

# The Unequal Distribution of Women in Science Careers

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*For Presentation at:*

7<sup>th</sup> Gender European Summit

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# Women in Academic Science: A Changing Landscape

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Psychological Science in the  
Public Interest  
2014, Vol. 15(3) 75–141  
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DOI: 10.1177/1529100614541236  
[pspi.sagepub.com](http://pspi.sagepub.com)



## Other work of mine on women in STEM

- “Does Science Promote Women? Evidence from Academia 1973-2001” in *Science and Engineering Careers in the United States* [joint with Donna Ginther., Richard Freeman and Daniel Goroff (eds), Chicago, IL: University of Chicago Press for NBER, 2009.
- “Women in Academic Science: A Changing Landscape.” With Stephen Ceci, Donna Ginther and Wendy Williams. *Psychological Science in the Public Interest* 15(3), 2014.
- Comment on “Expectations of brilliance underlie gender distributions across academic disciplines” with Donna Ginther. Technical Comment. *Science* 24 July 2015: Vol. 349 no. 6246 p. 391
- “Education and Academic Career Outcomes for Women of Color in Science and Engineering” with Donna Ginther. In *Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia: A Conference Report*. Wash D.C: National Academy Press, 2013.
- “Gender Differences in Academic Promotion and Mobility at a Major Australian University.” *Economic Record* 88(282). September 2012, pp. 407-424.

# Other work of mine on women in STEM

## Economists:

- "Gender Differences in Academic Career Paths of Economists." *American Economic Review (Papers and Proceedings)* 83(2), May 1993, 52-56.
- "Women in the Economics Profession." *Journal of Economic Perspectives* IX(4), Fall 1995, 193-205.
- "Women in Economics: Moving Up or Falling Off the Academic Career Ladder?" (With Donna K. Ginther). *Journal of Economic Perspectives*, 18(3), Summer 2004.

## Social Scientists in general:

- "Women's Careers in Academic Social Science: Progress, Pitfalls and Plateaus" with Donna Ginther. *The Economics of Economists*, Alessandro Lanteri and Jack Vromen, eds. Cambridge, UK: Cambridge University Press, 2014.

# Other work of mine on women in STEM

## Engineers:

- Are recent cohorts of women with engineering bachelors less likely to stay in engineering? with Donna Ginther. *Frontiers in Psychology*. August 19, 2015.

## Biomedical Science:

- Gender, Race, Ethnicity and NIH R01 Research Awards: Is There Evidence of a Double Bind? with Donna K. Ginther and Walter T. Schaffer. (under revise and resubmit at *Academic Medicine*, sequestered).
- The Gender Gap in Academic Biomedical Salaries with Donna Ginther. (submitted)

# Main conclusions

## 1. Early

The major gender differences in STEM careers start well before college.

## 2. Mutable

There are gender differences in measured math ability (average and at the top tail), but they are highly mutable (changeable) and shrinking.

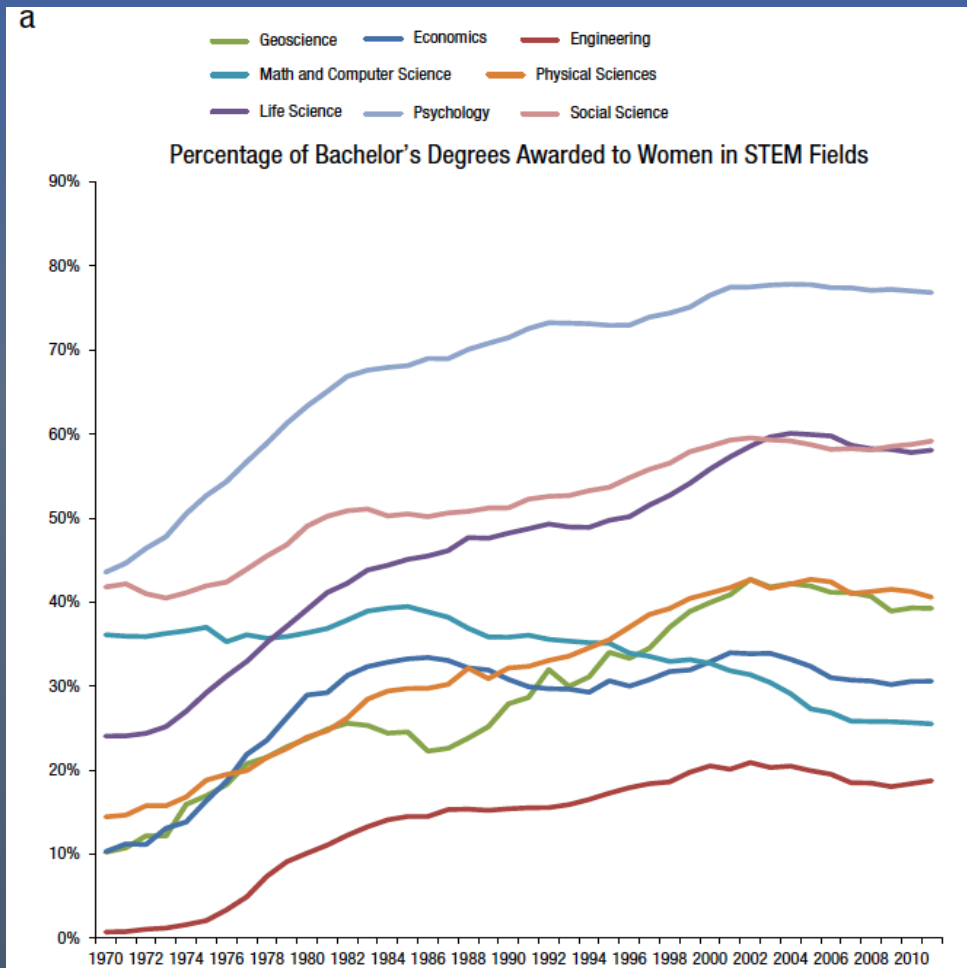
## 3. The pipeline doesn't leak everywhere for all fields.

There are definitely some transitions where bias does not slow women in some fields from being successful.

## 4. Math-intensive fields better.

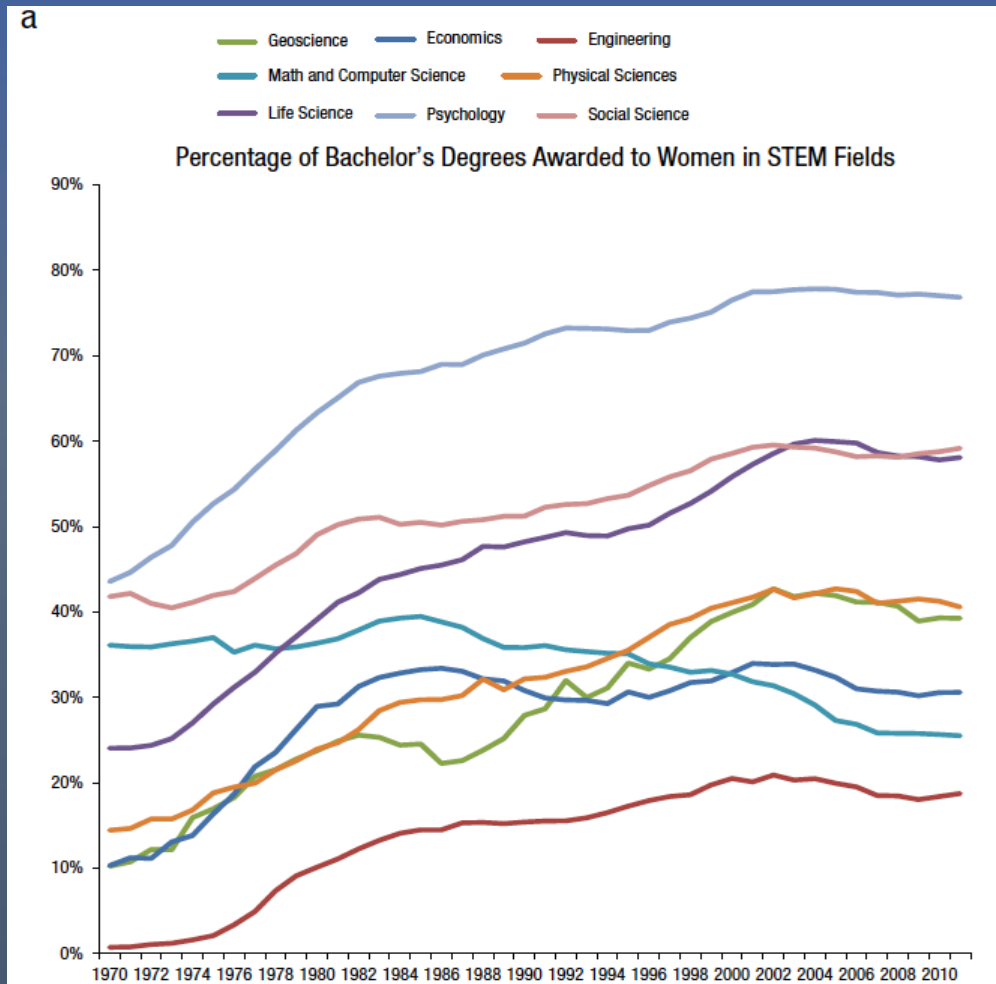
In academia, women have more equal treatment in math-intensive fields than other sciences.

# Majors of women and men in college are very different.



Women receive 55% of bachelor's degrees, 50% of STEM bachelor's degrees.

# Majors of women and men in college are very different.



STEM fields are not all alike.  
We divide STEM into:

**LPS**—Life Science, Psychology & Social Science (excluding Economics)

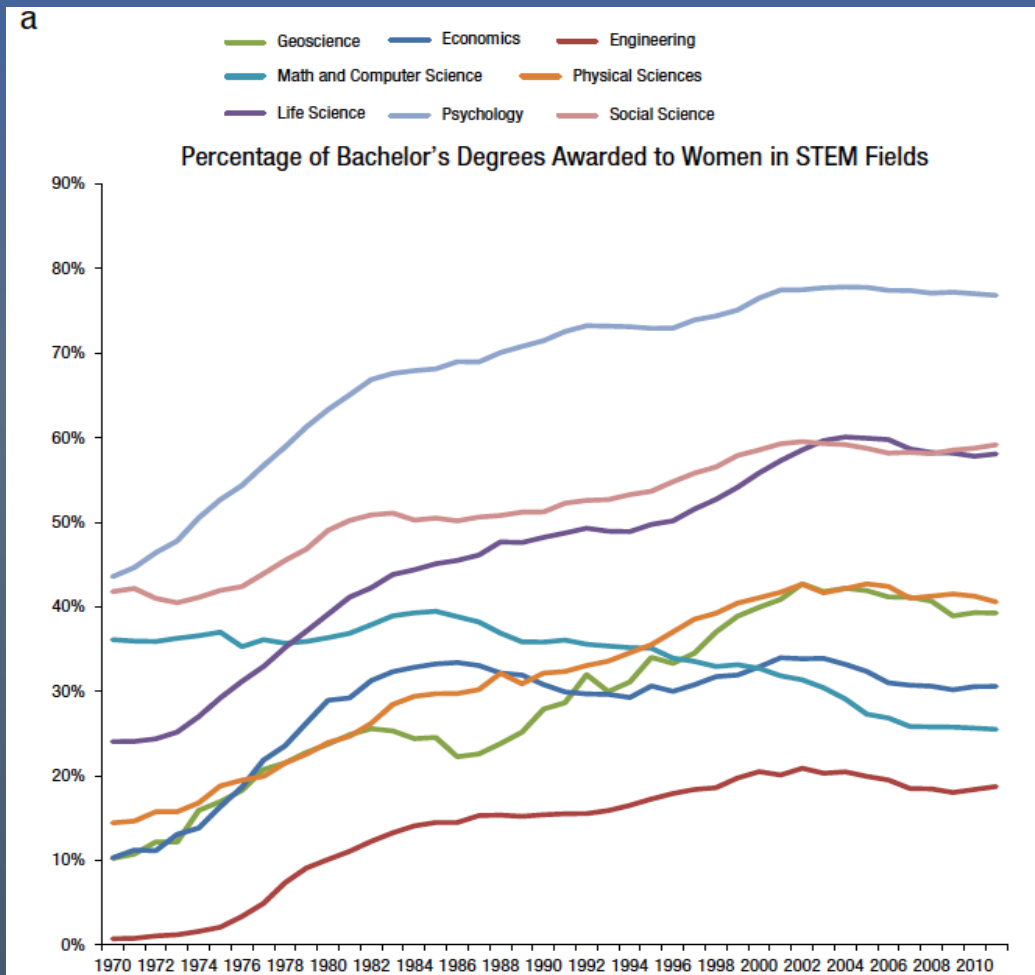
**GEEMP**—Geoscience, Economics, Engineering, Math & Computer Science & Physical Sciences.

