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How Diversity Matters in the US Science and Engineering Workforce: Integrating Teams, Fields, and Labs

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Institute for Social Science Research

The diversity argument: Beyond Why to How

- The question of "why care about diversity" misses the mark.
- Diversity in the US science and engineering workforce is a fact, and organizations need to be asking **how** to integrate the contributions of all members of diverse teams.

Overview of findings on teams

The evidence for scientific outcomes and demographic diversity is mixed.

And to date, much of the evidence is not from science and engineering contexts.

Q: Under what conditions does diversity promote innovation, creative problem solving, higher quality work, and more productivity?

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Q: Under what conditions does diversity promote innovation, creative problem solving, higher quality work, and more productivity?

A: One common theme across the research: diversity works best under conditions of equity/integration in the wider context (occupation, industry, discipline, organization).

Overview, cont.

In very masculine, hierarchical, and competitive environments (gender) diversity does not improve outcomes.

BUT when conditions allow for full participation from minority team members, diverse teams have better outcomes.

Take Away

When work environments are integrated they foster participation from diverse team members – everyone's contributions can be valued

What does integration look like?

- Occupational level—representational diversity (Joshi and Roh 2009)
- Organizational level—network form v. hierarchy (Smith-Doerr 2004)
- Teams—fewer interruptions (Wooley et al. 2010)
- Labs—more collaborative (Smith-Doerr, Stoutenburgh, and Sacco 2016)

Joshi and Roh (2009)

Joshi and Roh (2009) conducted a meta analysis of research on diversity in teams.

- 8,757 teams, 39 studies
- 60% diversity has no effect, 20% positive, 20% negative

What explains the mixed results in the research?

Joshi and Roh (2009)

TABLE 2
Main Effects: The Relationship between Team Diversity and Performance[a]

Diversity Type	Effect Sizes (k)	Total Teams (N)	Weighted Mean r	95% Confidence Interval	Failsafe k	Q
All diversity			−.01	−.02, .00	118	635.16** 479.54**
Relations-oriented diversity			−.03	−.05, −.02		
Gender			−.02	−.04, .01	48 73	155.63**
Race/ethnicity			−.01	−.04, .01	65	
Tenure	19	3,881	.03	−.01, .06		

[a] N is the total number of teams counted by effect sizes; failsafe k indicates the number of unpublished studies reporting null results needed to reduce the cumulative effect across studies to the point of nonsignificance ($p \geq .05$) and is only reported for statistically significant results ($p < .05$); Q is the effect size heterogeneity statistic indicating the possibility of moderators.

** $p < .01$

Demographic diversity has very weak, but significant negative effects in the literature

Joshi and Roh (2009)

TABLE 3
Contextual Influences: Occupational Demography[a, b]

Team Diversity × Occupational Demography[c]	Effect Sizes (k)	Total Teams (N)	Weighted Mean r	95% Confidence Interval	Failsafe k	Q_B
Gender diversity (Hypothesis 1a)						39.19**
Majority male settings			−.09	−.12, −.05		
Balanced settings			.11	.06, .15		48.65**
Race/ethnicity diversity (Hypothesis 1b)						
Majority white settings			−.07	−.10, −.04		
Balanced settings			.11	.07, .14		

"In occupations dominated by male or white employees, gender and ethnic diversity had more negative effects on performance outcomes" (p. 618). **In balanced occupations the effects were positive.**

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Data sources for Gender equity v. Hierarchy (Smith-Doerr)

- US life scientists' holding leadership roles in different organizational settings by gender: Smith-Doerr (2004).
- USPTO patenting by organizational setting and gender: Whittington and Smith-Doerr (2008).
- Massachusetts biotechnology firm founders by gender and immigrant status: Monti, Smith-Doerr and McQuaid (2010).

Network Organizations v. Hierarchies

- Network Organizations:

Indefinite and sequential interaction structure, norms govern relations, partners pool resources, expectations foster collaboration but are not rule bound, flows of non-redundant "freer" info (Powell 1990).

Life sciences example: **biotechnology** firms dedicated to human therapeutics

Question for women in science—do old boy networks flourish in the absence of rules?

