Testimony of

Sandra L. Hanson, Ph.D.

Professor of Sociology, Catholic University

Before the House Committee on Science and Technology

Subcommittee on Research and Science Education

Hearing on *"Encouraging the Participation of Female Students in STEM Fields"*

Chairman Lipinski, Ranking Member Ehlers, and distinguished members of the Subcommittee, I am Sandra Hanson, Professor of Sociology at Catholic University. I have been doing research on girls in science for several decades. It is a great compliment to be able to share my research with you today. Thank you for the opportunity to testify about encouraging female students in STEM fields.

Today I would like to address three issues regarding research on girls in science education: an overview of my research on the topic, the current status of research (in general) on girls in STEM; and ideas about disseminating research findings.

OVERVIEW OF MY RESEARCH: WHAT MY RESEARCH REVEALS ABOUT THE FACTORS THAT SHAPE GIRLS' INTEREST AND PARTICIPATION IN STEM.

Findings from my research show that *young girls do not start out with low achievement in STEM*. Early in the high school years, however, many girls experience the beginning of a departure from STEM typified by enrollment in fewer STEM courses, lowered achievement, and increasingly negative attitudes[1]. This "chilling out" occurs even for young women who have shown promise and talent in science. My research confirms that young women's increasing presence and success in STEM education is happening at a faster rate than in science occupations. In 2006, women earned 20% of

[1] See data from NCES (Appendix Table 1), NSF, and NCER (National Center for Education Research, Institute of Education Studies) (Figures 1 through 4) on gender and STEM achievement from kindergarten through post-secondary school in the Appendix.

Ph.D. Engineering degrees but they represented only 12% of employed Engineers[2]. In some areas (e.g., Bachelor's degrees in chemistry and in biological sciences) young women earn more degrees than young men. Employers can no longer argue that there is a shortage of qualified female science talent. We need to do more to make sure that all young people, regardless of sex, have a chance to succeed in STEM education. It is just as important that young women who acquire qualifications in STEM have equal access and opportunity in STEM occupations. Although I cannot summarize all of my research here, I briefly discuss a number of issues below, including: STEM as an elite area of the U.S. (and international) education and occupation systems, the intersection of gender and race in creating STEM talent, structural barriers and selection processes that filter women (even talented women) out of STEM, measurement of girls' STEM experiences, and sources of optimism about the future of girls in STEM.

STEM as an elite. My research suggests that we *view STEM as an increasingly powerful elite*. The study of elites has historically been an important part of social science theory and research. Elites have been described as those occupying powerful and influential positions in government, corporations, and the military. These elites share interests and attitudes, and have networks which work to encourage and include some and discourage and exclude others. In a technologically advanced, postmodern, global society, the status, power, shared interests and powerful networks of those in STEM suggests that they must be considered as members of the new elite. One of the most distinguishing features of the science elite (historically and currently) is the shortage of women and non-whites. In spite of the progress that women and minorities have made in STEM education and occupations, the culture of science continues to be a white male culture that is often hostile to women and minorities. In a technologically advanced society, it is the work of scientists that will determine our future. The need for a talented, diverse, well-educated workforce can no longer be questioned.

[2] NSF. 2009. Women, Minorities, and Persons with Disabilities in Science and Engineering (http://www.nsf.gov/statistics/wmpd).

The intersection of gender and race. Implicit in my research is the notion that *STEM is not just a male culture; it is a white male culture.* I am happy to hear that the subcommittee will also be holding hearings on minorities in science. An important lesson from my work on women in STEM is that one cannot just talk about "women" or "men" in STEM. Men and women across race and social class statuses have very different experiences in STEM. Gender cultures vary tremendously across race groups and my recent research on African American women in science suggests a considerable interest and engagement in science. Many people assume a double disadvantage associated with race and gender for young African American women as they enter the STEM education system. It is important that researchers not make any assumptions about the effect of being female or black without considering how these statuses might converge. In other words, we need to avoid talking about "women" in science. Instead, we should be looking at the experiences of different groups of women. Because of the unique gender system in the African American community, these young women actually have some advantages in the STEM system.