GEEMP fields are more math-intensive.

Women receive less than 30% overall of GEEMP bachelor's degrees (even recently).



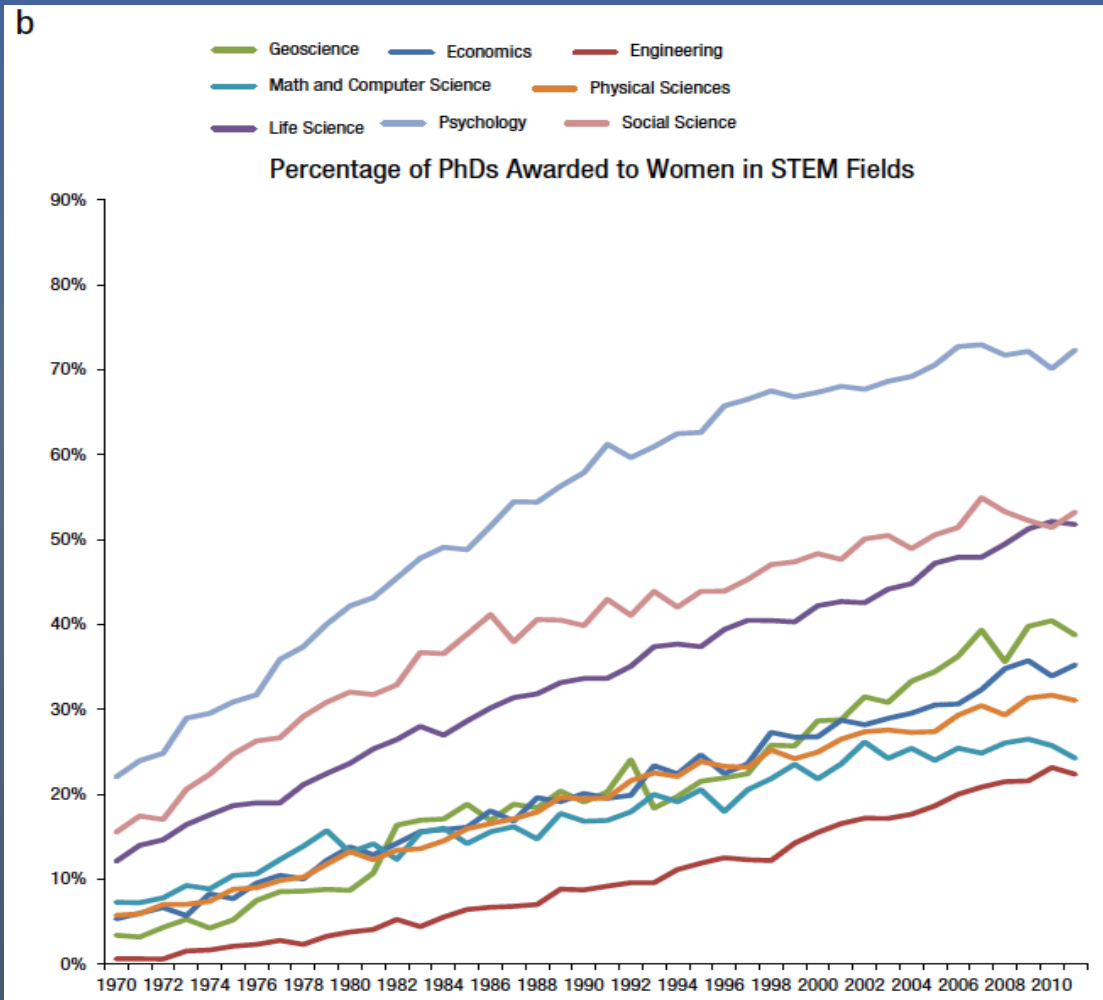
# Majors of women and men in college are very different across STEM fields.



With the exception of Math & Computer Science, the percentage of bachelor's degrees awarded to women in all STEM fields increased between 1970-1984s.

Since then growth of women mostly in LPS.

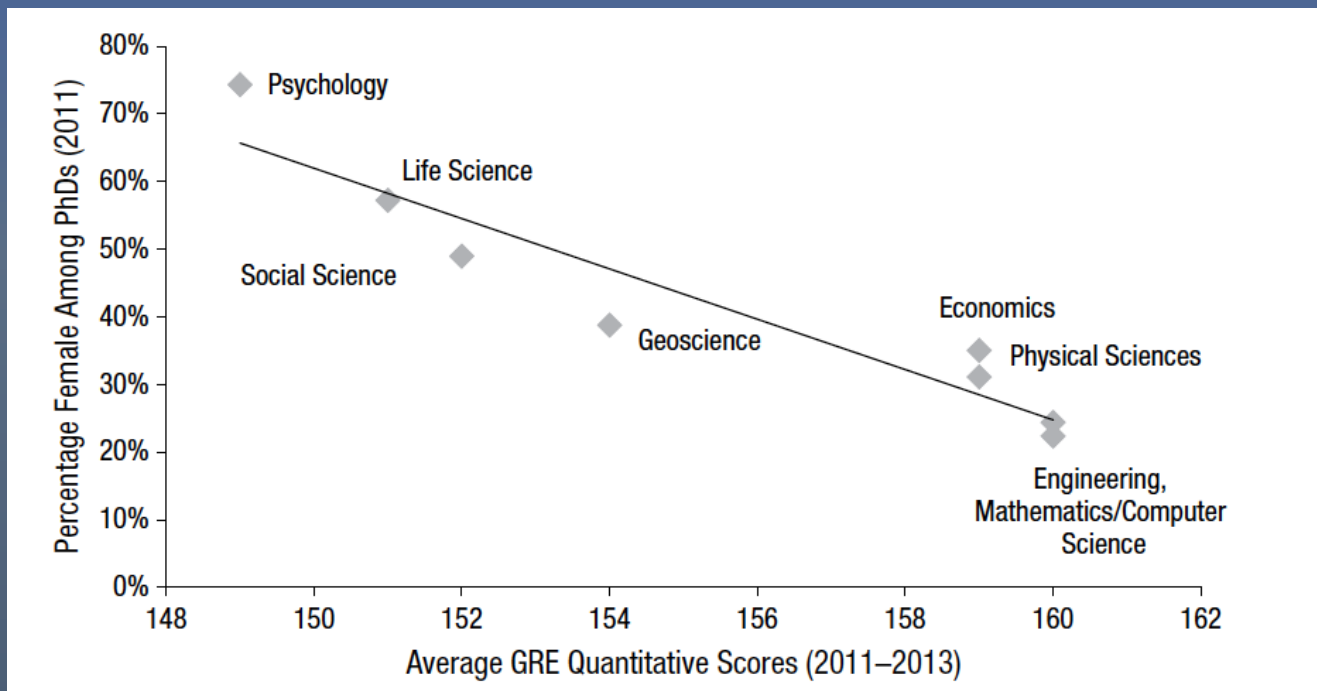
# PhDs of women and men are similarly different across STEM fields.



There is steady growth in women's representation in all fields.

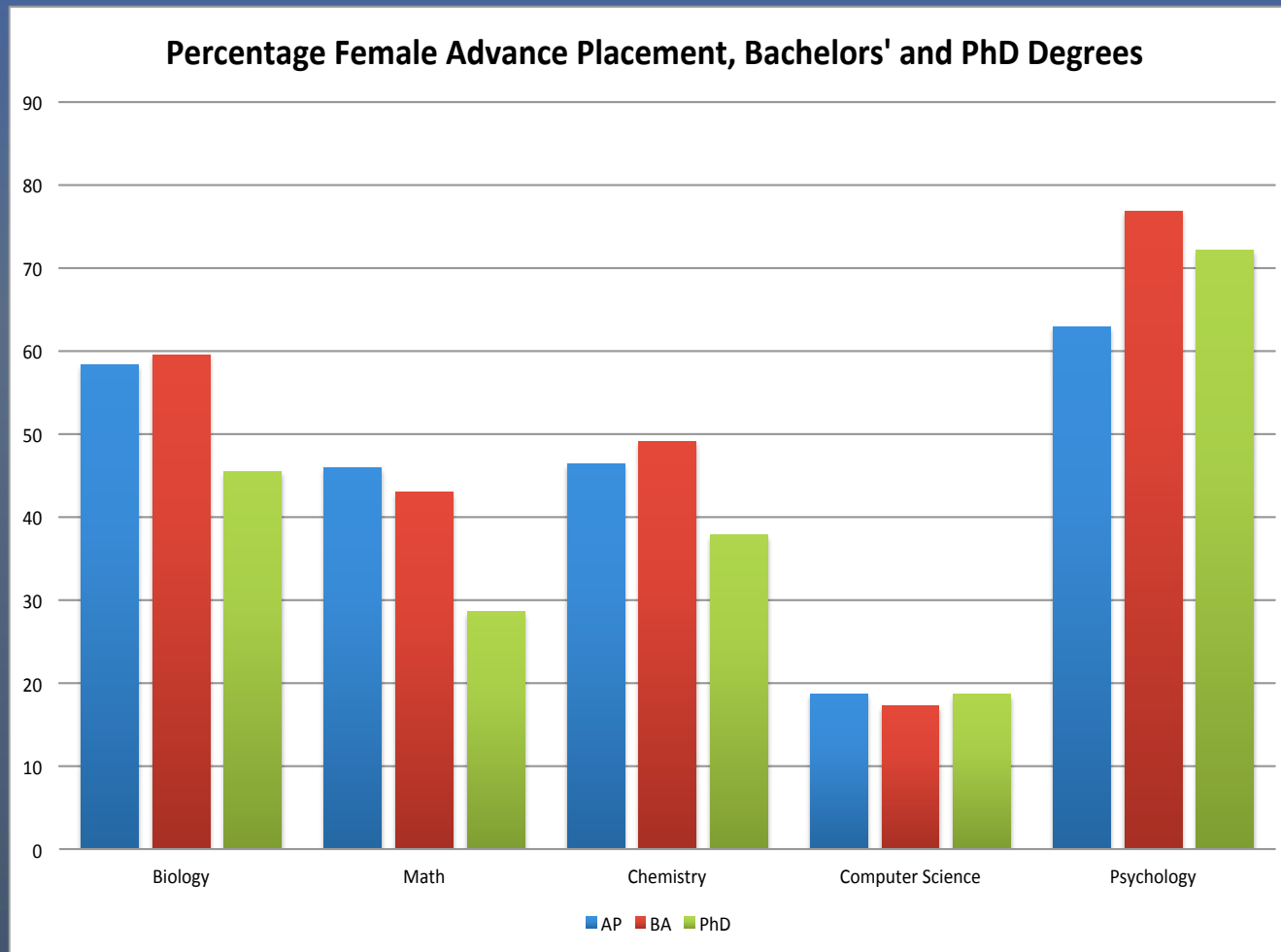
But LPS is far ahead of GEEMP.

# Distribution of **PhD** fields' math requirements are highly correlated with percentage of Female PhDs in field



Women are significantly less likely to obtain PhDs in fields with higher average GRE quantitative scores.

The distribution of women across fields is generally similar in **high school** AP STEM exams and **college** majors.



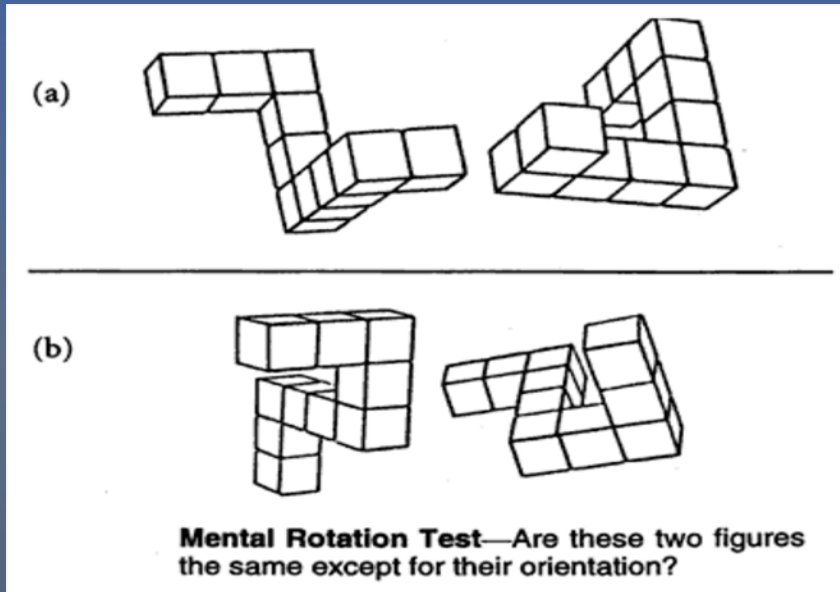
STEM field specialization starts very early.