- Hierarchies:

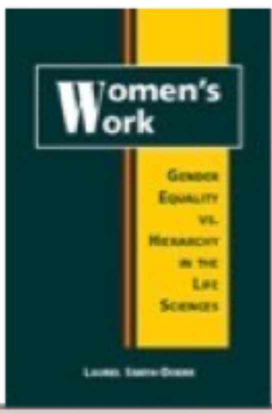
Employment in formal authority structure patterns interaction, rules govern relations, resources (including info) distributed according to rank, mass production of reliable products of a given quality.

Life sciences examples: multinational pharmaceutical corporations, universities

Question for women in science—does bureaucratic procedure combat discrimination, or hide biased informal organization?

Likelihood of scientists moving into supervisory positions, Network v. Hierarchical settings

	Change in Odds of Supervising in **Network firms**	Change in Odds of Supervising in **Hierarchies**
Men	*No difference*	*No difference*
Women	*7.9 times more likely*	*60% decrease in odds*



Source: Smith-Doerr (2004, *Women's Work*), based on logistic regression analysis controlling for years since PhD, prestige of PhD program; N=2,062

Likelihood of patenting, Network v. Hierarchical

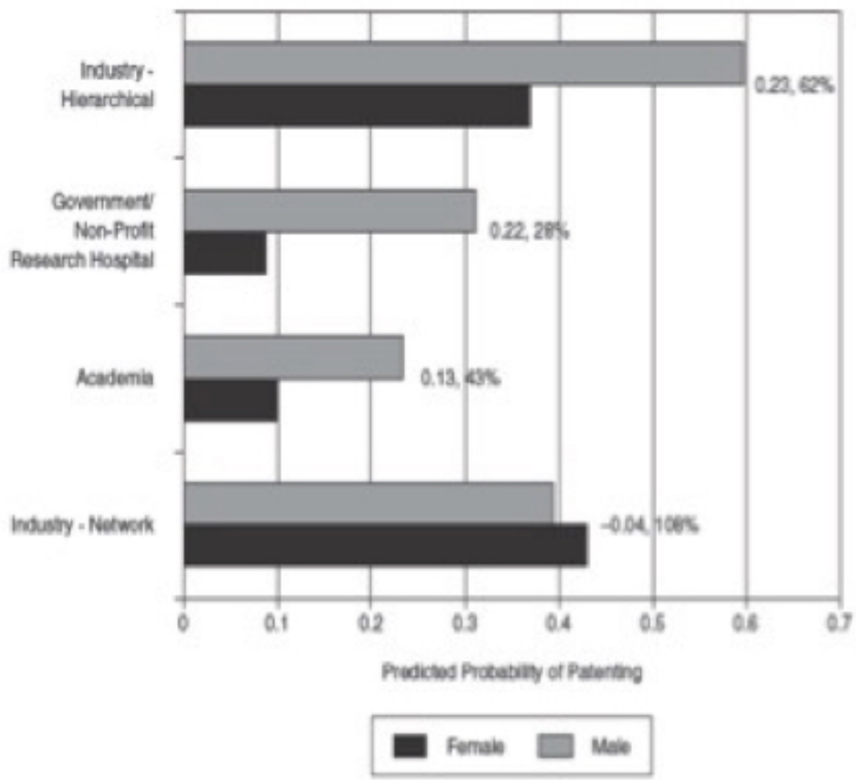
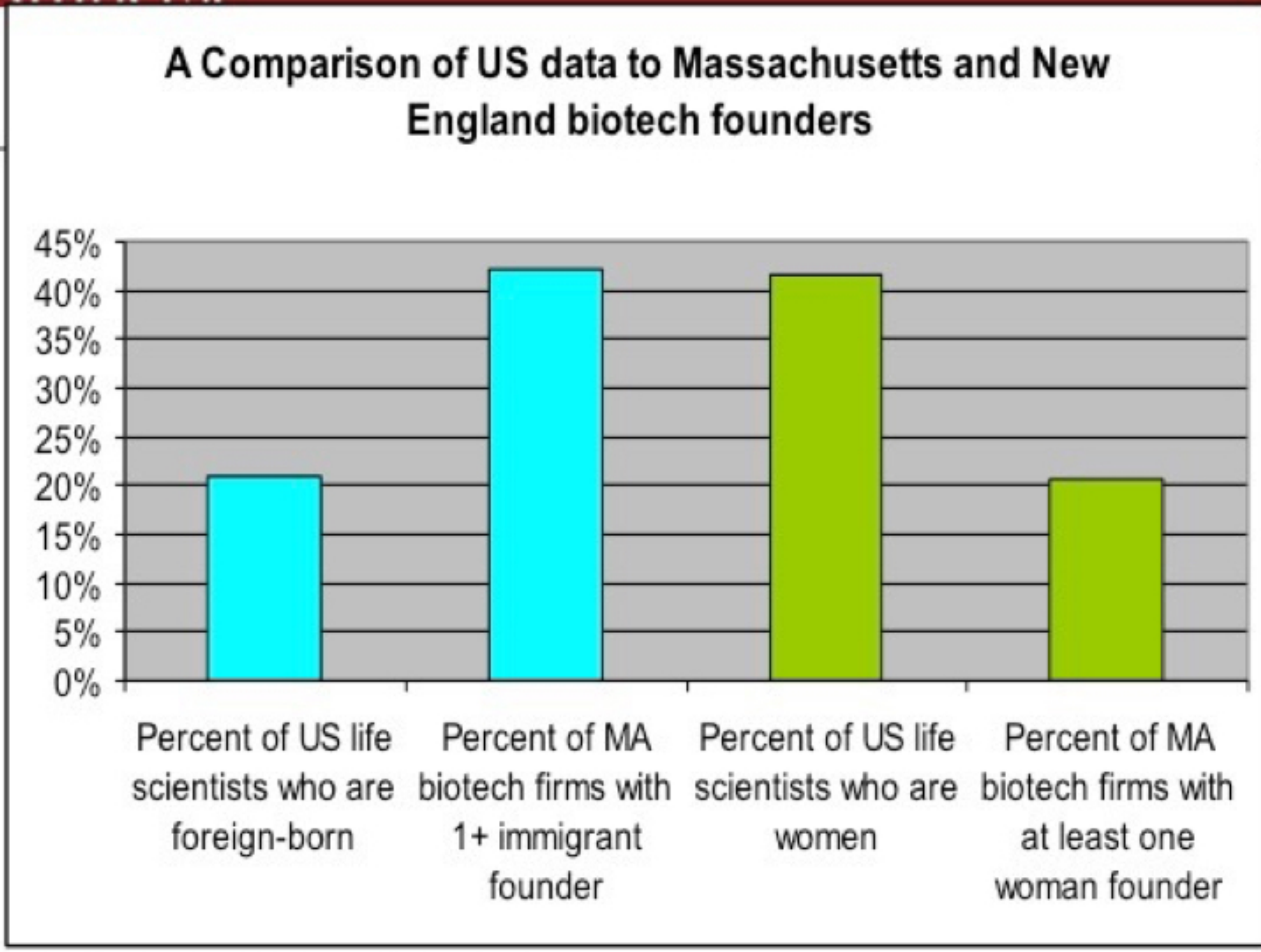


Figure 1: Predicted Probabilities of Patenting, by Sex and Sector
NOTE: Numbers in boxes refer to the difference in probabilities between men and women (M-F) and the F/M predicted probability ratio (multiplied by 100).

Note: All other variables are held at mean.
Source: Whittington and Smith-Doerr (2008). N=961.



US data in 2002 from CPST;
MA data in 2006 from Monti, Smith-Doerr & McQuaid

Why greater equity in biotech firms?

Clues from interviews (Smith-Doerr 2004, N=47).

- **1. Flexibility in collaboration**
  - About a woman scientist friend: "left a tenured position at [an elite university] to go to [a biotechnology firm]…said the university department under [Chairman] was an autocracy… could do science there [at firm]—working with who they wanted to rather than dealing with [Chairman]."
- **2. Transparency**
  - "From my experience at [academic setting] I could tell you many a true story about political infighting…[at biotech firm] we are not compartmentalized—and get to work with many good scientists both here and outside the firm. And we choose who to work with based on non-financial considerations, like how good they are in their field."
- **3. Collective rewards**
  - "While I was on maternity leave here [biotech firm] I could keep in touch with my colleagues who kept it moving forward…when I was a postdoc at [prestigious academic institute], people collaborated somewhat, on the fringes of their work, but still had their main turf which they guarded carefully."