In a related way some of my research has focused on the unique science experiences of another racial/ethnic group – Asian Americans. My surveys with hundreds of Asian American youth reveal considerable complexity in their science experiences in spite of stereotypes about the "model" minority. Both Asian American girls and boys outperform white youth (even male white youth) in science. This finding is an interesting one given the evidence of traditional gender systems in many Asian American cultures. My research does show, however, that Asian American girls do not have the same level of science achievement as Asian American boys. Although Asian (and Asian American) culture can be seen as a model for creating interest and achievement in science (for girls as well as boys), the youth in my survey reported considerable stress and anxiety associated with overwhelming familial pressure towards success in science.

The next ethnic group that I will focus on in my examination of the confluence of race and gender in STEM is Latino youth. There is a dearth of research on the experiences of Latino youth in the U.S. STEM education system in spite of the fact that Latinos are the fastest growing ethnic/racial minority in the U.S. Both Latino men and women are under-represented in STEM. Stereotypes about Latinos involving “marginalized populations,”“immigrants,” and “second-language users” as well as the assumption that the Latino experience is at odds with the larger U.S. culture work against these young people in the science education system. I hypothesize that Latino women will have considerable interest and potential talent in science in spite of stereotypes involving ‘marianismo” which see them as submissive, subservient, and thus uninterested in STEM. There is a growing, but limited research on Latino women that shows that they are breaking these old stereotypes and increasingly earning graduate degrees and higher salaries in professional (and science) areas.

<u>Structural barriers and selection processes</u>. My research also shows that *the problem of talented young women leaving science (and of a shortage of women in science in general) says less about the characteristics of young women and more about structural barriers and selection processes*. These processes directly affect STEM achievement through gender discrimination but they also affect achievement indirectly through the transmission of “gendered” socialization and unequal allocation of science resources in families, schools, and the media. My research supports structural theories of how education systems work. Here, individuals are not necessarily free to achieve according to their talents but rather are subject to systems that identify, select, process, classify, and assign individuals according to externally imposed (in this case biological sex) standards. Students then develop their expectations toward their future around these observed constraints.

Interestingly, my work shows that these processes often work in a subtle way that students and teachers may not be aware of. Instead, members of a society are largely in agreement on cultural ideas regarding gender. They share in this “world taken for granted” regarding gender and science which becomes so routine that it is seldom questioned. Studies of young girls show that they think they are making individual choices, but those choices tend to reproduce gender structures. In a similar manner, work by the Sadkers has shown that teachers (in science and other classes) teach male and female students differently without being aware of these behaviors.

My work supports the stereotype threat theory in psychology by showing that many young African American women adjust their behavior to stereotypes about race, gender and STEM. These adjustments sometimes result in leaving STEM fields. In addition, the stress of trying to resist stereotypes actually results in reduced STEM achievement.

Measurement of girls' STEM experiences. An important finding coming out of my recent research involves the *way in which we measure girls' STEM experiences.* Social scientists need to think carefully about their methods, measures, and samples when making conclusions about gender and science. Gender continues to be a sensitive topic in U.S. culture and standard methods of data collection via surveys often result in responses that are socially desirable and culturally biased. In my recent book SWIMMING AGAINST THE TIDE, I used a series of vignettes to provide insight into STEM attitudes and experiences. Instead of asking young women directly about their STEM experiences, I asked the young women to respond to a story of a young woman and her experience in the science classroom. I also allowed the young women to answer unstructured, open-ended questions about their STEM experiences so that they could describe these experiences in their own words. When the young women (both white and African American) were asked about a "chilly" climate in the science classroom for women like those in the vignette (as opposed to for themselves), they were twice as likely to report this problem[3]. Additionally, the open-ended responses from the young women provided rich insights into the difficulties that young women have in the science classroom. One young African American woman talked about her love of science, the science camps her family had sent her to, and the posters of African American scientists hanging in her bedroom. But when this young woman entered the science education system, she felt like she was "swimming against the tide." Another young African American woman reported that the science teachers "looked at us like we were not supposed to be scientists."

Another factor in the research process has to do with the samples that we use. STEM research based on non-representative samples of youth must be considered cautiously. Although findings from this research might help in formulating concepts and theory, it should not be (but often is) generalized. In sum, my research shows that the

[3] See Table A.3.3 in the Appendix for my findings using the Vignettes presented in Hanson (2009) Swimming Against the Tide.

methods we use to study gender and STEM need to be carefully considered. The ultimate goal of researchers should be to use multiple methods and representative samples.

