

# *Revitalizing Graduate STEM Education for the 21<sup>st</sup> Century: Skills, Motivation, and Structure*

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# Premises of the PhD

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## Knowledge and skill development

- Theory
- Methodology
- Current state of the field

## Acculturation

- Learn and use the language of the academy
  - Publication
- Social and collaborative networks



# Three-Career Model

(Laudel & Gläser, 2008)



## Cognitive Career

- Skills
- Knowledge Claims



## Community Career

- Citations
- Awards
- Reputation



## Organizational Career

- Access to necessary resources
- Compensation
- Benefits

## THE AUTHOR LIST: GIVING CREDIT WHERE CREDIT IS DUE

**The first author**  
Senior grad student on the project. Made the figures.

Michaels, C., Lee, E. F., Sap, P. S., Nichols, S. T., Oliveira, L., Smith, B. S.

**The third author**  
First year student who actually did the experiments, performed the analysis and wrote the whole paper. Thinks being third author is "fair".

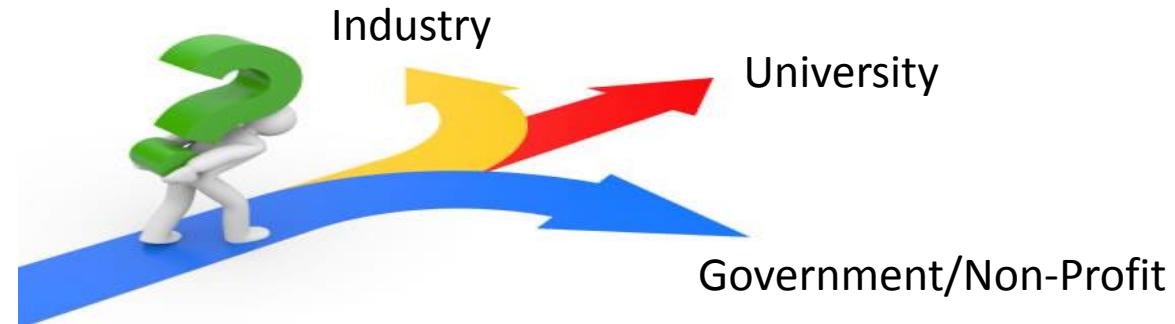
**The second-to-last author**  
Ambitious assistant professor or post-doc who instigated the paper.

**The second author**  
Grad student in the lab that has nothing to do with this project, but was included because he/she hung around the group meetings (usually for the food).

**The middle authors**  
Author names nobody really reads. Reserved for undergrads and technical staff.

**The last author**  
The head honcho. Hasn't even read the paper but, hey, he got the funding, and his famous name will get the paper accepted.