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Woolley and Colleagues

Woolley, Chabris, Pentland, Hashmi & Malone, *Science,* 2010

- 40 groups spend 5 hours in the lab together working on a range of tasks—experimental conditions for teams

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    - Measure what they call collective intelligence (how well team expected to do on a new task based on past lab tasks)

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- 40 groups spend 5 hours in the lab together working on a range of tasks
  - Measure what they call collective intelligence (how well team expected to do on a new task based on past lab tasks)
  - Not predicted by individual IQs of team members or personality attributes

Woolley and Colleagues

Equity of speaking turns predicted higher collective intelligence scores – and gender integrated teams tended to have more equitable speaking behavior.

Face-to-Face

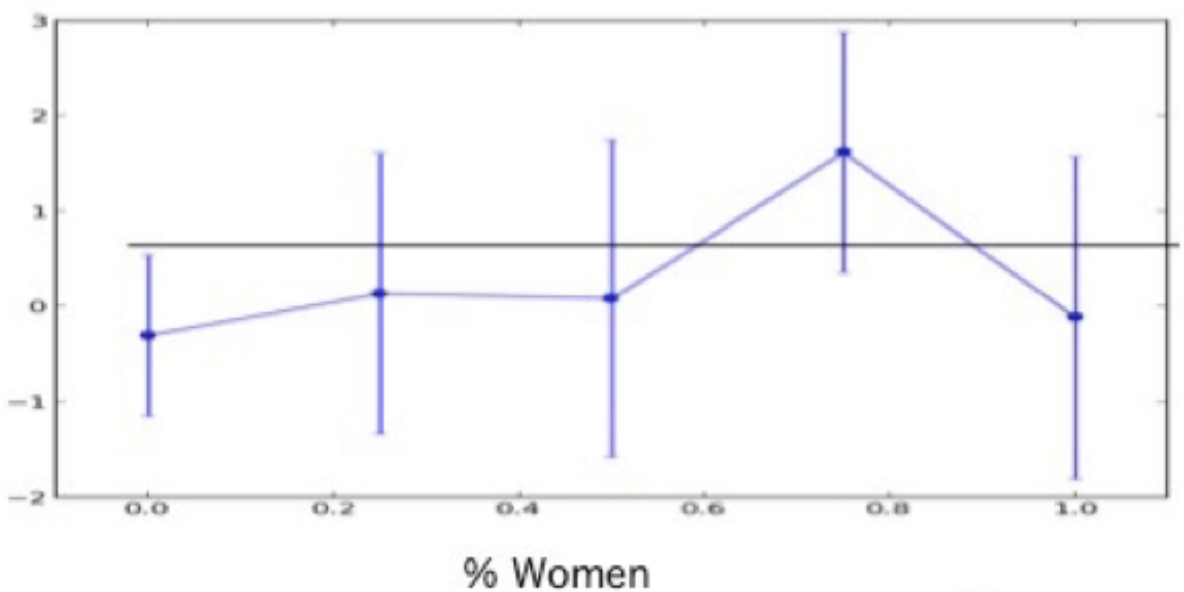

Figure courtesy of Anita Woolley

Woolley and Colleagues

Perceived task conflict was a negative predictor of performance for gender integrated teams