Sources of optimism. Although my research shows a loss of talented young women from the STEM pipeline, my *research results have also provided me with considerable optimism* about the future of women in science. Some of the sources of optimism come from:

- The gains that women are making in STEM (course taking, achievement scores, degrees, and jobs). Recently, for the first time ever, girls were awarded both grand prizes in the prestigious Siemens national math and science competition.
- The high level of interest and engagement in STEM among young minority women and the important role of minority families and communities in creating and maintaining this interest (schools and educators need to be aware of this resource)
- The important resource that sport provides in enhancing young women's science access and achievement. My research has shown that sport encourages independence, teamwork, and competition – the same traits that tend to be associated with women's success in the male domain of science. Female athletes have an advantage in science over non-athletes. Young girls who are given an early opportunity to be involved in sport may well be less intimated and more prepared for the culture of science classrooms and work settings.
- The increasing body of research addressing issues regarding gender and STEM
- The ongoing support of research and programs on girls in STEM by organizations such as The National Science Foundation and the cumulative knowledge (as well as applications) resulting from this support
- The increasing evidence that there is a large and talented pool of women to fill the increased demand in STEM. Additionally, the compelling evidence that the absence of women and minorities in STEM robs employers of diverse

strategies, skills, and competence that translate into economic gain in an age of global markets

- My review of the education literature and surveys of young women show a clear direction for how we can change science education to make it more inclusive.[4] Other research supported by NSF concurs and, importantly, suggests that these changes would benefit all youth[5]. The young women in my sample suggested, e.g.: better preparation in STEM in the early years and access to advanced STEM tracks in the later years, making science more accessible, better trained and motivated teachers, smaller classes, more work in groups (cooperative learning), more hands-on experiences (and an active laboratory component), more gender and race diversity in science teachers and curriculum (especially textbooks), high expectations for all students, special programs to encourage women and minorities in science, and more access to mentoring and networking.

THE CURRENT STATUS OF RESEARCH ON THE INVOLVEMENT OF GIRLS IN STEM. WHAT DO WE KNOW?

In the paragraphs below I briefly highlight some of the recent research on girls in STEM. I begin the discussion with research compiled by NSF on myths associated with girls in STEM.

<u>Myths</u> The NSF Research on Gender in Science and Engineering program has published the following myths about girls and science based on findings generated by their funded research[6]:

1. *From the time they start school, girls tend to be less interested in science than are boys*. In fact, boys and girls start out with equal interest and abilities in science. Things start changing, though, as early as the second grade. One study showed that when

[4] Hanson, S.L. 2009. *Swimming Against the Tide*. Philadelphia: Temple University Press.
[5] National Science Foundation. 2007. Back to School: Five Myths about Girls and Science. (Press Release 01-108).
[6] http://www.nsf.gov/news/news_summ.jsp?cntn_id=109939

second grade boys and girls draw a scientist, most draw a while male in a lab coat. The scientist is generally shown to be alone with a beaker or test tube. When they draw women scientists she looks severe and unhappy.

2. *Classroom interventions that work to increase girls' interest in STEM turn off boys.* Researchers have found that what works to increase girls' interest in STEM also tends to increase boys' interest in STEM.

3. *Science and math teachers are not biased toward male students*. Research shows STEM teachers continue to interact more with boys than girls. They often encourage independence for boys and requests for help from girls.

4. *Parents can't do much to motivate girls when they are not interested in science.* Research shows that the support of parents is crucial to a girl's interest in STEM. Parents can make girls aware of STEM careers and their relevance. They can help in planning the courses and preparation which are required for a STEM career.

5. *Changing the STEM curriculum at the college level might water down important STEM coursework.* The idea of having to "weed out" weaker students tends to discourage young women in STEM. One researcher found that young women with B's in STEM classes are likely to perceive these as inadequate and drop out. Young men with C's, on the other hand, were more likely to persist in the class. Changes in STEM curriculum (e.g., working in pairs on programming in entry level computer science and engineering courses) contributes to greater retention for both men and women.

