawing from the pipeline model and its associated cumulative disadvantage theory, and the alternative framework of revolving door theory, analyses from this study indicate that men are more likely than women to follow the complete persistence pathway to attain STEM degrees, but women are as persistent as men once they expect a major in STEM as high school seniors. High school achievement, attitudes, and course taking are related to the subfields attainment, as well as the pathways of the STEM degree attainment. Conclusions: Taken together, the results are more aligned with revolving door theory and support the contextual variability in the salience of gender to understand gender differences in attaining STEM fields.

Mann, A., & Diprete, T. (2013). Trends in gender segregation in the choice of science and engineering majors. *Social Science Research*, 42(6), 1519–1541.

Abstract: Numerous theories have been put forward for the high and continuing levels of gender segregation in science, technology, engineering, and mathematics (STEM) fields, but research has not systematically examined the extent to which these theories for the gender gap are consistent with actual trends. Using both administrative data and four separate longitudinal studies sponsored by the U.S. Department of Education, National Center for Education Statistics (NCES), we evaluate several prominent explanations for the persisting gender gap in STEM fields related to mathematics performance and background and general life goals, and find that none of them are empirically satisfactory. Instead, we suggest that the structure of majors and their linkages to professional training and careers may combine with gender differences in educational goals to influence the persisting gender gap in STEM fields. An analysis of gendered career aspirations, course-taking patterns, and pathways to medical and law school supports this explanation.

Margolis, J., & Miller, F. (n.d.). *The anatomy of interest: Women in undergraduate computer science*. Pittsburgh, PA: School of Computer Science, Carnegie Mellon University. Retrieved on September 8, 2014, from http://www.cs.cmu.edu/afs/cs/project/gendergap/www/papers/anatomyWSQ99.html

Excerpt: In this paper we focus on the process by which women students who enter with high enthusiasm and interest in computing quickly lose faith in their ability and their interest in the subject. We believe it is critically important to gather carefully rendered accounts of how these women students lose *interest* in computer science, particularly in light of the commonly held belief that girls and women are not as "intrinsically interested" as males in technology. We look at the ways that interest in a subject area is influenced by factors beyond an individual's intellectual preference for an abstract body of knowledge. We have found women's departing statements that they are "just not interested" to be a misleading endpoint to a complex process we've seen over time, involving the interplay of gender-biased norms of interest and eroded confidence. We look at

the mechanisms that promote a male focus of interest as the standard for success, while casting doubt upon women's interest and ability in computing.

Robnett, R., & Leaper, C. (2013). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence (Wiley-Blackwell), 23*(4), 652–664.

Abstract: Friendship group characteristics, motivation, and gender were investigated in relation to adolescents' science, technology, engineering, and math (STEM) career interest. The sample was comprised of 468 high school students (M = 16 years, range = 13–18) from diverse ethnic backgrounds. Participants rated their friendship group's support of STEM as well as their personal motivation in science. They separately rated the friendship group's support of English and personal motivation in English. Other predictors included friendship group characteristics (importance, gender composition) and background variables such as gender. Group support of STEM (but not English) and science motivation (but not English motivation) predicted STEM career interest. Group characteristics and participant gender moderated the effects. Findings suggest social identities and self-concepts may shape youths' STEM career choices.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education, 96*(3), 411–427.

Abstract: This retrospective cohort study characterizes how interest in science, technology, engineering, mathematics (STEM) careers changes during high school for more than 6,000 students in a representative national sample of 34 two- and four-year colleges taking mandatory college English courses. Overall, large gender differences in career plans were found, with males showing far more interest particularly in engineering, whereas females were more attracted to careers in health and medicine during their high school years. The key factor predicting STEM career interest at the end of high school was interest at the start of high school. There was an additional effect of gender, indicating both a lower retention of STEM career interest among females and a greater difficulty in attracting females to STEM fields during high school. During the high school years, the percentage of males interested in a STEM career remained stable (from 39.5 to 39.7), whereas for females it declined from 15.7 to 12.7. The students' initial specific (disciplinary) career interests were found to influence the stability of their interest in a STEM career, with those interested in physics careers at the start of high school having the highest retention in STEM.