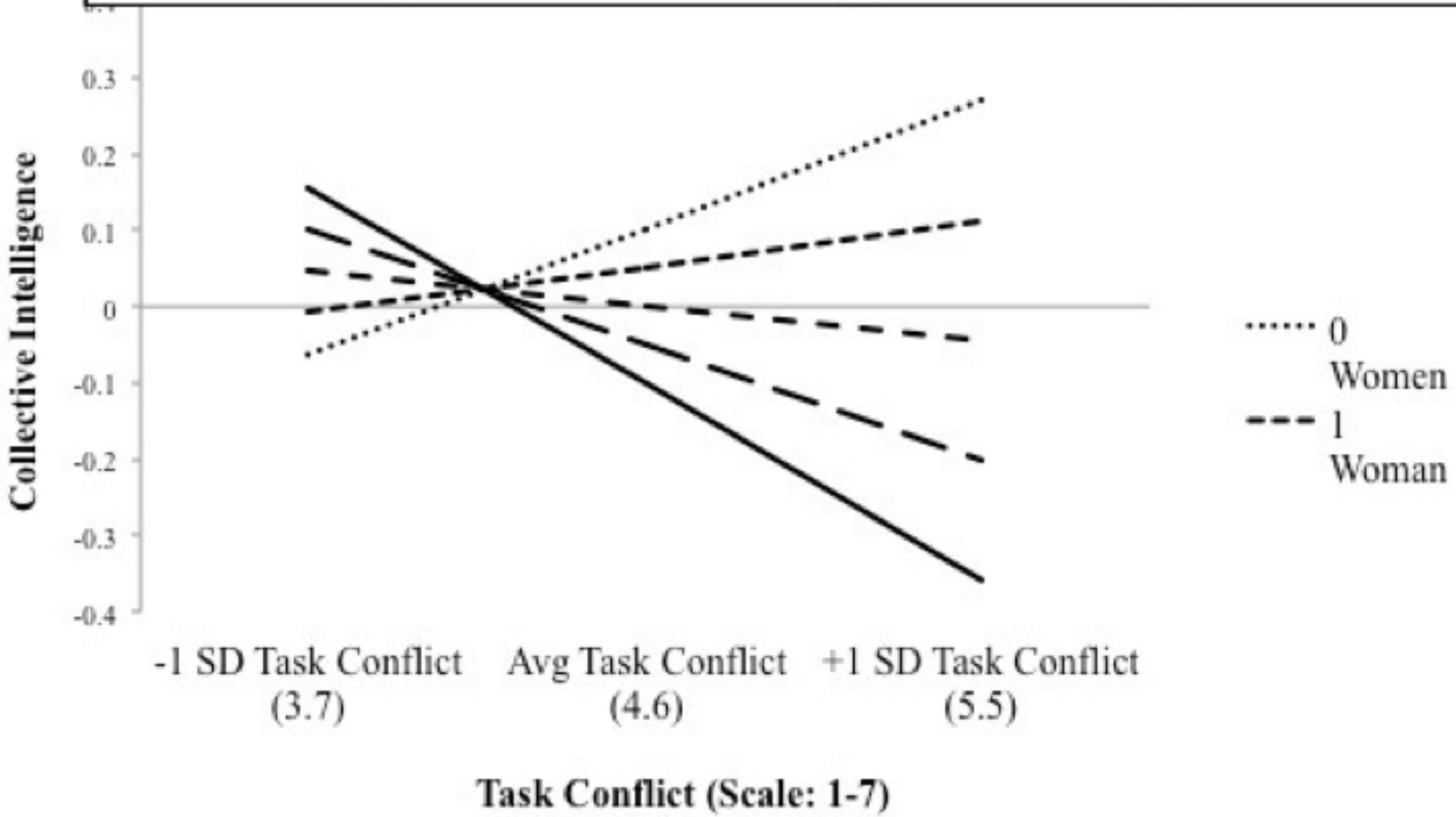

Figure courtesy of Anita Woolley

Woolley, Chow, Mayo, Riedl & Chang

Woolley and Colleagues

Gender diversity has positive effects on performance; the mechanism appears to be cooperation and equity within the team.

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Gender diversity has positive effects on performance; the mechanism appears to be cooperation and equity within the team.

This positive diversity effect is reversed when conflict and competition within the team is high.

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Collaboration in chemical sciences (Smith-Doerr & Croissant)

- Data in the field: ethnography
  - Four settings in chemical sciences:
    - lab of academic PI,
    - lab of formerly industry now academic PI,
    - large academic research center PI's lab,
    - biotech firm lab group
  - Ethnographic field notes: from observing lab meetings
    - 72 presentations observed
      - 36 by men
      - 36 by women
  - Interviews: 106 semi-structured interviews

Research question: What contexts and situations produce barriers to gender equity in scientific collaboration?