The National Science Foundation provides resources for teachers (and parents) in each of these areas of STEM education.

International trends   Although women are under-represented in many science systems around the world, some countries have been more successful in creating gender equity than others. Countries that have made great progress in this area include New Zealand, Iceland, Finland, Albania, and Thailand. Some scholars have suggested that we examine science education practices in these countries and attempt to implement successful strategies here[7]. Data from TIMSS (Trends in International Mathematics and Science Study) show that in the U.S. boys score higher than girls on fourth grade math and

[7] Davis, H. 2009 (http://www.kon.org/urc/v7/davis.html)

science scales. There are no sex differences on these scales in many of the countries examined. In others, girls score higher than boys [8].

The importance of nurture over nature The notion that boys are "naturally" better at math and science continues to be a popular one for many. A recent study on 3,000 pairs of British twins (at 9, 10, and 12 years of age) informs the nature vs. nurture debate in STEM. The researchers were able to examine the genetic and environmental influences on science ability. They found that there were no differences in standardized math and science achievement scores between boys and girls at any age. The researchers found no difference between the boys and girls in how they were influenced by genetic and environmental factors. Given these findings the authors conclude that causal factors influencing science achievement have more to do with attitudes than aptitude[9].

Media and image of scientists Young people often have a negative image about scientists. Many of the young women in my survey resisted science because they thought it was "dumb," "not fun," "boring," for "bookworms," "geeks," and "nerds." [10] Unfortunately, there are a considerable number of negative stereotypes about science. Not only is science seen as being for old white males, but it is also perceived as being boring, and those with an interest in science are sometimes labeled as geeks and nerds. One researcher asked science teachers to draw a picture of scientists using a Draw a Scientist Test (DAST) and discovered that these teachers often view scientists in the same negative way. The pictures tended to portray scientists as serious, ominous, lonely people [11]

Textbooks If students don't see images in textbooks of people that look like themselves, they cannot connect. Science textbooks are improving but they continue to

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[8] Lamb, T.A. and R. Bybee. 2005 (http://www.asanet.org/footnotes/jan05/fn10.html).
[9] Haworth, C., Dale, P., Plomin, R. 2009. Sex differences and science: the etiology of science excellence. Journal of Child Psychology and Psychiatry DOI: 10.111/j.1469-7610.2009.02087.x
[10] Hanson, S.L. 2009. Swimming Against the Tide. Philadelphia: Temple University Press.
[11] See research by Vinchez-Gonzalez, J. M. and F.J.P Palacios. 2006. "Image of science in cartoons.." Physics Education 41 (3): 240-49. and McDuffie (2001) (http://proquest.umi.com/pqdlink?Ver=1&Exp=07-13-2014&FMT=7&DID=73462424&RQT=309&clientId=31807&cfc=1)

disproportionately show images of male scientists. Recent NSF funded research at Colorado State University found that 66% of images in elementary science textbooks were male and 34% were female[12].

Evidence from single-sex STEM education Research has shown the success of single-sex girls' schools in recruiting young women into STEM courses. A disproportionate number of women scientists have spent time in single sex colleges. The presence of a critical mass of women has been suggested to be an important ingredient for this success.[13] In 2006, researchers at the University of Michigan studied the progress of girls in a single-sex and coed school in similar math classes. When the researchers examined the math proficiency scores for these two groups of women, they discovered that the young women in the single sex school outscored those in the coed school by over 50%[14]

Resources Girls have fewer out-of-school science experiences than do boys. Researchers stress the importance of exposing girls to out-of-school programs at an early age. Successful programs such as "The Magic of Chemistry" program sponsored by the University of Missouri tend to involve hands-on activities, role models, emphasis on practical applications, and equitable learning environments for girls[15].

HOW CAN DISSEMINATION OF THESE RESEARCH FINDINGS BE IMPROVED SO THAT FORMAL AND INFORMAL EDUCATORS AND EDUCATION POLICYMAKERS IMPLEMENT BEST PRACTICES?