Smith, T. J., Pasero, S. L., & McKenna, C. M. (2014). Gender effects on student attitude toward science. *Bulletin of Science, Technology & Society July 15, 2014.*

Abstract: The present study examined gender and attitude toward science in fourth- and eighth-grade students in the United States and also assessed to what extent the relationship between science attitude and science achievement differed by gender. Results showed that both fourth- and eighth-grade boys demonstrated more confidence in science than girls, while eighth-grade boys also showed greater liking for science than girls. Additionally, gender moderated the relationship between science achievement and (a) liking science (for fourth-grade students) and (b) confidence in science (eighth-grade students). Results are discussed in terms of addressing gender inequities in science education and career opportunities.

Tanenbaum, C., & Upton, R. (2014). *Early academic career pathways in STEM: Do gender and family status matter?* Washington, DC: American Institutes for Research. Retrieved on September 8, 2014, from http://www.air.org/resource/early-academic-career-pathways-stem-do-gender-and-family-status-matter

Abstract: This brief examines the extent to which factors related to work-life balance may be pushing or pulling women of all races and ethnicities out of science, technology, engineering, and mathematics (STEM) academic careers early in the academic career pathway. This brief examines the extent to which gender differences exist in the types of positions new STEM PhD recipients secure upon earning their degrees. Specifically, whether recipients secured an academic or nonacademic position and, among those with academic positions, whether the position is at a research or nonresearch institution.

Wang, M., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science*, *24*(5), 770–775.

Abstract: The pattern of gender differences in math and verbal ability may result in females having a wider choice of careers, in both science, technology, engineering, and mathematics (STEM) and non-STEM fields, compared with males. The current study tested whether individuals with high math and high verbal ability in 12th grade were more or less likely to choose STEM occupations than those with high math and moderate verbal ability. The 1,490 subjects participated in two waves of a national longitudinal study; one wave was when the subjects were in 12th grade, and the other was when they were 33 years old. Results revealed that mathematically capable individuals who also had high verbal skills were less likely to pursue STEM careers than were individuals who had high math skills but moderate verbal skills. One notable finding was that the group with high math and high verbal ability included more females than males.

Methods

Keywords and Search Strings Used in the Search

("Gender" or "gender differences") AND ("interest in STEM" OR "STEM" OR "computer science"); ("gender" or "gender differences") AND "motivation" AND "computer science"; "girls" AND "motivation" AND ("STEM" OR "computer science").

Search of Databases

EBSCO Host, Google, and Google Scholar

Additional Organizations/Websites Searched

Education Commission of the States; U.S. Department of Education, Institute of Education Sciences

Criteria for Inclusion

In general, when REL West staff review resources, we consider—among other things—four factors:

- **Date of the Publication:** The most current information is included, except in the case of nationally known seminal resources.
- **Source and Funder of the Report/Study/Brief/Article:** Priority is given to IES, nationally funded, and certain other vetted sources known for strict attention to research protocols.
- **Methodology:** Sources include randomized controlled trial studies, surveys, self-assessments, literature reviews, and policy briefs. Priority for inclusion generally is given to randomized controlled trial study findings, but the reader should note at least the following factors when basing decisions on these resources: numbers of participants (Just a few? Thousands?); selection (Did the participants volunteer for the study or were they chosen?); representation (Were findings generalized from a homogeneous or a diverse pool of participants? Was the study sample representative of the population as a whole?).
- **Existing Knowledge Base:** Although we strive to include vetted resources, there are times when the research base is limited or nonexistent. In these cases, we have included the best resources we could find, which may include newspaper articles, interviews with content specialists, organization websites, and other sources.

This memorandum is one in a series of quick-turnaround responses to specific questions posed by educators and policymakers in the Western region (Arizona, California, Nevada, Utah), which is served by the Regional Educational Laboratory West (REL West) at WestEd. This memorandum was prepared by REL West under a contract with the U.S. Department of Education's Institute of Education Sciences (IES), Contract ED-IES-12-C-0002, administered by WestEd. Its content does not necessarily reflect the views or policies of IES or the U.S. Department of Education nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government.