If gender differences in choices to pursue specific STEM fields are determined before college, and field choice seems highly correlated with fields' required math ability ... then the key is what affects boys' and girls' STEM math ability which correlates with their interests



# Earliest sex differences in spatial ability

- Spatial skills have *some* predictive power in determining choices for STEM but not all that much.



- Young male infants outperform females in mental rotation tasks in some studies; in others they don't.
- This early mental rotation ability is highly correlated with early environmental differences (e.g. crawling).

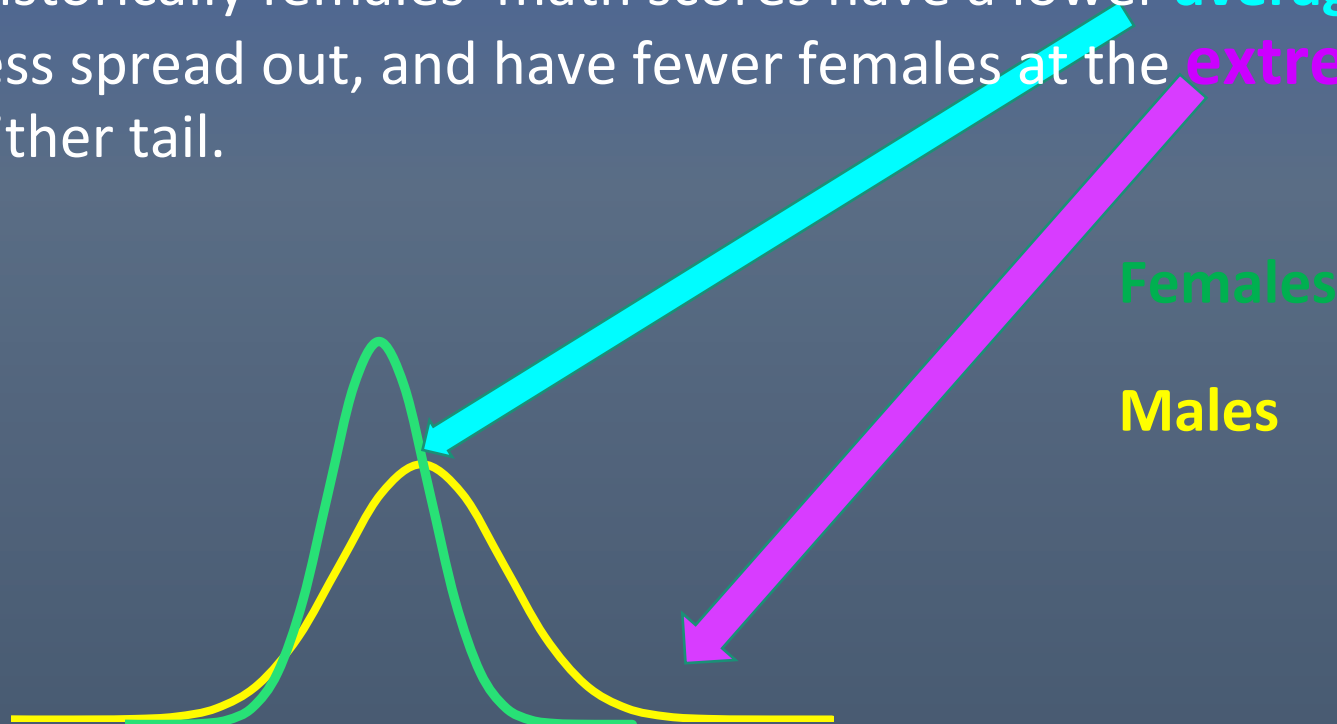
- Among adults, mental rotation is important for engineering (and correlated with gender), but these skills can be easily taught (e.g. Sorbey and Baartmans 2000).

This is the first indication that mathematics is **mutable** –  
it changes, and can be changed

To measure math ability in school – we look at the **average** math test scores, at the spread in test scores, and the percent in the **top tail**

This is a schematic of the distribution of math test scores.

Historically females' math scores have a lower **average**, are less spread out, and have fewer females at the **extremes** at either tail.





# Gender differences in **average** math ability are mutable: They change with grade

## Differences between Boys and Girls in Avg. US NAEP Math Test Scores

Mean and Variance (hundreds of thousands of observations)

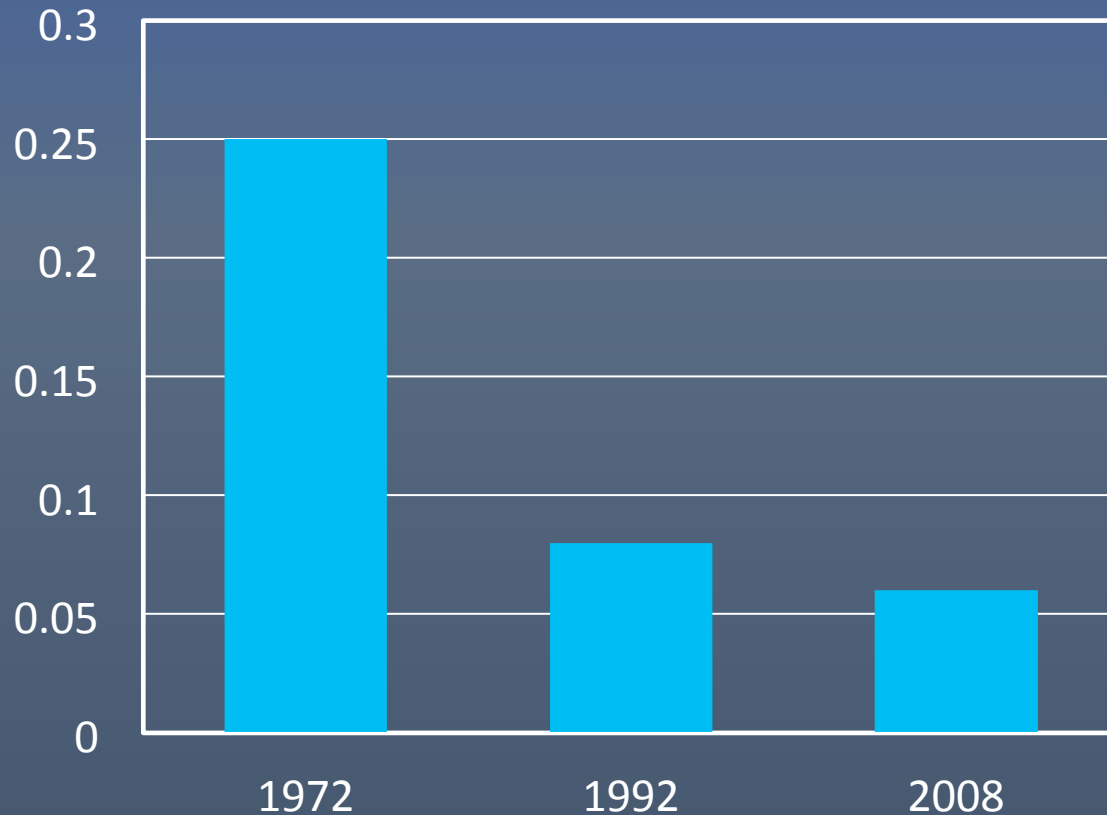
From Hurler, Liskow, Ling, Ellis, Williams, Science, Sept. 2, 2008

	<b>Avg Male – Avg Female difference</b> (measured in standard deviations)	<b>Variance of males/ variance of females</b>
<b>Grade 2</b>	<b>0.06</b>	<b>1.11</b>
<b>Grade 3</b>	<b>0.04</b>	<b>1.11</b>
<b>Grade 4</b>	<b>-0.01</b>	<b>1.11</b>
<b>Grade 5</b>	<b>-0.01</b>	<b>1.14</b>
<b>Grade 6</b>	<b>-0.01</b>	<b>1.14</b>
<b>Grade 7</b>	<b>-0.02</b>	<b>1.16</b>
<b>Grade 8</b>	<b>-0.02</b>	<b>1.21</b>
<b>Grade 9</b>	<b>-0.01</b>	<b>1.12</b>
<b>Grade 10</b>	<b>0.04</b>	<b>1.18</b>
<b>Grade 11</b>	<b>0.06</b>	<b>1.17</b>

Differences disappear, then start reappearing in high school (others find middle school).

# Gender differences in **average** math ability are mutable: They change with time

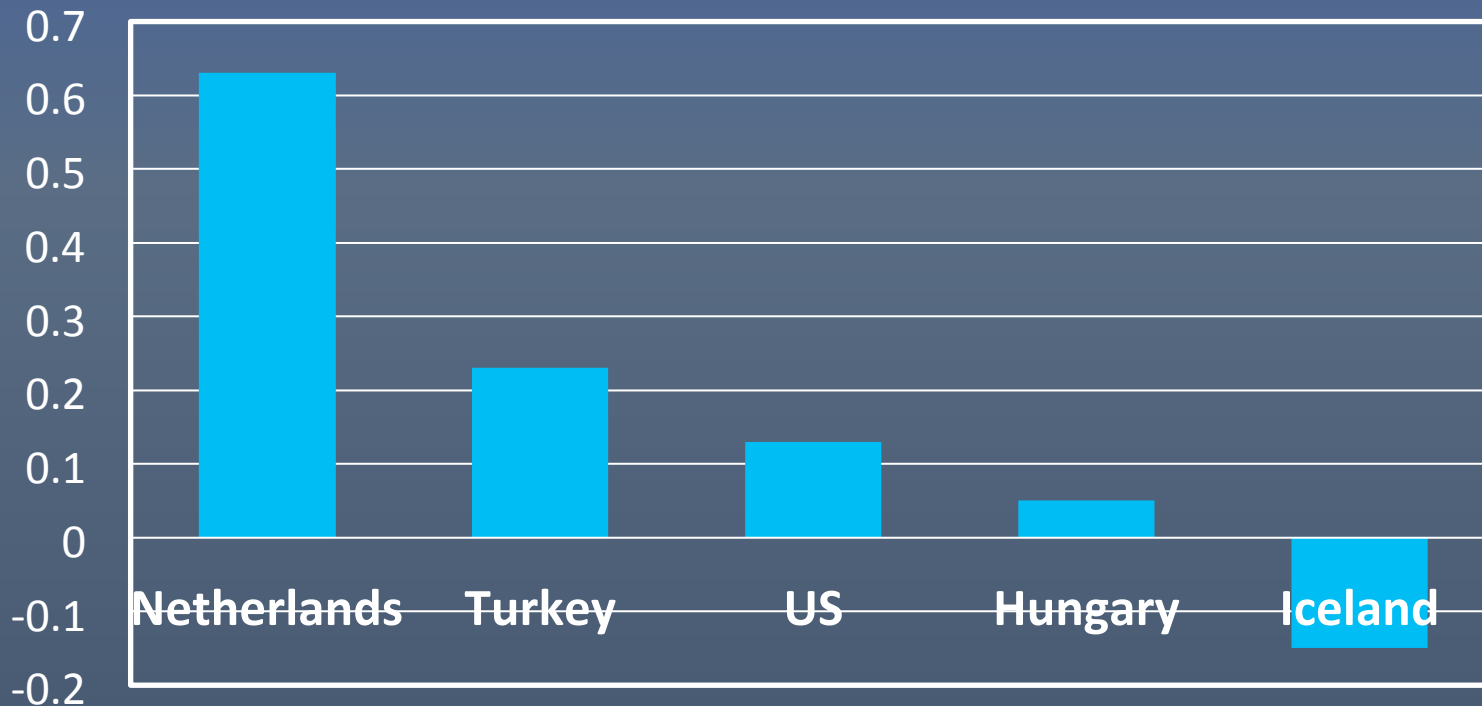
Average Male – Average Female High School math scores  
(in standard deviations)



Gender differences in **average** math ability are mutable:

They are different in different countries

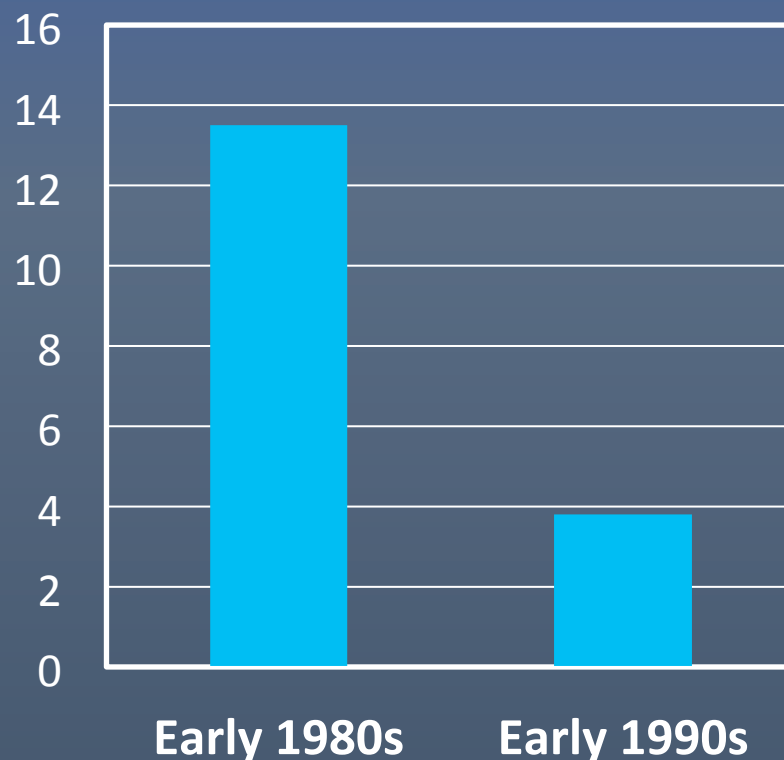
Average Male – Average Female math scores (2003)  
(in standard deviations)



Gender differences in **top tail** of math ability are mutable:

They change with TIME

Number of boys per girl in **top .01%** of math scores (7th grade)

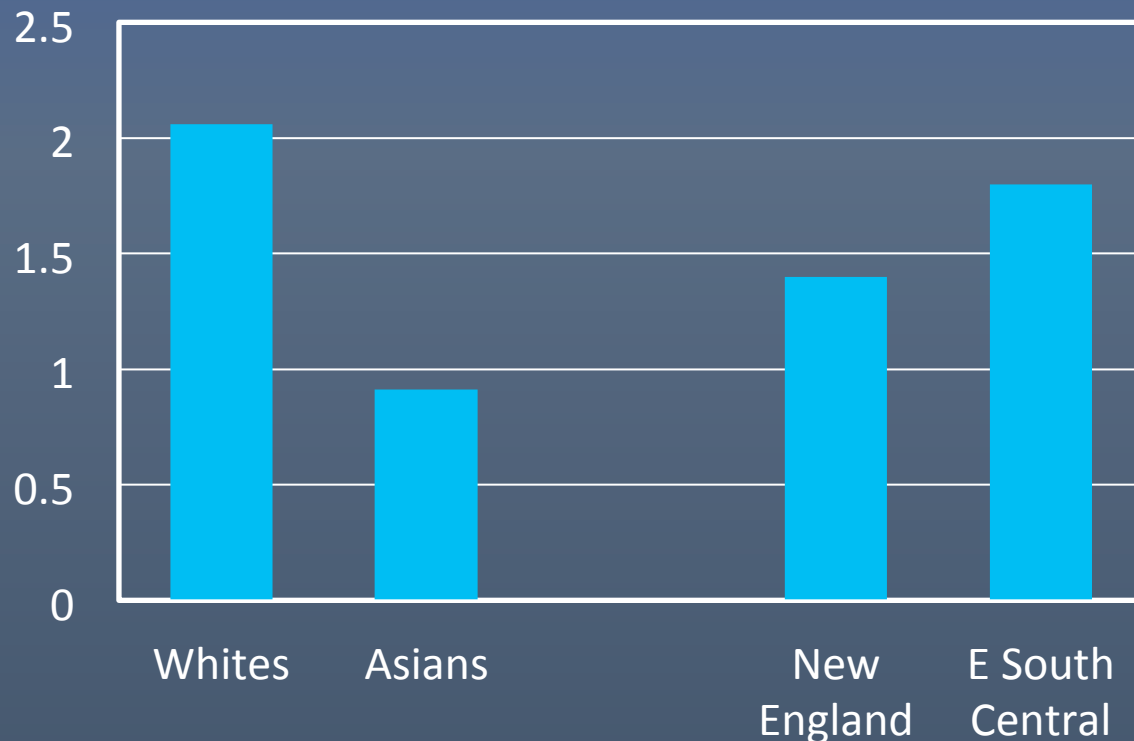


Gender differences in **top tail** of math ability are mutable:  
They change with US race and region

## Number of boys per girl

In top 1% math scores

in top 5% math scores



# Why do fewer girls perform well in math?

Considerable evidence of stereotype threat

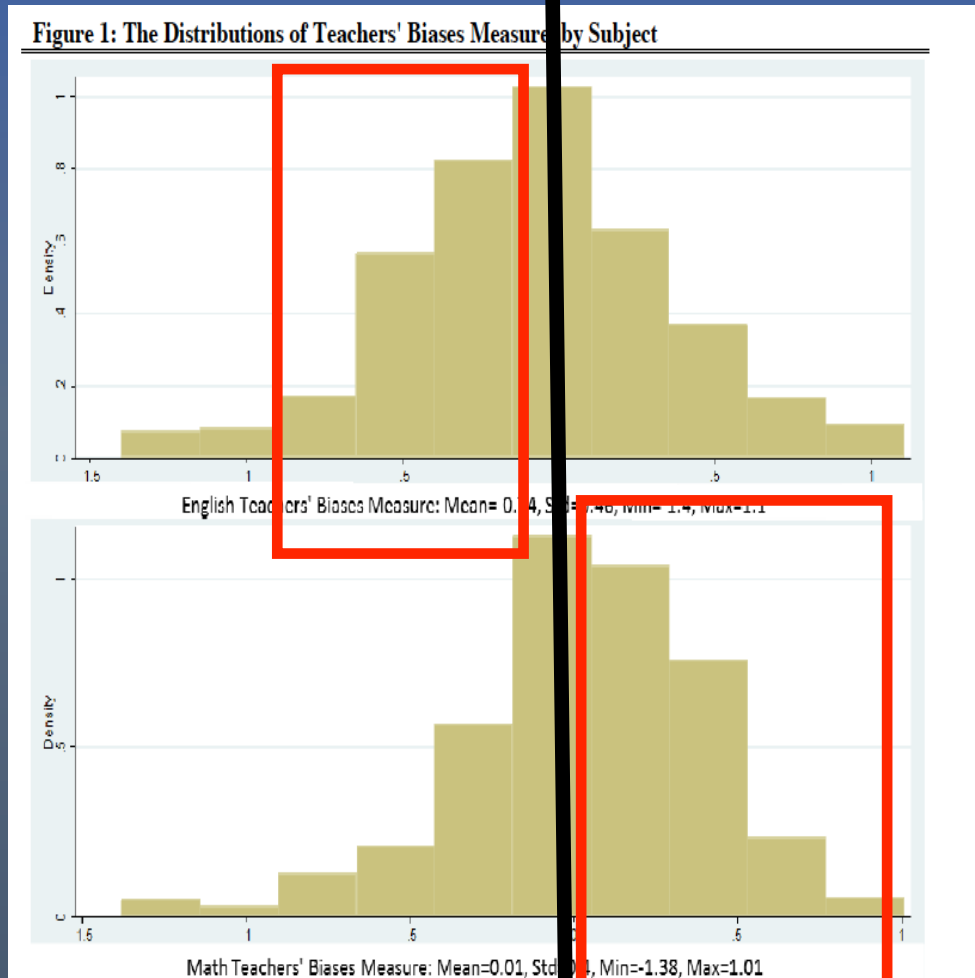
- Regional gender norms affect gender gap.
  - The gender math gap in the top tails is much narrower in areas with a norm of gender equality (like Northeast) than in than in Southern states with more traditional gender norms (Pope & Sydnor ).

# Teachers and parents perpetuate stereotype biases. e.g. Lavy & Sand (2015)

(In Israel. Teacher bias is identified by comparing results to blinded national tests. Teachers were randomly assigned.)

English teachers are biased in favor of girls (distribution is left of zero).

For math teachers, the right tail shows significant bias in favor of boys in mathematics.



Gender differences in math ability are mutable:  
Educators can do things that minimize or accentuate the stereotype threat

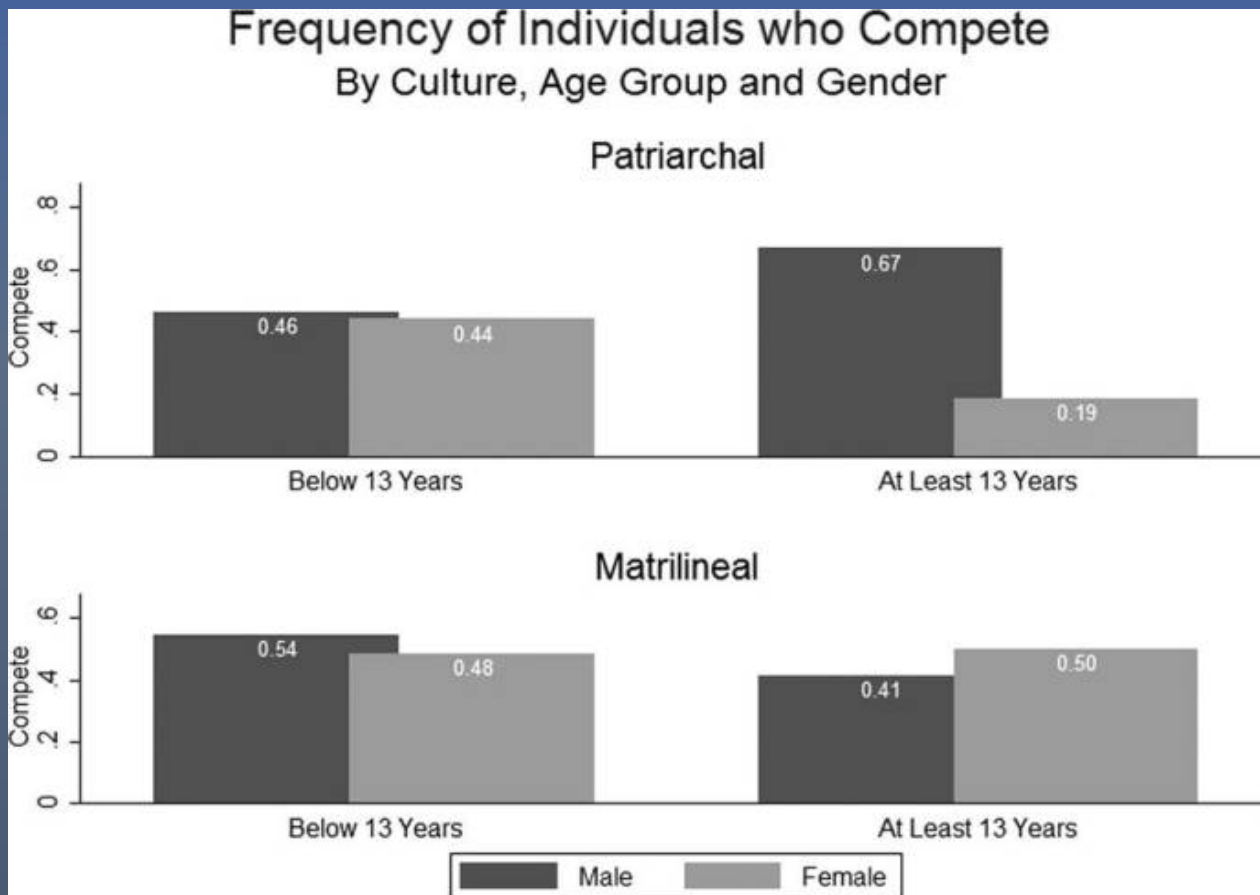
- Girls and minorities do much better in high school math classes if they are primed before and during the class **to think that math is something that can be learned** (as opposed to being inherent) (e.g. Good, Aronsom and Inzlicht 2003, Bages and Martinot 2011)
- If people **check the gender box before** they take the math SAT instead of after, girls do worse.
- Girls do much better if a problem is **posed as an art problem** instead of a math problem.