We have a perfect opportunity to increase the dissemination of research on best practices for girls in STEM. President Obama's economic stimulus package involving federal research monies has given the green light to increasing our knowledge about science education. Discussions about rigorously applying Title IX to STEM education (as in sport) are beginning. This is a tremendous opportunity for organizations such as NSF

[12] http://www.cmmap.org/scienceEd/colloquium/colloquium08/April_Biasiollia.ppt
[13] See Hanson, S.L. (2009) Swimming Against the Tide for a brief review of this research.
[14] http://sitemaker.umich.edu/johnson.356/math___science_education
[15] Tucker, S.A., D.L Hanuscin, and C.J. Bearnes. 2008. 'Igniting girls' interest in science." Science 319: 1621-22.

(National Science Foundation), WEPAN (Women in Engineering Proactive Network), NCES (National Center for Education Statistics), the NSB (National Science Board), NRC (the National Research Council) and others who collect data and fund research and programs on girls in STEM. These organizations have considerable knowledge and expertise on best practices. We know a lot about the changes we need to make in STEM classrooms. Only with the assistance of the U.S. Department of Education and mandated science standards can we assure that these resources would be required tools for all science teachers. The new practice guide by the National Center for Education Research ("Encouraging Girls in Math and Science") offers five recommendations for schools and teachers for increasing girls' participation and interest in science. Guides such as this one need to be integrated in a routine way into U.S. STEM programs. Girls deserve equal access to STEM. The Title IX legislation brought about tremendous change and improvement in young women's access to sport in public schools by requiring evidence of progress toward equity. We could do the same in science. Both boys and girls would benefit from improving our STEM education.

Mr. Chairman, this concludes my remarks. I would be happy to answer any questions.

APPENDIX: Tables and Figures

Appendix table 1-2

Average mathematics scores of students in kindergarten and grades 1, 3, and 5, by student and family characteristics: 1998, 2000, 2002, and 2004

Student/family characteristic	Fall 1998 kindergarten	Spring 2000 grade 1	Spring 2002 grade 3	Spring 2004 grade 5	Gain from kindergarten to grade 5
All students	22	39	91	112	89
Sex					
Male	22	39	93	114	92
Female	22	39	89	110	87
Race/ethnicity					
White, non-Hispanic	25	43	97	118	93
Black, non-Hispanic	19	33	79	99	80
Hispanic	19	36	85	108	89
Asian	25	39	94	118	93
Other[a]	20	38	86	107	86
Mother's education					
<High school	17	29	75	95	79
High school diploma	21	37	86	107	86
Some college[b]	22	39	92	113	90
Bachelor's or higher degree	28	47	103	125	97
Poverty status[c]					
Below poverty threshold	18	31	78	99	81
Above poverty threshold	24	42	95	116	92

[a]Includes non-Hispanic Native Hawaiians, Pacific Islanders, American Indians, Alaska Natives, and children of more than one race.
[b]Includes vocational and technical education.
[c]Federal poverty thresholds define households below poverty level based on household income and number of household members.

NOTES: Early Childhood Longitudinal Study (ECLS) mathematics scale ranged from 0 to 153. In 2004 followup for ECLS kindergarten class of fall 1998, 86% of cohort was in grade 5, 14% was in a lower grade, and <1% was in a higher grade. For simplicity, students in ECLS followups referred to by modal and expected grade, i.e., first graders in spring 2000 assessment, third graders in spring 2002 assessment, and fifth graders in spring 2004 assessment.

SOURCES: National Center for Education Statistics, ECLS, fall 1998 and spring 2000, 2002, and 2004; and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Science and Engineering Indicators 2008

Table A.3-3: Multiple Classification Results Showing Means (and Deviations from Sample means) on Science Variables for Young Women by Type of Vignette†

Vignettes	Science Outcomes: Has This Ever Happened to You	Science Outcomes: Others Like Woman in Vignette Don't Feel Welcome in Science
A. Sample: African American Women		
1. Girl in Vignettes: African American		
• Race as issue	.31 (.06)	.52 (.12)
• Gender as issue	.16 (-.08)	.53 (.14)
• Neutral	.53 (.29)	.63 (.23)
2. Girl in Vignettes: White		
• Gender as issue	.21 (-.03)	.35 (-.05)
B. Sample: White Women		
1. Girl in Vignette: African American		
• Race as issue	.16 (-.07)	.36 (-.04)
• Gender as issue	.18 (-.06)	.36 (-.03)
• Neutral	.36 (.11)	.39 (-.01)
2. Girl in Vignette: White		
• Gender as issue	.18 (-.06)	.31 (0.08)
Mean across groups	.24	.40
F	9.95*	5.03*

* Anova model is significant at .05 level.

