Social factors and (under)representation in STEM

Margaret Beck (BU)
based on a presentation given with Moon Duchin (Tufts)
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“We must eliminate barriers that prevent the full mobilization of our nation’s talent in addressing the challenges before us.”
National Research Council conference Seeking Solutions

“She was doing everything I was doing, but just like Ginger Rogers, it was backward in heels.”
Obama on Clinton, DNC, July 27, 2016
Warm up activity

Make a list of your personal strengths.

There are no right or wrong answers. These could be academic strengths (good at subject x, good at remembering facts, good at solving problems, etc), but I also encourage you to think more broadly (eg the ability to work with others, organizational skills, good at completing tasks on time, good at communicating, leadership qualities, etc).

(This is private, just for yourself; you need not show it to anyone.)
From the NSF report “Women, Minorities, and Persons with Disabilities in Science and Engineering” 2015:
Race and the STEM workforce

From American Community Survey Reports “Disparities in STEM Employment by Sex, Race, and Hispanic Origin” 2013:

Figure 9.
Racial and Ethnic Representation in the STEM Workforce
(In percent. Data based on sample. For information on confidentiality protection, sampling error, nonsampling error, and definitions, see www.census.gov/acs/www/)

<table>
<thead>
<tr>
<th>Race Category</th>
<th>Total Workforce</th>
<th>STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>White alone, not Hispanic or Latino</td>
<td>66.9</td>
<td>70.8</td>
</tr>
<tr>
<td>Black or African American alone</td>
<td>10.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Asian alone</td>
<td>14.5</td>
<td></td>
</tr>
<tr>
<td>American Indian and Alaska Native alone</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Some Other Race and Native Hawaiian or Other Pacific Islander alone</td>
<td>4.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Hispanic or Latino (of any race)</td>
<td>14.9</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Note: Native Hawaiian or Other Pacific Islander alone was combined with Some Other Race because of a small number of sample observations. 
Source: U.S. Census Bureau, 2011 American Community Survey.
STEM academic faculty gender - leaky pipeline

From the Association of American Universities Data Exchange report “Women in the Academic Pipeline for Science, Technology, Engineering and Math” 2013:

Figure 11. Gender distribution of tenure-line professorial faculty by rank at select AAUDE institutions in STEM and non-STEM disciplines

<table>
<thead>
<tr>
<th></th>
<th>STEM</th>
<th></th>
<th>Non-STEM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assistant Professor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td>25.3%</td>
<td></td>
<td>49.2%</td>
<td></td>
</tr>
<tr>
<td>2006-2008</td>
<td>27.4%</td>
<td></td>
<td>49.2%</td>
<td></td>
</tr>
<tr>
<td>2008-2010</td>
<td>29.0%</td>
<td></td>
<td>50.3%</td>
<td></td>
</tr>
<tr>
<td>2010-2012</td>
<td>31.1%</td>
<td></td>
<td>50.5%</td>
<td></td>
</tr>
<tr>
<td><strong>Associate Professor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td>31.1%</td>
<td></td>
<td>42.5%</td>
<td></td>
</tr>
<tr>
<td>2006-2008</td>
<td>31.1%</td>
<td></td>
<td>43.7%</td>
<td></td>
</tr>
<tr>
<td>2008-2010</td>
<td>78.6%</td>
<td></td>
<td>44.7%</td>
<td></td>
</tr>
<tr>
<td>2010-2012</td>
<td>22.3%</td>
<td></td>
<td>45.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Professor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004-2006</td>
<td>89.8%</td>
<td></td>
<td>25.4%</td>
<td></td>
</tr>
<tr>
<td>2006-2008</td>
<td>83.6%</td>
<td></td>
<td>27.1%</td>
<td></td>
</tr>
<tr>
<td>2008-2010</td>
<td>87.8%</td>
<td></td>
<td>27.7%</td>
<td></td>
</tr>
<tr>
<td>2010-2012</td>
<td>86.7%</td>
<td></td>
<td>29.3%</td>
<td></td>
</tr>
</tbody>
</table>
From American Community Survey Reports “Disparities in STEM Employment by Sex, Race, and Hispanic Origin” 2013:

![Figure 14. Share of Total Employment, Science and Engineering Degrees, and STEM Employment by Sex](image)

*With a science or engineering bachelor’s degree. Source: U.S. Census Bureau, 2011 American Community Survey.*
Wage gap

From the US Department of Commerce report “Women in STEM: A Gender Gap to Innovation”:

Figure 3. Average Hourly Earnings by Gender and Occupation, 2009

- 14% gender wage gap:
  For every dollar earned by a man, women in STEM earn $0.86.