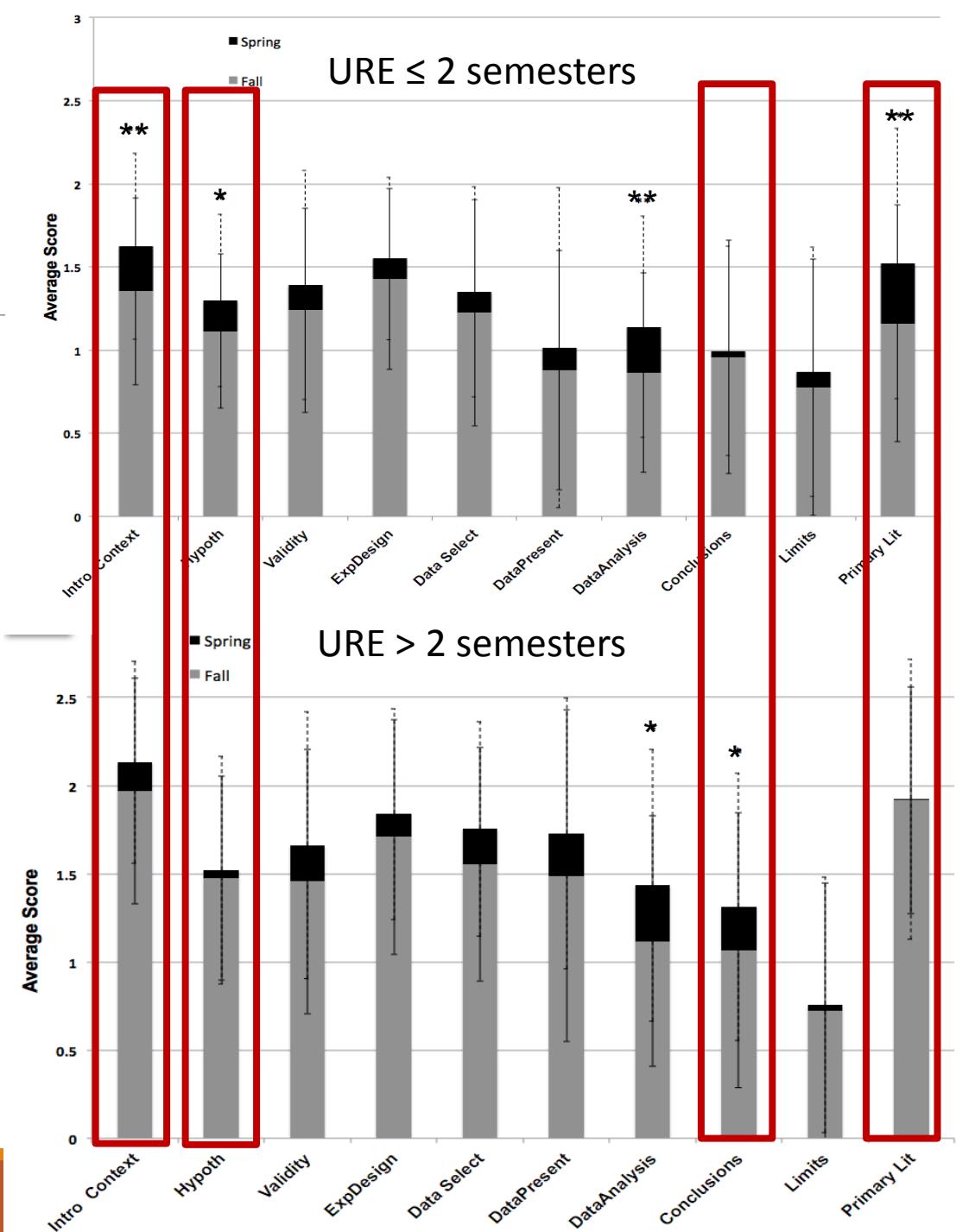