† Higher score indicates greater support for the student which, in general measures problems/discomfort in science,

Table: SAT Table A.3-3

Figure 1. Percent of degrees awarded to women by major field

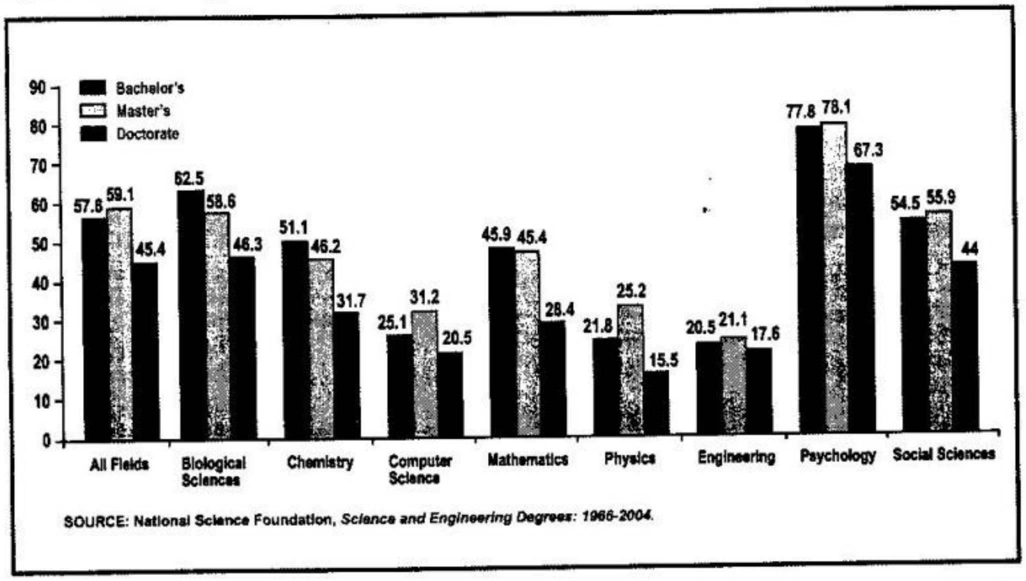


Figure 2. Percent of public high school graduates who completed various mathematics and science courses in high school, by gender: 2000