Source: ESA calculations from American Community Survey public-use microdata.
Note: Estimates are for full-time year-round private wage and salary workers age 16 and over.
So, Why So Few? It’s not just family...

From the Guardian reporting on Professionals Australia survey, 2015:

**Reported barriers to career advancement in STEM**

Respondents said the following factors significantly impeded their career progress:

- Balancing work/life responsibilities: 28.3%
- Workplace culture: 28.2%
- Lack of access to senior roles for women: 26.9%
- Lack of women in senior roles: 23.9%
- Lack of job opportunities: 22.6%
- Lack of role models: 20.7%
- Lack of career support: 19.6%
- Discrimination: 13.2%
- Lack of access to flexible work arrangements: 13.1%
- Lack of networks: 11.6%
- Lack of other women in the workplace: 10.5%
- Access to training: 9.5%
So, Why So Few?

We’ll look at some factors and partial explanations for underrepresentation of women in STEM, keeping in mind that biases and stigmas are far stronger against other groups and identities.

- Implicit bias
- Stigmatization
- Stereotype threat
- Rejection sensitivity
- Microaggressions and multipliers
- Imposter syndrome

We’ll close with some positive suggestions for improving the climate in STEM.

But first.....why should we care?
Why Diversity Matters

Moral duty:
- Correct social injustice
- Provide people with “reflections of themselves”

Better outcomes for problem solving in large groups [Hong and Page (2004)]
- Randomly selected, and hence more diverse, groups outperform groups comprised of the highest-scoring individuals
- For large groups, diverse groups have broader ideas about representing and approaching problems
- Surprisingly, this is particularly important in tasks, such as problem solving, where the success of a single individual implies success for the entire group.

Better outcomes in racially diverse juries [Sommers 2006]
- There is more communication: longer deliberation and a wider range of information considered
- Fewer factual errors are made, and inaccuracies more likely to be corrected
- Whites are more open to discussing race-related considerations
- Benefits of diversity not dependent on contributions of minority members
Implicit social cognition: thoughts and feelings outside of conscious awareness and control; can activate stereotypes and result in bias

Deeply ingrained and nearly-universal social messaging creates associations of white/male with intelligence and leadership qualities

- Well-meaning efforts to correct bias can backfire: Perceptions of preferential policies create a vicious stigma where you’re constantly told you’re getting more than you deserve
- People are demonstrably bad at countering implicit bias: see Goldin and Rouse, Orchestrating Impartiality: The Impact of “Blind” Auditions on Female Musicians (2000)

Findings: Use of a screen to hide the auditioning musician increases by 50% the likelihood that women will advance from early rounds, and increases by “severalfold” the likelihood of having a women chosen first overall.
Where Is Implicit Bias Found?

Absolutely everywhere that people need to rate or evaluate each other.

Implicit gender bias in science faculty [Moss-Racusin et al 2012]:
- Faculty at research-intensive universities asked to rate student applicants
- Applicants randomly assigned male or female name
- “Faculty participants rated the male applicant as significantly more competent and hireable than the (identical) female applicant”
- Male applicants offered higher starting salary and more mentoring
- Gender of the faculty participant did not affect the response

Citation analysis across STEM:
- Articles with women in dominant-author positions received fewer citations than those with men in the same positions [Sugimoto et al 2013]
Implicit Bias in Letters of Recommendation

Letters for female applicants to medical faculty were [Trix and Psenca 2003]:

- Shorter and contained fewer status terms, e.g., scientific terminology
- Higher percentage of “doubt raisers,” e.g., health issues, unmet goals
- “women as teachers and students”; “men as researchers and professionals.”

Findings extremely robust across many independent studies

[Madera et al 2009], [Schmader et al 2007], [Biernat-Eidelman 2007], [Heilman et al 1988]
Implicit Bias in Evaluations

...or, as the NYTimes put it in a headline:
*Is the Professor Bossy or Brilliant? Much Depends on Gender*

“Men are more likely to be described as a star, knowledgeable, awesome or the best professor. Women are more likely to be described as bossy, disorganized, helpful, annoying or as playing favorites. Nice or rude are also more often used to describe women than men.”