Why do fewer girls perform well in math?  
Experiments show that girls shy away from competing, particularly with boys

- Many experiments showing that girls perform better when competing against other girls & worse where boys outnumber the girls etc. (e.g. Niederle & Vesterlund 2010)
- However, shying away from competition is cultural and mutable...

One experiment compared competitiveness in two societies, one matrilineal and one patriarchal & patrilineal (in NE India) (Andersen, Ertac, Gneezy, List, Maximiano 2013)



# Main conclusions #1 and #2

## 1. Early

The major gender differences in STEM careers start well before college.

## 2. Mutable

There are gender differences in measured math ability (average and at the top tail), but they are highly mutable (changeable) and shrinking.

There are no measurable differences in  
women and men leaving STEM during  
college (both do it)

or in changing their STEM field

(remember the graph with AP field and college major)

Are there gender differences in graduate scientific education and careers for those who did pursue STEM in college?

The pipeline doesn't leak everywhere at all transitions.

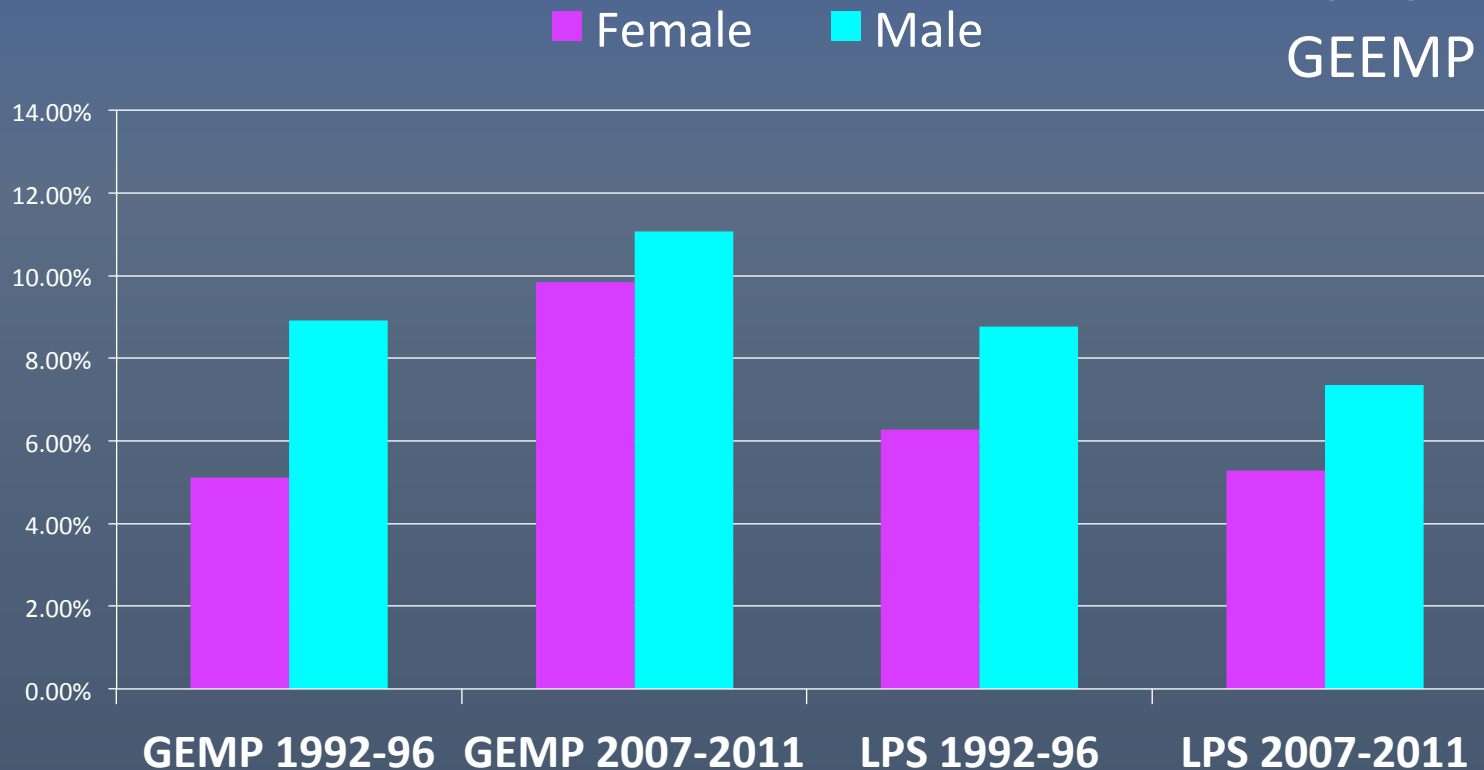


	LPS	GEMP
PhD Programs	<b>Fewer females than males transition from majors to PhDs.</b>	The percent of baccalaureates who transition from BA to PhDs is equivalent for both sexes.
Biased Interviewing/Hiring	Fewer % of female PhDs applying for TT posts. No evidence that women applicants are hired into TT posts less often than men; good evidence that they are offered these posts more often, both in real-world hiring and in experimental studies.	
Publications	Men are more productive in journal publishing. Gap narrowed through mid-90s but then plateaued.	
Citations	Although women publish fewer papers, there are no sex differences in citations per article.	
Grants	Women apply for fewer grants, particularly follow-up ones. Women are equally likely as men to get NIH grants that they apply for. Men on average get larger grants because they are PIs on larger projects.	
Biased Work Evaluation	Editors and grant reviewers rate both sexes equivalently.	
Tenure and Promotion	<b>Some evidence of women having harder time getting tenure in biology and psychology.</b>	No evidence of women having harder time getting tenure in any GEMP field but economics.
Salary	Mixed evidence— <b>women in life science paid less than men at assistant professor rank.</b> Children explain half of this gap. Others paid equivalently.	<b>Economists (assistant and full professors), and geoscience, engineering, and physical science full professor women paid less than men.</b> Others paid equivalently.
Opting Out	Fewer female PhDs apply for TT positions. In the life sciences more women leave between PhD and obtaining a tenure track position.	There are no sex differences in the likelihood of entering a TT job or in leaving academic science. However women are more likely to leave non-academic engineering careers.
Job Satisfaction	<b>Women are less satisfied in social science.</b> Recently, women and men are similar in other LPS fields.	<b>Women are less satisfied in economics.</b> Recently, women and men are similar in other GEMP fields.
Children and Opting Out	In the life sciences and social sciences, women are more likely to leave between PhD and tenure track positions if they are married and/or have children.	No evidence that marriage or children deter women entering tenure track jobs in physical science or engineering.

# Women STEM majors are less likely to enter and complete STEM PhDs (data from NSF SESTAT )

## Estimated Percentage of STEM Bachelors Graduating with PhDs

Differences narrowed in GEEMP only





# Female applicants are more likely to be offered academic STEM positions.

Fraction of Female Applicants for Tenure-Track Positions Invited to Interview and Offered Positions at 89 Research Universities

FIELD	Mean % Female Applicants	Mean % Invited to Interview	Mean % Offered Position
Physics	12%	19%	20%
Biology	26%	28%	34%
Chemistry	18%	25%	29%
Civil Eng.	16%	30%	32%
Electr. Eng.	11%	19%	32%
Mathematics	20%	28%	32%

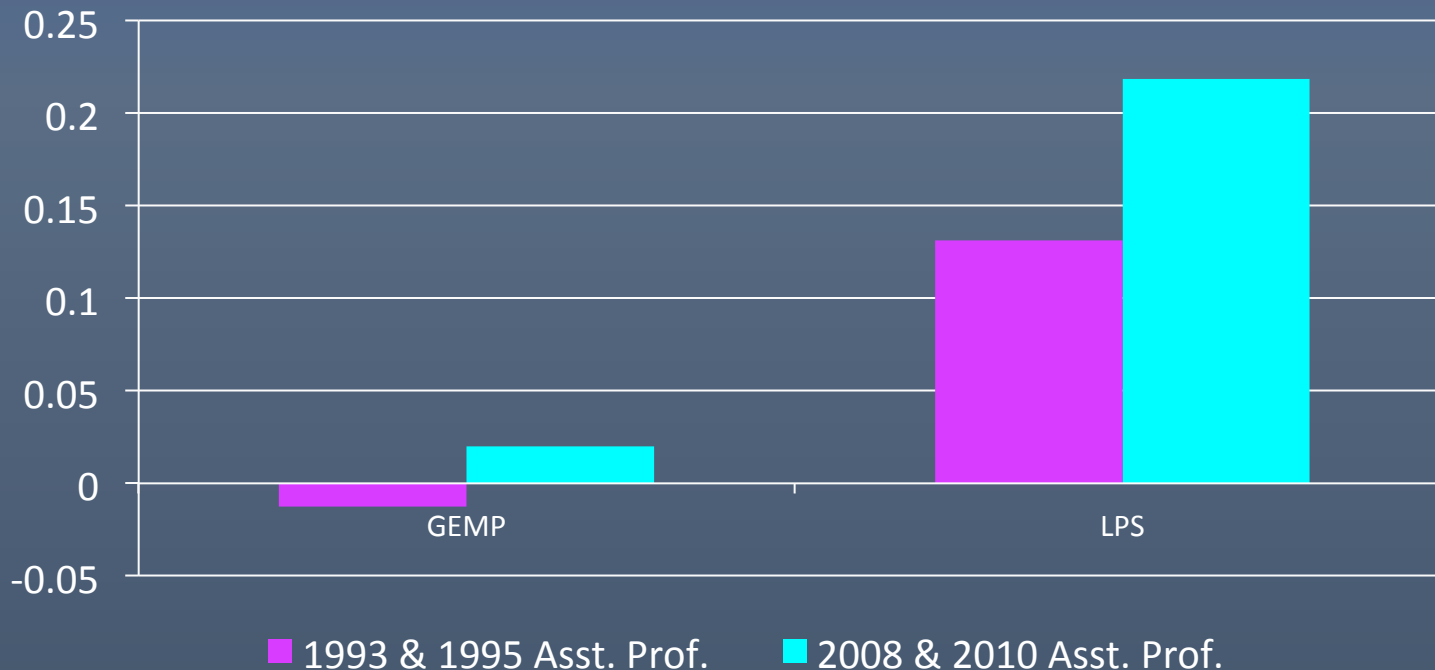
In a different experimental study, (Ceci and Williams 2015) ,

faculty were given identical profiles of male and female candidates for tenure-track positions in biology, engineering, economics, psych.

Women candidates were if anything preferred.

Nevertheless, women STEM are much less represented in LPS at Tenure-Track Academic jobs (5-6 yrs post PhD) than they were among PHDs.

### Gap between % Female among PhDs & % Female Tenure Track Assistant Professors 5-6 years post-PhD



# Why? Our research shows

- LPS particularly bad for women because of long postdocs in addition to PhD program itself.
- US NIH funding – average age get first R01 (own major grant) is 42.
- In LPS especially, children affect women's choices.