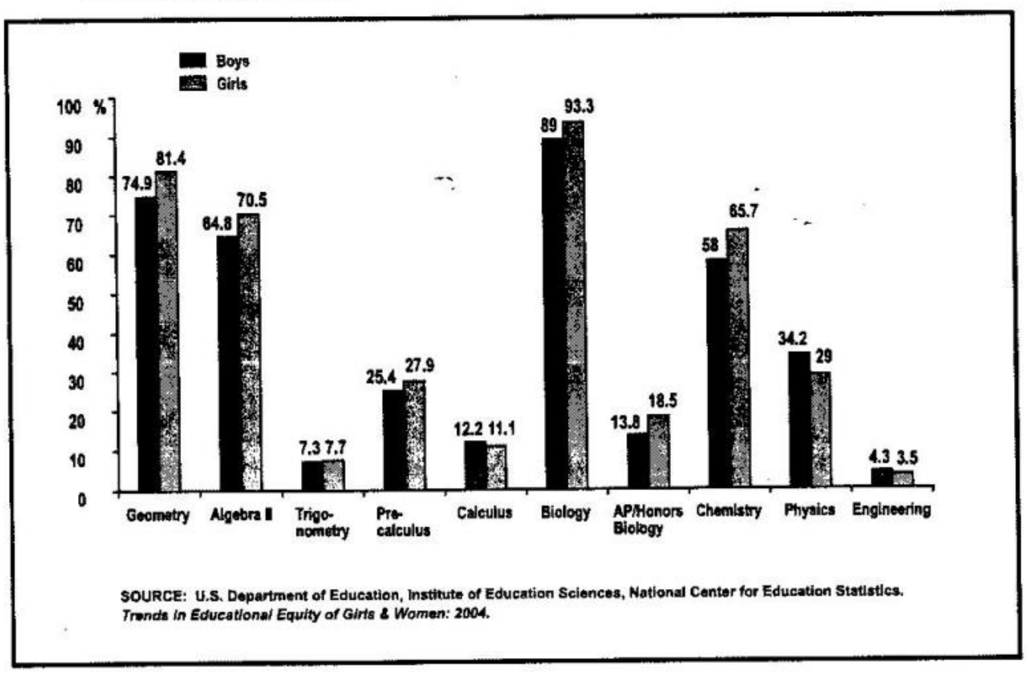
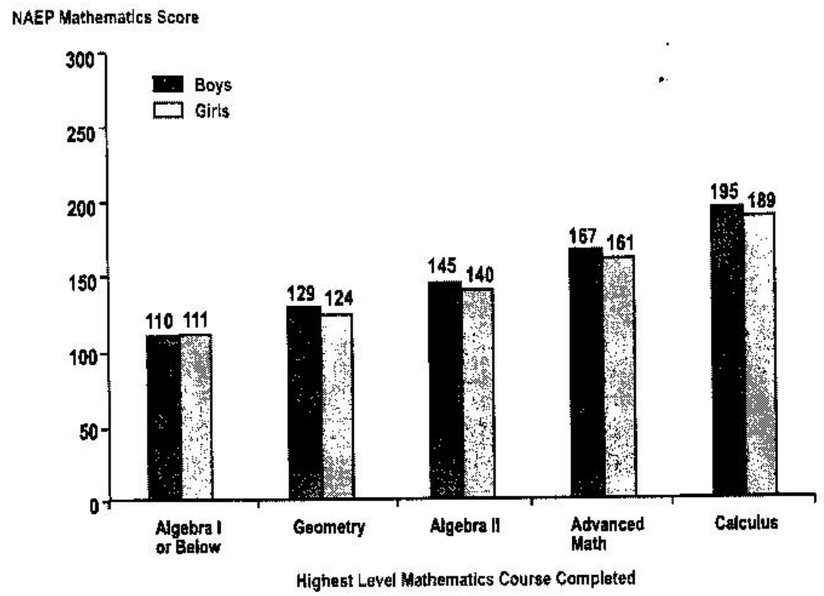


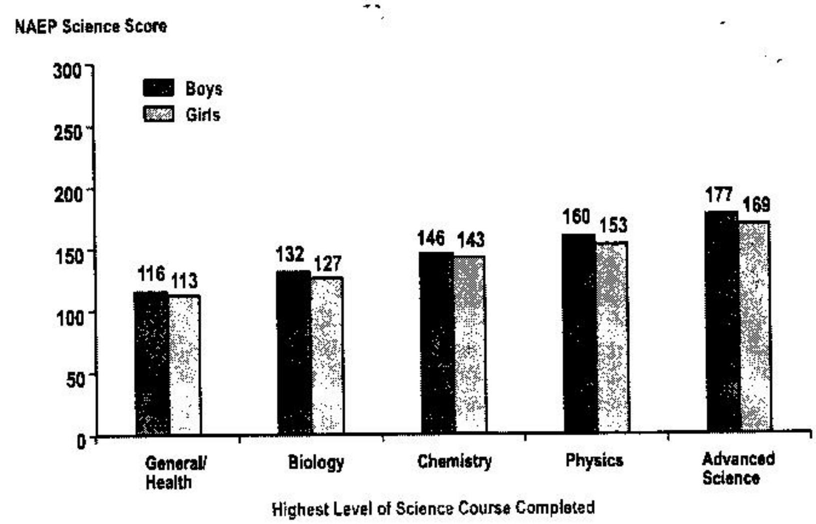
Figure 3. NAEP mathematics scores by highest course completed and gender: 2005



NOTE: Advanced mathematics courses, other than calculus, are courses generally taken after Algebra II (e.g., AP statistics and precalculus).

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS), 2005.

Figure 4. NAEP science scores by highest course completed and gender: 2005



NOTE: Advanced science courses are courses that contain advanced context (like AP Biology, IB Chemistry, AP Physics, etc.) or are considered second-year courses (Chemistry II, Advanced Biology, etc.).

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS), 2005.