Amazing visualization: [http://benschmidt.org/profGender/](http://benschmidt.org/profGender/)
Take an implicit bias test:

https://implicit.harvard.edu/implicit/takeatest.html

Keep in mind that everyone has these biases. Having them does not mean that you are a bad person. The point is to recognize them, be aware of them, and try to reduce them.

Also keep in mind that studies have shown that, the more educated a person is, the more they tend to assume that they do not have any implicit biases, as if they are somehow smart enough to not have any. Education doesn’t prevent the creating of implicit bias, but education about implicit bias can help people prevent those biases from affecting their actions.
Stigma: A *mark of disgrace or infamy, regarded as impressed on a person or thing; A distinguishing mark or characteristic (of a bad or objectionable kind)*

- In modern language, social stigma is a taint of disapproval or disdain that attaches to people who have transgressed against cultural norms or who belong to a disfavored group; Goffman used the term “tribal stigma” to refer to group disapproval

Stigma can be:

- Internalized, shaping individual behavior (perceived through body language, eye contact, nature of praise and criticism, appraisal of threat, feelings of superiority and inferiority, inclusivity, or shame); or
- Structural or institutionalized, to the disadvantage of stigmatized groups (treatment by doctors and police, availability of loans)

The absence of (tribal) stigma is: being seen, acknowledged, and treated as normal or belonging to the in-group.
Stigma and Group Identity

http://xkcd.com/385/
Effects of Stigma

High-status person wants to be liked and worries about seeming prejudiced; Stigmatized person wants respect and worries about being subject to prejudice

Within a mentoring context, women and minorities receive more praise, but fewer resources than others (Vescio et al 2005); Praise often conforms to stereotypes (Madera et al 2009)

- Impeded trust: feedback distortion may cause members of stigmatized groups to
  - Discount negative feedback, assuming it results from bias
  - Discount positive feedback, assuming it is due to overcompensation or preferential policies
- Reduces motivation to respond to feedback

[Goffman 1963], [Cohen and Steele 2002], [Remedios 2015], [Kleinman and Halll-Clifford 2009]
Stereotype threat

Stereotype: generalized expectation or belief applied to group.

Stereotype threat: “a situational predicament in which individuals are at risk...of confirming negative stereotypes about their group” [Inzlicht and Schmader 2012] and this threat triggers reduced performance. (Note that some researchers question this, particularly with respect to gender and math.)

Stereotypes of math ability [Steele 2011, Shih et al 1999]:

- Direct: Reminding women of sexist stereotypes leads to reduced performance on test
- Indirect: White men perform worse if reminded of stereotype that Asians are better at math
- Implicit: Even having women fill out a gender field on a test suffices to trigger this effect

Stereotype threat can result in avoidance and attrition from high-threat situations, which can drive stigmatized groups out of STEM fields
Stereotype threat

Research shows that the following can reduce stereotype threat:

- Having students reaffirm their self-integrity, the extent to which they see themselves as virtuous and efficacious.
- Remove cues that trigger worries about stereotypes, such as physical cue that suggest that the environment is defined by the majority group.
- Convey that diversity is valued, and create a critical mass.
- Value students’ individual identities.
- Improve cross-group interactions.
- Convey high standards and students’ ability to meet those standards.
- Promote a growth mindset about intelligence; people are not “born” to be good at something. Intelligence is like a muscle - it is not fixed and will grow with effort.

Taken largely from
Rejection Sensitivity

Rejection sensitivity (RS): a personality disposition developed through early experiences of rejection, causing heightened fears/expectations of rejection/failure; often triggers maladaptive responses like hostility and aggression.

[Ahlqvist et al, 2013] studied female freshman and sophomore STEM majors:
- Women with higher RS were more likely to reduce their “identity compatibility” over time, perceiving clash between their various group identities;
- This led to reduced STEM GPA and sense of belonging, and an increased susceptibility to stereotype threat.
(Micro)aggressions

Famous examples of aggressions:

- everydaysexism.com
- Tim Hunt, nobel laureate, said labs should be gender segregated because women cause men to fall in love with them and cry when criticized. Lead to #distractinglysexy
(Micro)aggressions

Famous examples of aggressions:

- Matt Taylor of the Rosetta mission at press briefing; he also said it was “the sexiest mission there’s ever been. She’s sexy, but I never said she was easy.”