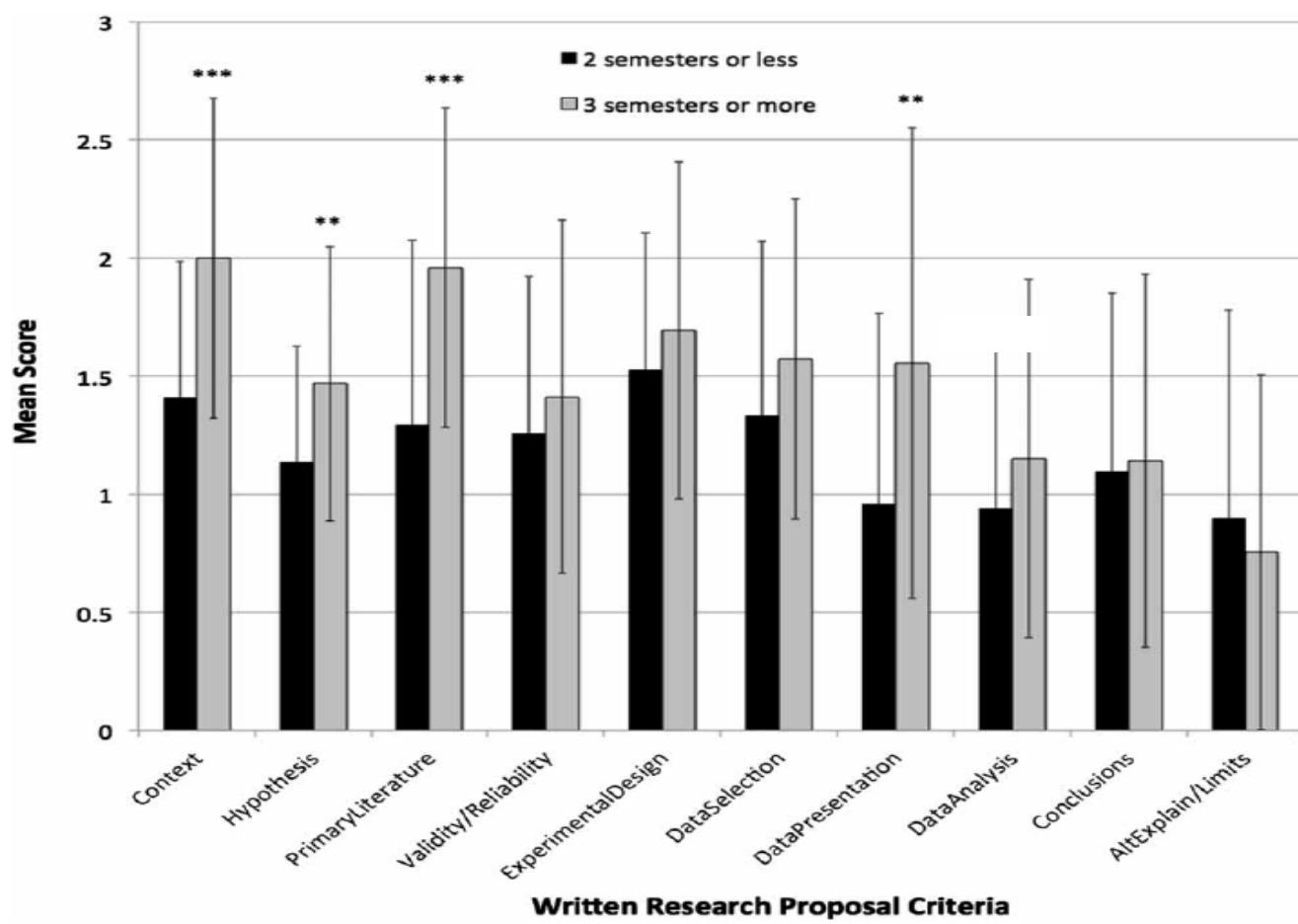
JORGE CHAM © 2005