Intersectionality as a theory of gender

- Intersectionality:

  An approach to understand overlapping systems of inequality. Gender intersects with race and class; expected performance varies for women by other socially salient identities (e.g., Collins 1986; Ong 2005; Wooten & Branch 2012).

Our new question for women in science—how does the intersection of age and gender affect performance of expertise?

Crisis of Confidence in Chemical Sciences Labs

Table 6.1: The Gendered Crisis of Confidence in Lab Presentations

	Young Women	Young Men
Instances where lack of confidence displayed	45	7
Types of instances		
Apologetic	12	2
Giving credit to colleagues, unsure of own expertise	3	0
Physical signs of nervousness	20	3
Declares nervousness	4	2
Unsure tone	6	0

(N=72 presentation observations, 36 women presenters, 36 men presenters, note: multiple instances of lack of confidence in some presentations)

(Note: No displays of lack of confidence by older men or older women scientists)

Smith-Doerr, Laurel, Timothy Sacco, and Angela Stoutenburgh. 2016. "Crisis of Confidence: Young Women Doing Gender and Science." In *Beyond the Pipeline: Potholes and Pathways in STEM*, edited by Enobong H. Branch. Lexington.

Smith-Doerr, Sacco, Stoutenburgh (2016)

- Common signs include fidgeting, getting caught on words, reluctance to address group.
- Example in the traditional academic lab:

Cassandra, the newest student on the project, begins her presentation. She stands off to the side of the room, away from her laptop with PowerPoint slides located in the center of the room. While presenting, she fidgets back and forth between her legs. Her voice is shaky, and she stumbles on her words. Sentences are filled with "um"s and she licks her lips. She tries clearing her throat several times as she talks. Approximately 5 minutes into the presentation, she pauses momentarily to collect herself.

Crisis of confidence in interactions

- Beyond the individual performance of confidence—considering interactions in hierarchical orders
- Observations of common interactions that may heighten awareness of power differences:
  - Interruptions and corrections
  - Deference and acknowledging status differences

Interruptions and responding to mistakes

Pls teach by correcting. Expectation of 'perfect' expertise or of learning from mistakes?

"Eva", a grad student, begins her presentation confidently, but after a few moments "Dr. Michelle," the PI, points out a mistake. Eva stops talking as she tries to offer a correction; it is obvious she doesn't quite know what to say. Her voice trails off, until all of a sudden she realizes that it's not really a mistake, but rather a strange notation pulled from an article. Dr. Michelle interjects a few more times as Eva continues through her slides. Eva becomes more and more nervous, and has lost her seemingly calm demeanor from the beginning of her presentation.

"Malcolm," first year graduate student presenting literature review says: "first I want to give a little info on cancer drugs."

Dr. Michelle: "anticancer maybe..."

Everyone in the room laughs.

Malcolm seems very calm. He laughed off the "anticancer comment." There is also no shakiness audible in his voice and very few "ums." Like the other lab members, he writes out all of the molecule diagrams on the board as well as all the equations. However, he does make some effort to turn around and make eye contact with the group. His breathing is normal.

Deference

- Grad students and postdocs (often young women) defer to faculty (often older men) by giving credit or otherwise explicitly acknowledging their status and expertise.
- Example in the industry turned academic PI lab:

Dr. Paul asks Dr. Melvin (another faculty member) a question, and the two of them engage in a lengthy exchange. After some time, Matilda – the postdoc – interjects to ask a clarification question. She begins her question with a shy smile and the following qualification "My question is less complex [compared to Dr. Paul's]…" [She is clearly lowering expectations, signaling that the exchange between Paul and Melvin is expert territory, not to be entered easily].

Discussion—crisis in context

- Young women talk about expertise in the same normative way as everyone else; yet a crisis of confidence is displayed in presentation situations by young women and not by other age/gender groups in the labs.
  - Amplification of lack of confidence in hierarchical settings where age and gender is confounded with status—interruptions and deference
- This work demonstrates the clear need for more systematic analysis of the intersection of age and gender.

Summary points: How (and okay, a nod to Why)

Diversity and equitable/integrated work environments are positively related

When the conditions are right for diversity to be beneficial it leads to:

- Creativity
- Innovation
- Productivity
- Reputational effects

My questions to you: Your Experience and Ideas for integration in Chemical Sciences?