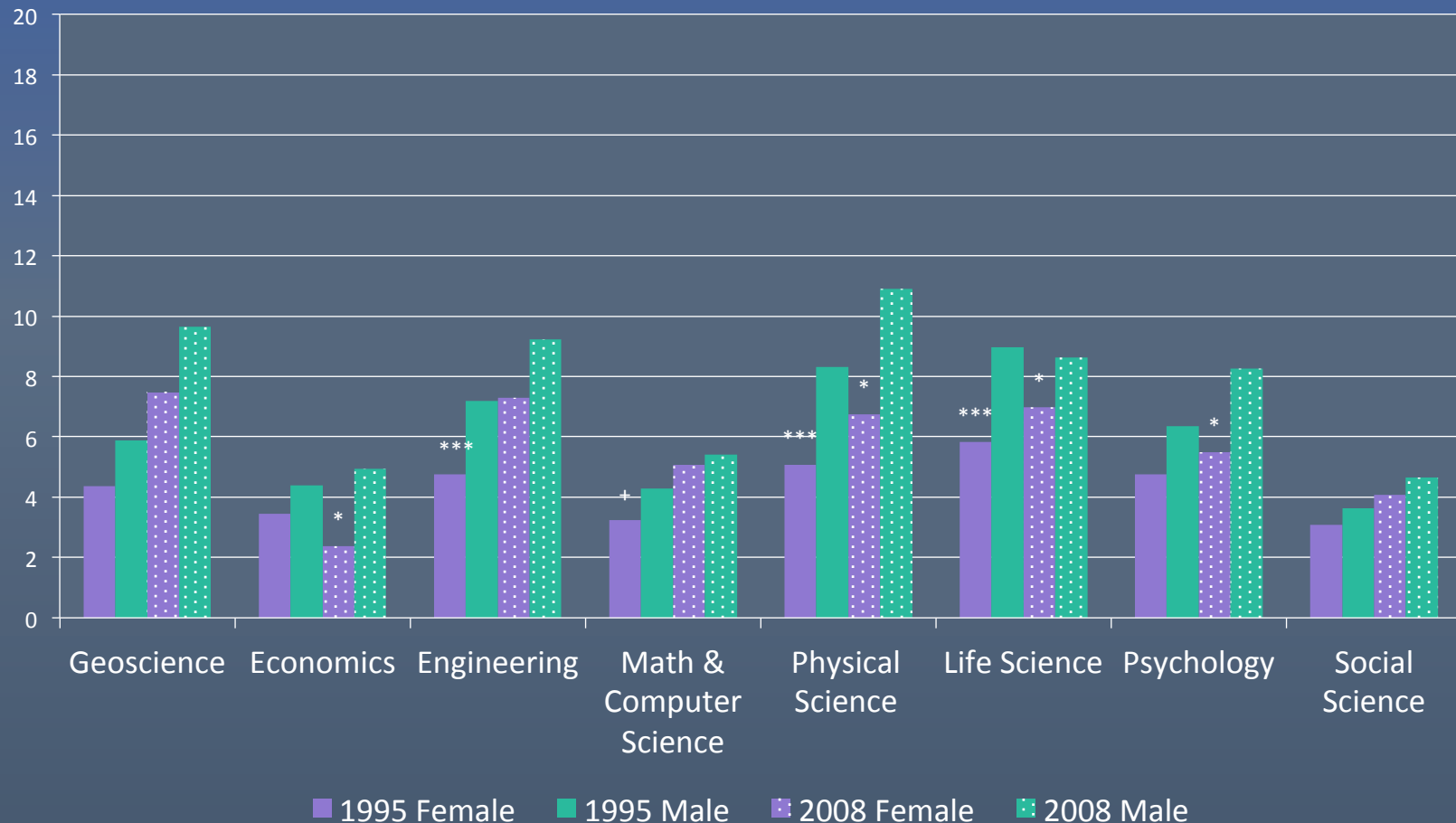
Women and men get tenured at equal rates in some STEM fields, and not in others.

- Equal in most GEEMP fields (except economics).
- Unequally in:
  - Life sciences
  - Economics
  - Psychology
  - Sociology

WHY?

# There is evidence that tenure-track women publish less than men.

## Average Publications over Previous 5 Years Assistant Professors

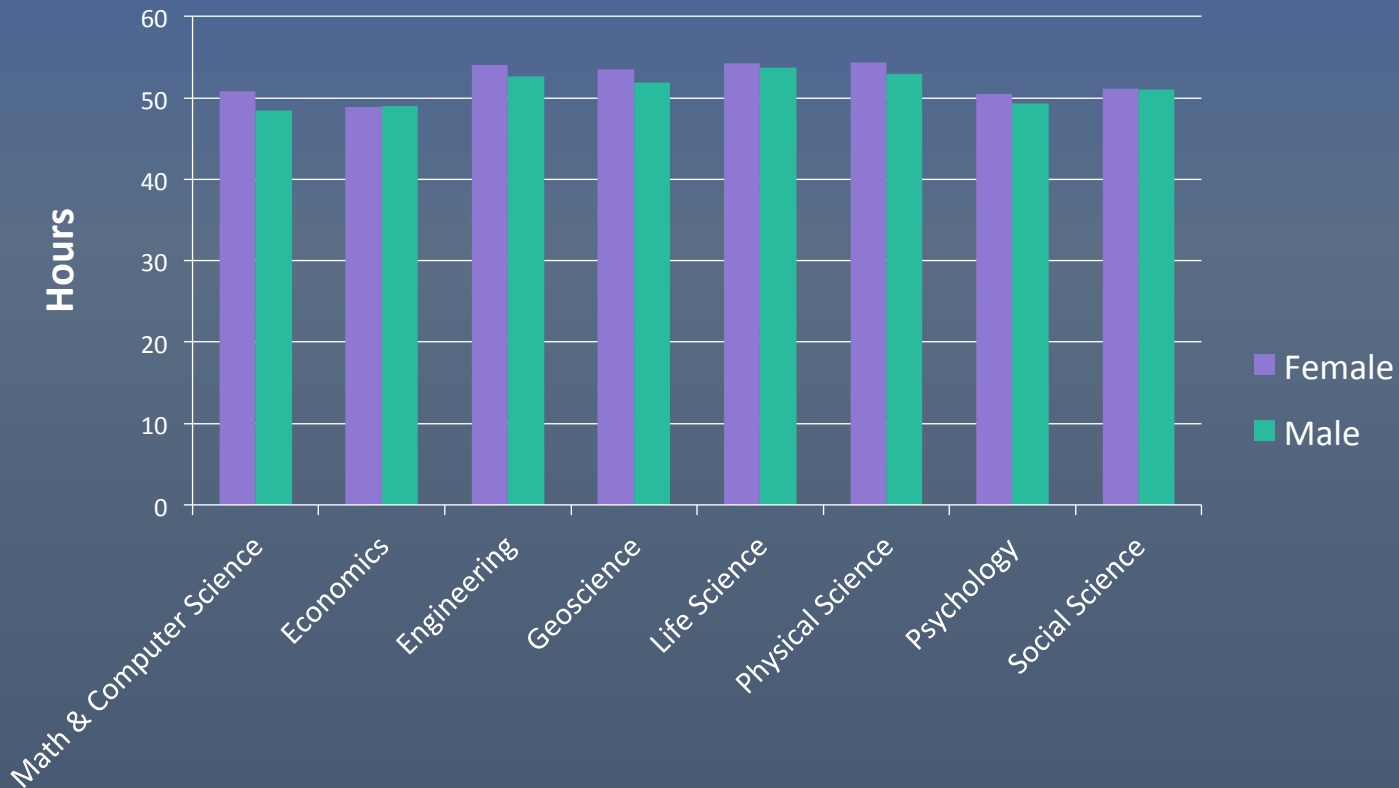


There is evidence that women are less likely than men to apply for grants and to reapply (either if the first was funded or not)

- Although they seem equally likely to receive funding if they apply.
- Gender, Race, Ethnicity and NIH R01 Research Awards: Is There Evidence of a Double Bind? with Donna K. Ginther and Walter T. Schaffer. (under revise and resubmit at Academic Medicine, sequestered).

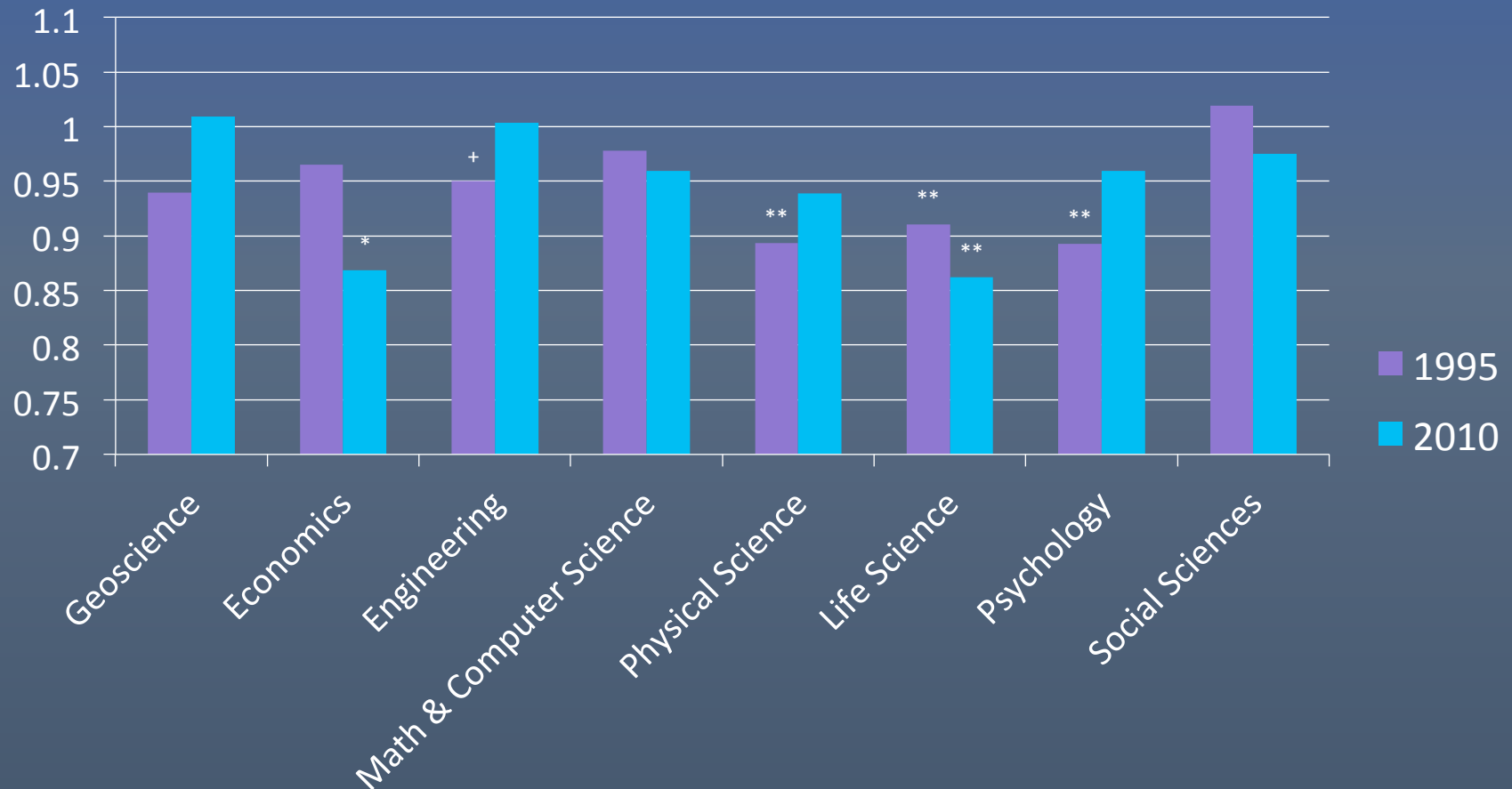
# There is no evidence that tenure-track women work fewer hours

**Average Hours Worked per Week for Tenured and Tenure-Track Faculty, by Field**



# Do women get paid less as asst professors? Yes in some fields, no in others.

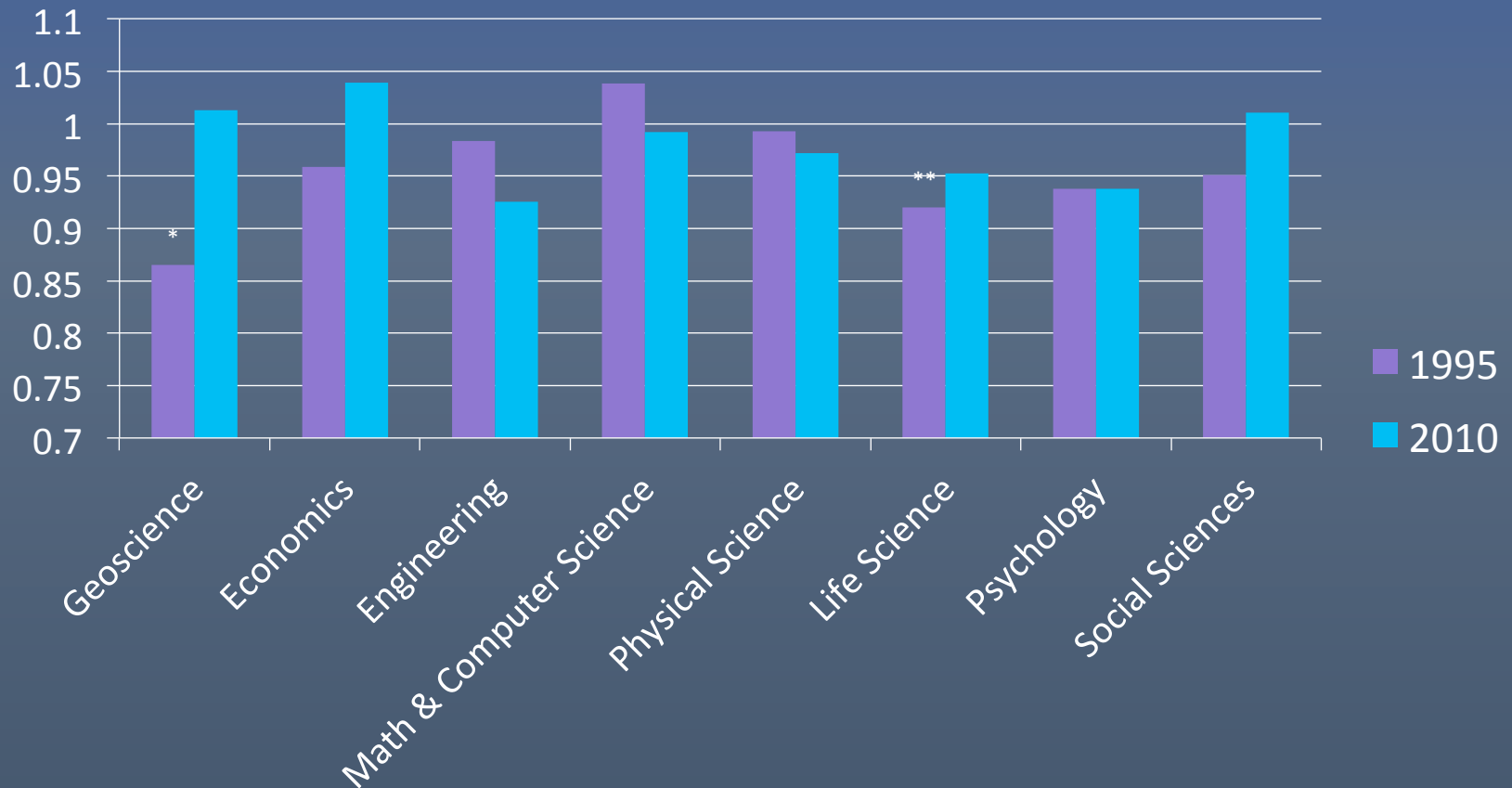
Assistant Professor Female Salaries as a Percentage of Male Salaries  
(1 means equality)