- Shrinivas Kulkarni, astronomy and planetary science professor at CalTech during NPR interview said “Many scientists, I think, secretly are what I call ‘boys with toys.’”
(Micro)aggressions

http://sarahcandersen.com/
**The Petrie Multiplier**

...or, “Quadratic Snark.”

Thought experiment by Karen Petrie (Dundee, CS) popularized in blog post by Ian Gent (St Andrews, CS)

Math model explains why, in the presence of very imbalanced group ratio, even casual “microaggressions” can be magnified to create a hostile atmosphere

- Assumption: Group A and Group B are equally likely to make a clueless or snarky remark to a person of the other group.
- Result: If ratio of A to B is $1/R$, A members receive $R^2$ as many snarky remarks as B.
- Reasoning: There are $R$ times as many B to give snark, so $R$ times as much B-snark is given. There are $R$ times fewer A to receive it, so each A is $R$ times as likely to receive a given remark.

http://blog.ian.gent/2013/10/the-petrie-multiplier-why-attack-on.html
Intersectionality

- Describes how multiple identity factors (gender, race, sexuality, class, mental health, parent status, etc) can overlap and interact
- Term coined by Kimberlé Crenshaw in 1989 in context of black feminism
- Key idea is that identity factors cannot be easily separated, and oppression can be additive (or superadditive)

Now rerun Petrie multiplier on, say, three overlapping stigmatized identities...

NSF data on scientists and engineers, 2010
Imposter Syndrome

- Term coined in 1978 by Clance and Imes referring to high-achieving women who thought they were not really bright despite numerous achievements.
- Can affect anyone, regardless of race, gender, etc, but it can be particularly detrimental to stigmatized groups when combined with other factors.
- Can be reinforced by well-meaning programs to promote diversity, eg ”I only got this job/fellowship/grant because I’m a woman...”
Improving the Climate

Build community. Practice self-care.

Work on “effortful thinking” to counter stereotypes, stigmas, and implicit bias.

With respect to higher-status groups that you are in, make space for marginalized groups to center their own narratives. Step aside when it’s appropriate and speak up when you can. Fight against defensiveness.

Become a mentor. Lots of evidence shows that the best way to accept advice is to give it.

Find a mentor for yourself.

Remember that it is everyone’s responsibility to correct inequities, especially those with privilege.
Organizations at Boston University:

- **UWISE**: [https://uwisebu.wordpress.com/](https://uwisebu.wordpress.com/)
- **GWISE**: [http://www.bu.edu/gwise/](http://www.bu.edu/gwise/)
- **ARROWS**: [http://www.bu.edu/arrows/](http://www.bu.edu/arrows/)
- **Underrepresented Graduate Student Organization (UGSO)**: [https://sites.google.com/view/ugsosurvivalguide/home](https://sites.google.com/view/ugsosurvivalguide/home)
- **Howard Thurman Center**: [http://www.bu.edu/thurman/](http://www.bu.edu/thurman/)
Resources: National organizations that promote diversity

Gender-specific resources:
- Association for Women in Mathematics Mentor Program: https://sites.google.com/site/awmmath/programs/mentor-network
- The Edge Program: http://www.edgeforwomen.org/
- Women in Math Project: http://darkwing.uoregon.edu/~wmnmath/
- Nebraska Conference for Undergraduate Women in Mathematics: http://www.math.unl.edu/~ncuwm/19thAnnual/
- Center for Women in Mathematics at Smith College: http://www.math.smith.edu/center/
- American Association of University Women: http://www.aauw.org/
- Association for Women in Science: https://awis.site-ym.com/

Other Diversity Resources:
- Alliance for Building Faculty Diversity in the Mathematical Sciences: https://www.math.ncsu.edu/alliance/index.php
- Advancing Chicanos/Hispanics and Native Americans in Science: http://sacnas.org/
References


• Hong and Page, “Groups of diverse problem solvers can outperform groups of high-ability problem solvers,” PNAS (2004).


References

• Remedios, slides on “Mentoring in diverse settings,” from the conference “Mentoring Workshop for Graduate Advisors in Mathematics” (2015).
References

- AMS Annual Surveys:
  http://www.ams.org/profession/data/annual-survey/annual-survey