Integration and equity for all scientists by gender and race

- Field/occupation
- Organizations/industries
- Teams/labs

What are the barriers to integration?

Further discussion welcome!

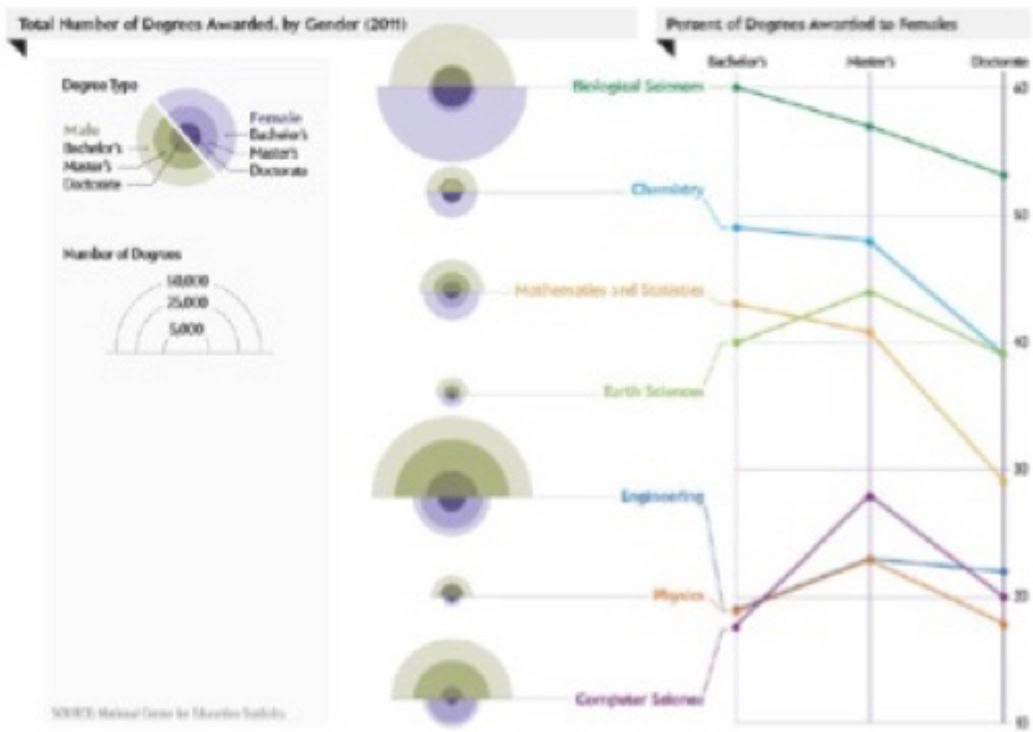
- Contact: Lsmithdoerr@soc.umass.edu

- Our review and argument published this month in *Engaging Science, Technology and Society* (http://estsjournal.org/article/view/142)
- We are grateful to our coauthors and collaborators Jennifer Croissant and Angela Stoutenburgh (U Arizona), Tiamba Wilkerson, and Chaia Flegenheimer.

- Mathias Nielsen and Londa Schiebinger's NSF funded workshop was formative to our thinking: held Feb 2016 at Stanford University. (Nielsen et al. 2017, "Gender Diversity Leads to Better Science," *PNAS* 114(8): 1740-2)