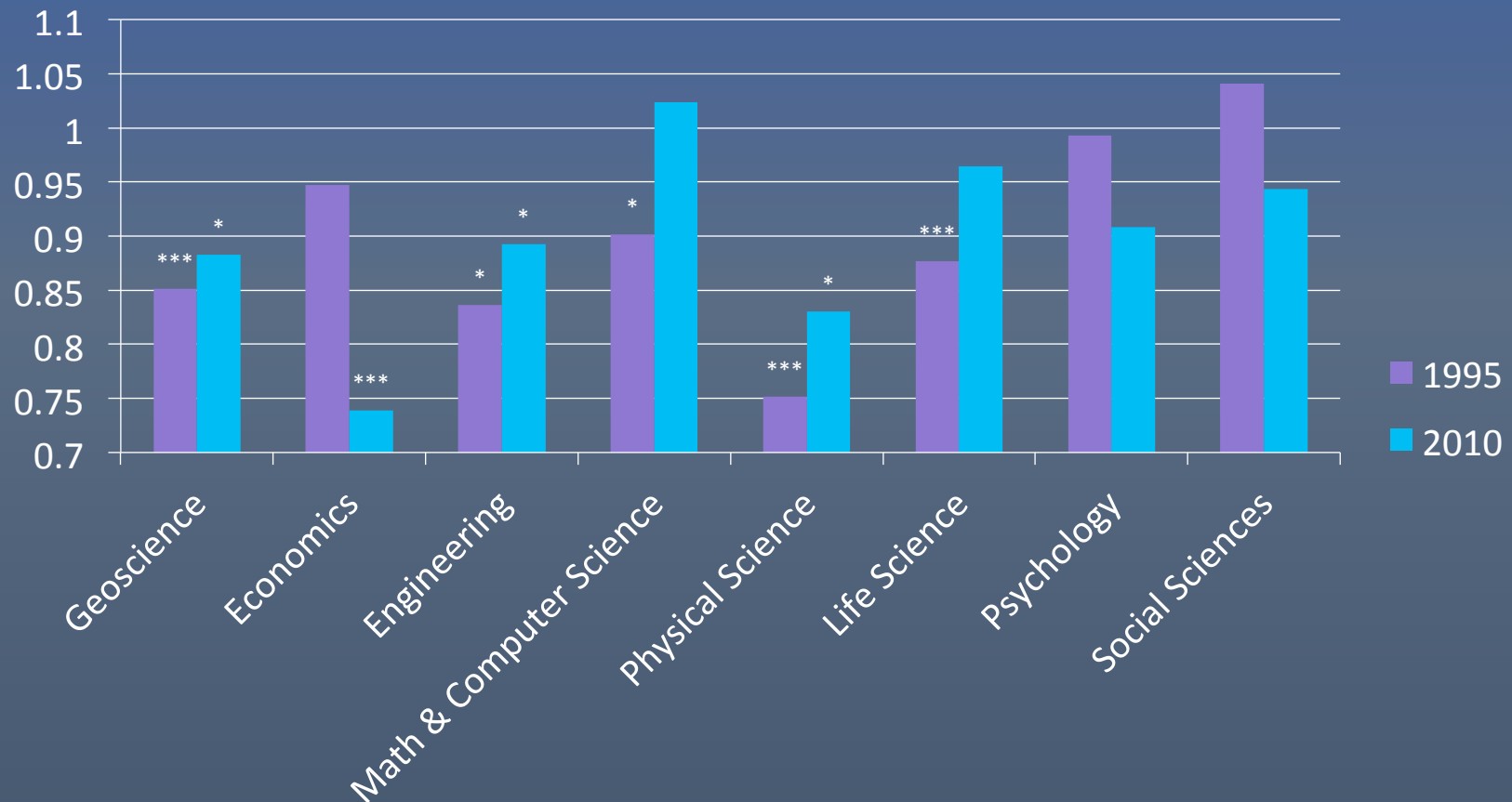
As associate professors, 2010 salaries are more equal (except in life sciences and psychology)

Associate Professor Female Salaries as a Percentage of Male Salaries



At the **full** professor level, things are bad.  
They are getting worse in economics, social science

**Full Professor Female Salaries as a Percentage of Male Salaries**



# Main conclusions

## 1. Early

The major gender differences in STEM careers start well before college.

## 2. Mutable

There are gender differences in measured math ability (average and at the top tail), but they are highly mutable (changeable) and shrinking.

## 3. The pipeline doesn't leak everywhere for all fields.

There are definitely some transitions where bias does not slow women in some fields from being successful.

## 4. Math-intensive fields better.

In academia, women have more equal treatment in math-intensive fields than other sciences.

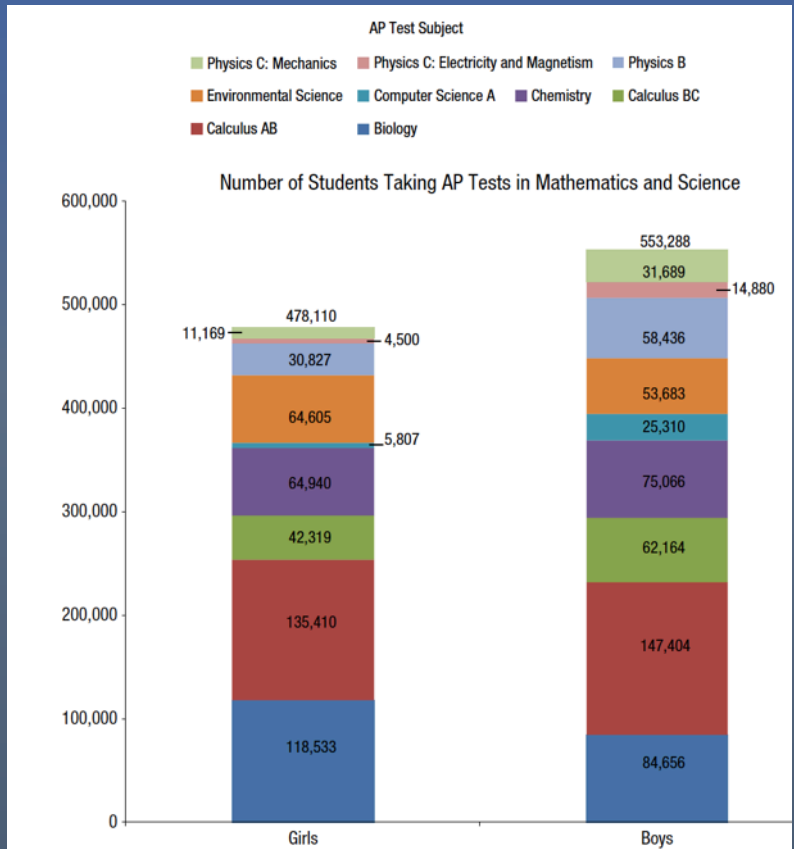
# What steps does this suggest?

- Focus on early grades at school, and throughout K-12.
  - e.g. convincing teachers and students in early-grades that math skills can be learned.
- Focus on life science, economics, psychology, sociology.
  - Try to change institutions that serve little value but help keep women out.
  - e.g. postdocs, age of grants, funding of initial labs.
  - Encourage women scientists to act as role models and mentors.

# Thank you!

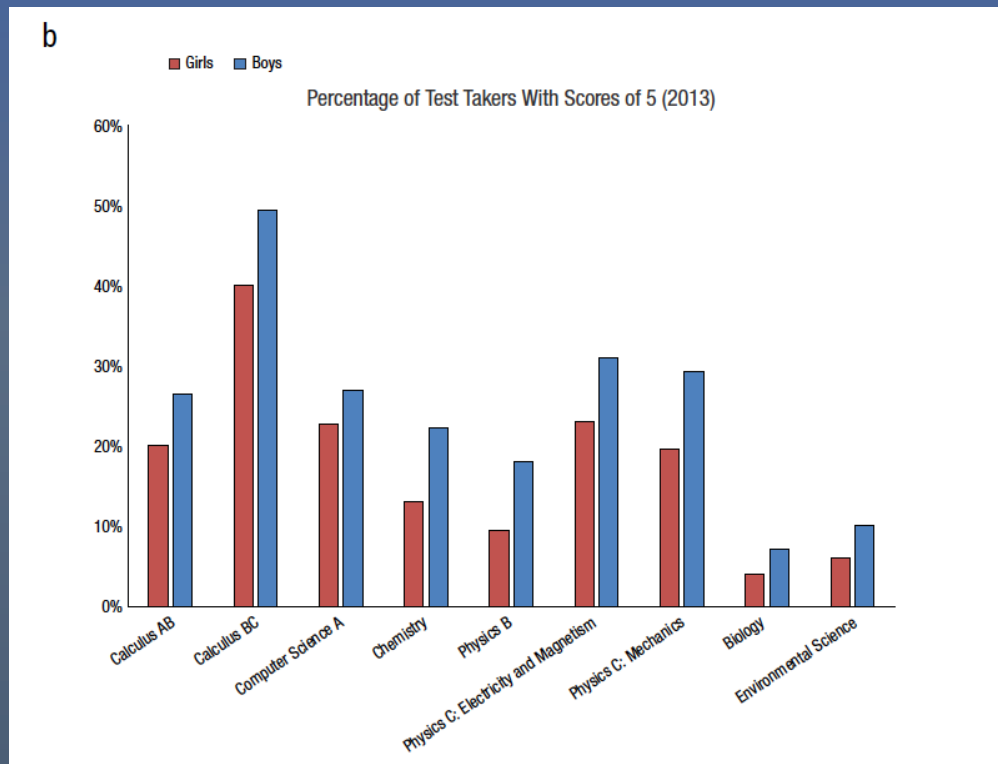


# Girls Less Likely to Take Math-Intensive Advanced Placement Exams



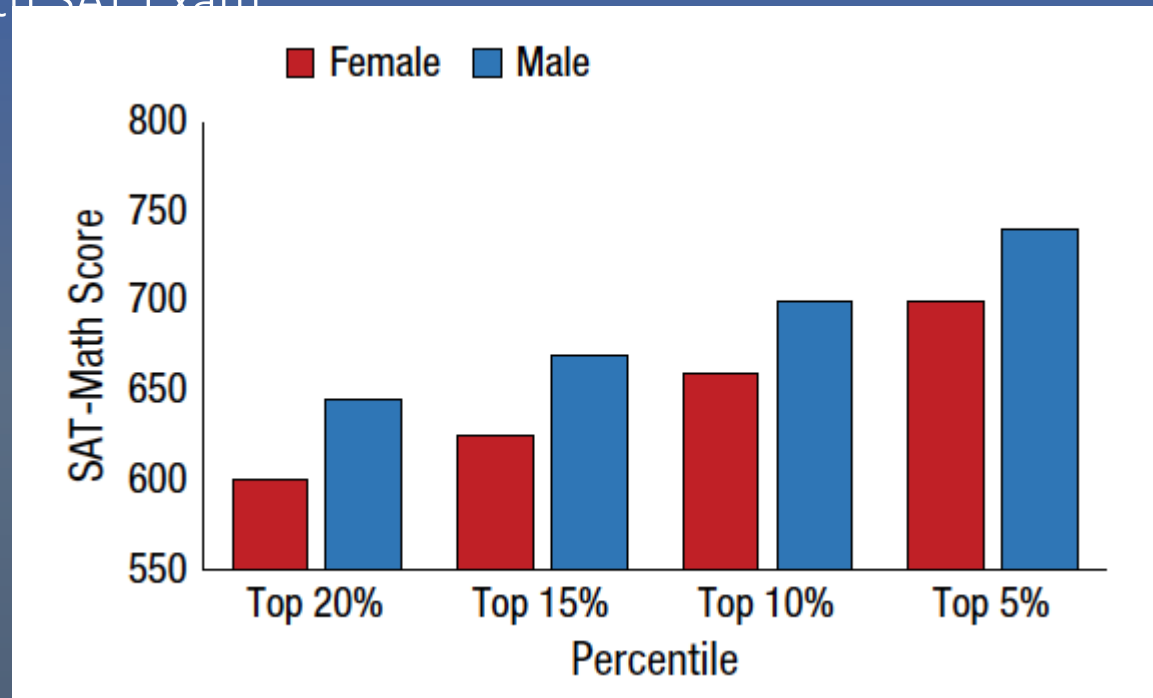
14% fewer girls take AP exams in STEM...  
 More girls take biology and environmental science, far fewer girls take Calculus, Computer Science & Physics exams.