# Cognitive Career

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# Research Skills Develop Sequentially



# Equity-Trajectory Interaction

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Significantly less participation in undergraduate research with faculty for (Kim & Sax, 2009):

- African Americans
- First-generation college students
- Students from lower socioeconomic backgrounds

Latent growth models in current study (Feldon et al., in prep.):

- First-generation students have significantly lower skills at PhD program outset
- Same students demonstrate significantly greater (positive) slope for skill growth over time

# Effective Practices for Developing Skills

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## Diverse training experiences

- Teaching + Research (Feldon et al., 2011, *Science*)
  - Medium effect sizes
    - Testability of Hypotheses ( $d = 0.40$ )
    - Experimental Design ( $d = 0.48$ )
- Student-Faculty Coauthorship (Feldon et al., 2016, *IJRD*)
  - Medium effect size ( $\Delta R^2 = 0.068$ )

# Do Bootcamps and Summer Bridge Programs Help PhD Development? (Feldon et al., 2017, *PNAS*)

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Participation (n=46 of 286; 16%) did not predict:

- Research skill scores or gains ( $0.3 \leq p \leq 0.9$ )
  - Data analysis and writing skills ( $0.7 \leq p \leq 0.9$ )
- Publication rates or gains ( $0.5 \leq p \leq 0.8$ )
- Socialization scores or gains ( $0.1 \leq p \leq 0.9$ )
  - Campus Climate & Commitment (Nora & Cabrera, 1996)
  - Perceived Cohesion Scale (Bollen & Hoyle, 1990)
  - Research Experience Self-Ratings (Kardash, 2000)
  - Socialization of Doctoral Students to Academics (Weidman & Stein, 2003)

# Do Skill Gaps Close Overall? (Feldon et al., 2016, *AERJ*)

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Skill gaps widen, but not based on mentor access