Appendix slides

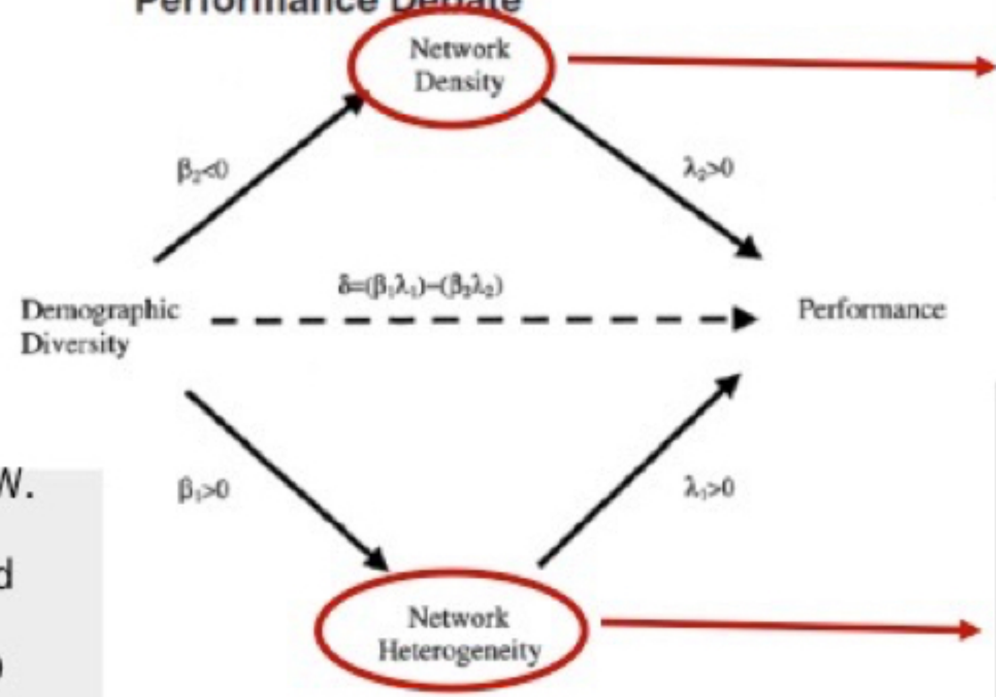
Chemistry has representational gender diversity



Source: *Scientific American*

Network density and homophily

Figure 3 **The Causal Model Underlying the Diversity-Performance Debate**



Strong ties between team members lead to higher team productivity

Access to different resources and information leads to higher team productivity

Reagans, Ray, and Ezra W. Zuckerman. 2001. "Networks, diversity, and productivity: The social capital of corporate R&D teams." Organization science 12(4):502-517.

Network density and homophily

Table 4 **Networks and Productivity**

Predictors	Controls	H1: Network Density	H2: Network Heterogeneity	Network Density and Heterogeneity
Control Variables				
Constant	−0.88	−1.6	−0.97	−6.05
Basic Research	−0.04	−0.02	−0.01	0.05
Applied Research	−0.40**	−0.34*	−0.31*	−0.34*
Product Development	0.02	0.04	0.07	0.09
Product Improvement	−0.19	−0.09	−0.24	−0.23
Market Competition	0.09**	0.10**	0.10**	0.10**
Network Variables				
Network Density		0.88**	0.89**	1.3**
Network Heterogeneity			5.5**	5.0**
× Network Density				22.9**
Firm Differences				
F-statistic	2.47	2.19	2.23	2.48
degrees of freedom	28, 174	28, 173	28, 172	28, 171

Both Density and Diversity are associated with higher productivity, but demographic diversity is associated with lower density.

Note. Estimates based on ordinary least squares with team performance as the dependent variable. The units are clustered within firms and

Teams have to learn to work across differences to get the benefits of diversity

Kinds of Diversity

Demographic

Ascribed aspects of identity – race, gender, nation of origin

Cognitive

Training, ideas, and skills relevant to completing the task

> Demographic diversity indirectly increases creativity through cognitive diversity (Page 2010)

Diversity and Performance

Cognitive diversity is associated with better performance outcomes

Improves how teams gather, exchange, and process information, provide feedback, and integrate information and perspectives (Joshi and Roh 2009).

BUT when gender stereotypes are strong and salient (i.e. engineering) demographic diversity does not have significant positive effects on team performance.

Discussion—Crisis of Confidence

- Future work is needed that also considers the intersection of age and gender with nationality and race. Consider one interviewee comment:
  - "I think the hardest part for me as an international student or all of international students are, is presenting in front of people because in science… I found it hard, or I get nervous easily, standing in front of a lot of people." --Ianna, grad student

How to Run a Feminist Science Lab Meeting

Posted by Max LiboironMarch 31, 2017
The main place where people notice feminism-at-work when they join our lab is in how we run our weekly lab meetings. Here are some resources on how we do it.