# Girls Less Likely to Score in the Right Tail on STEM AP Exams



Boys are more likely to receive the top score (5) on all AP STEM exams than girls.

## Girls Less Likely to Score in the Top Percentiles of the math SAT Exam

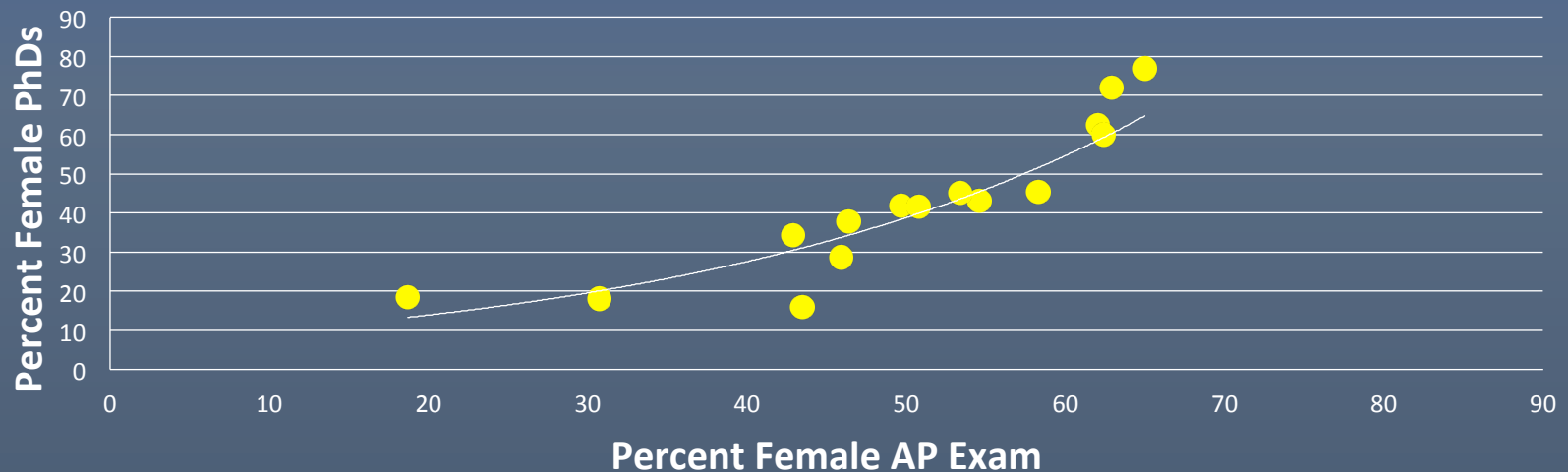


The Top Percentiles of Boys have higher SAT Math Scores than the Top Percentiles of Girls



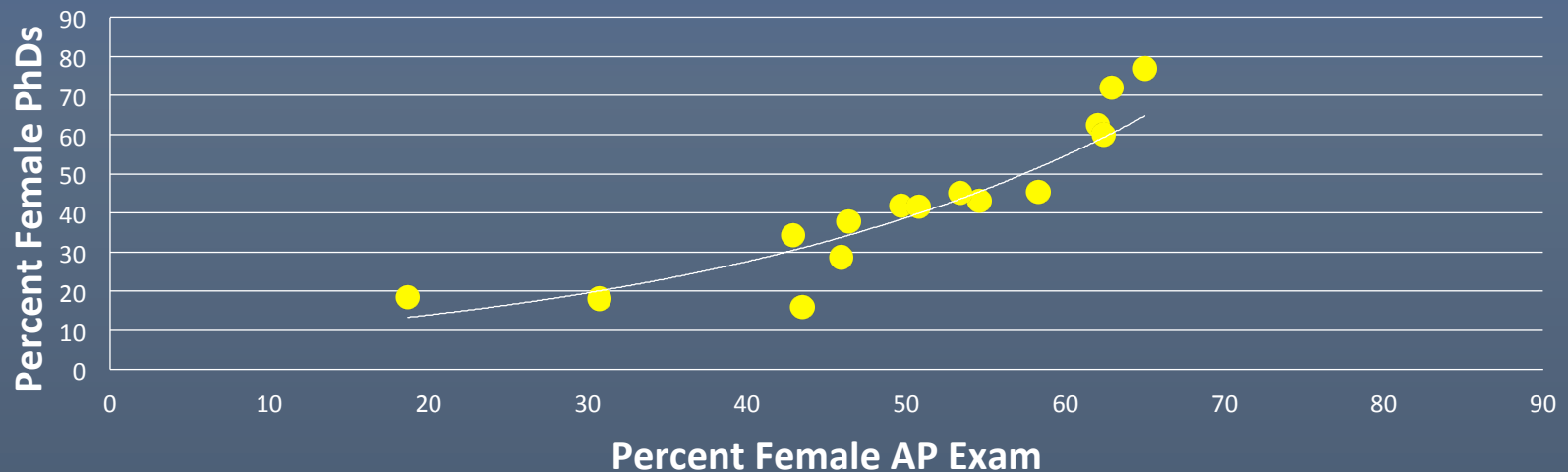
Distribution of women among STEM fields is highly correlated with distribution of women among high school AP test-takers fields

**Percent Female PhDs & Average High School AP Exam Scores in the field**



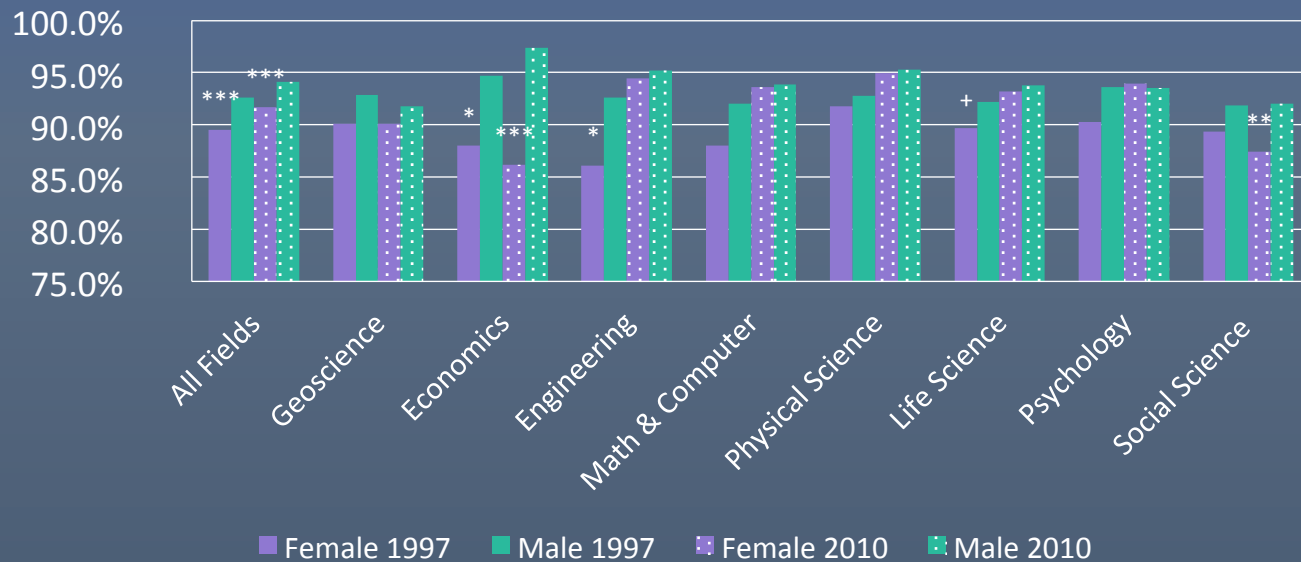
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**Percent Female PhDs & Average High School AP Exam Scores in the field**

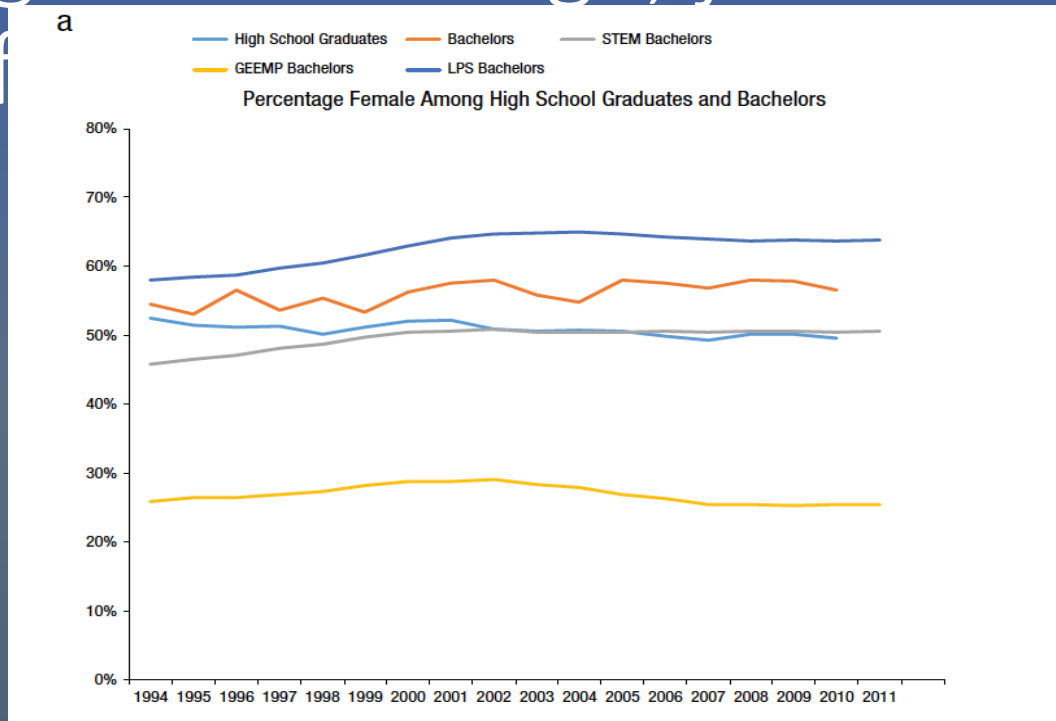


There is evidence that tenure-track/tenured women are less satisfied with their job.

**Percent of Tenure Track & Tenured Faculty Reporting Very or Somewhat Satisfied 1997 & 2010 SDR**



# Girls do receive STEM degrees in college, just different



Girls receive 50% of high school diplomas, 55% of bachelor's degrees, 50% of STEM bachelor's degrees. However, we divide STEM into two groups LPS—Life Science, Psychology & Social Science (excluding Economics) GEEMP—Geoscience, Economics, Engineering, Math & Computer Science & Physical Sciences. These are more STEM intensive. Girls receive less than 30% of GEEMP degrees.