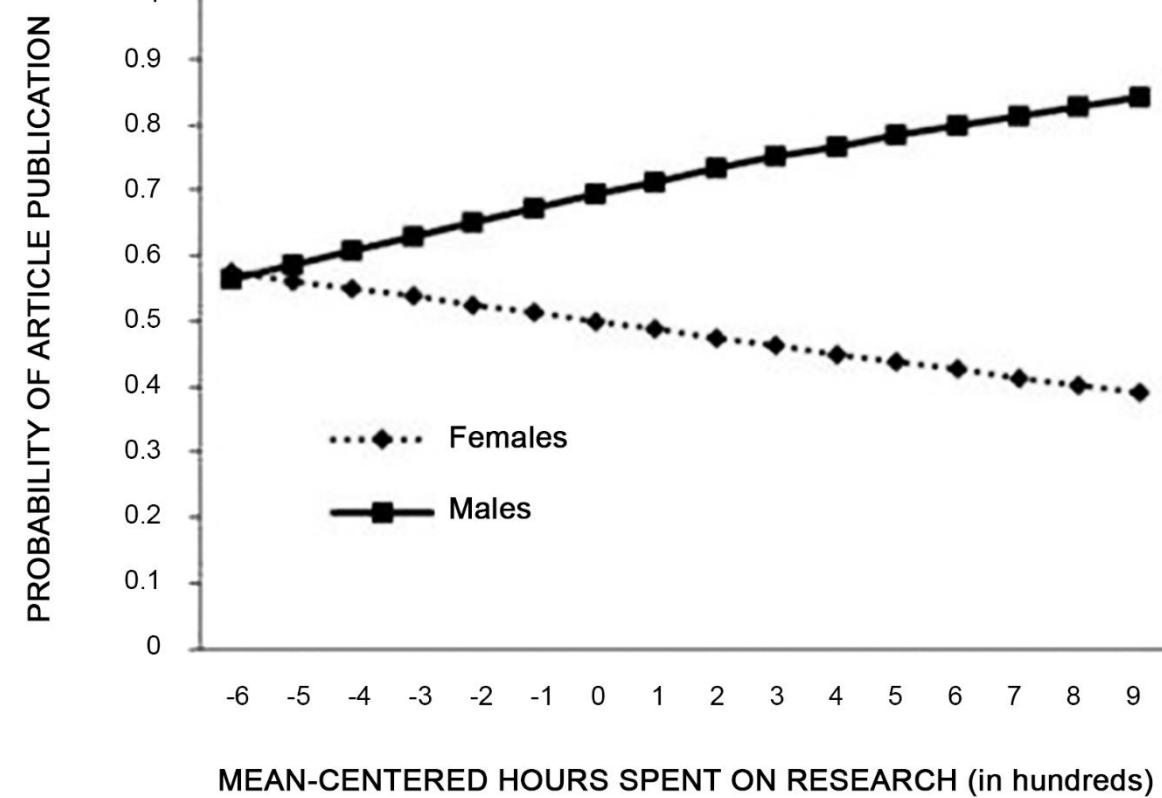
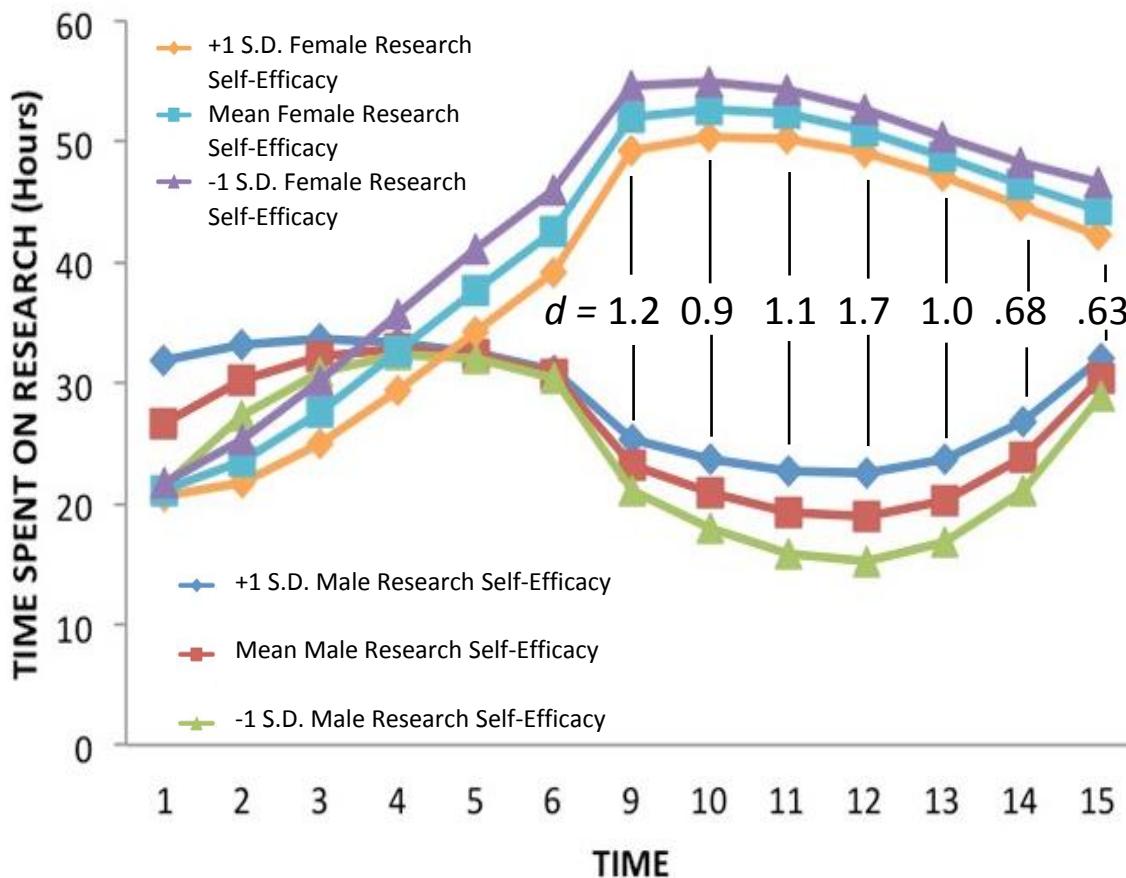
- High performers and low performers are farther apart after two semesters on every measured skill, even after controlling for pre scores ( $0.001 \leq p \leq 0.03$ ;  $0.54 < d < 1.01$ )
- All students received comparable mentoring
  - Equally positive relationships with faculty advisors
  - Equally high advisor expectations of research activity
  - Equal rates of coauthorship with advisor
- Differences between groups:
  - High performers' advisors held clear expectations of self-direction and productivity
  - Low performers' advisors held more flexible expectations
  - High performers are more independent decision-makers
  - Low performers are less likely than high performers to value mundane tasks (e.g., data collection)

# Community Career

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# Time-to-Credit Gender Inequities in Publication

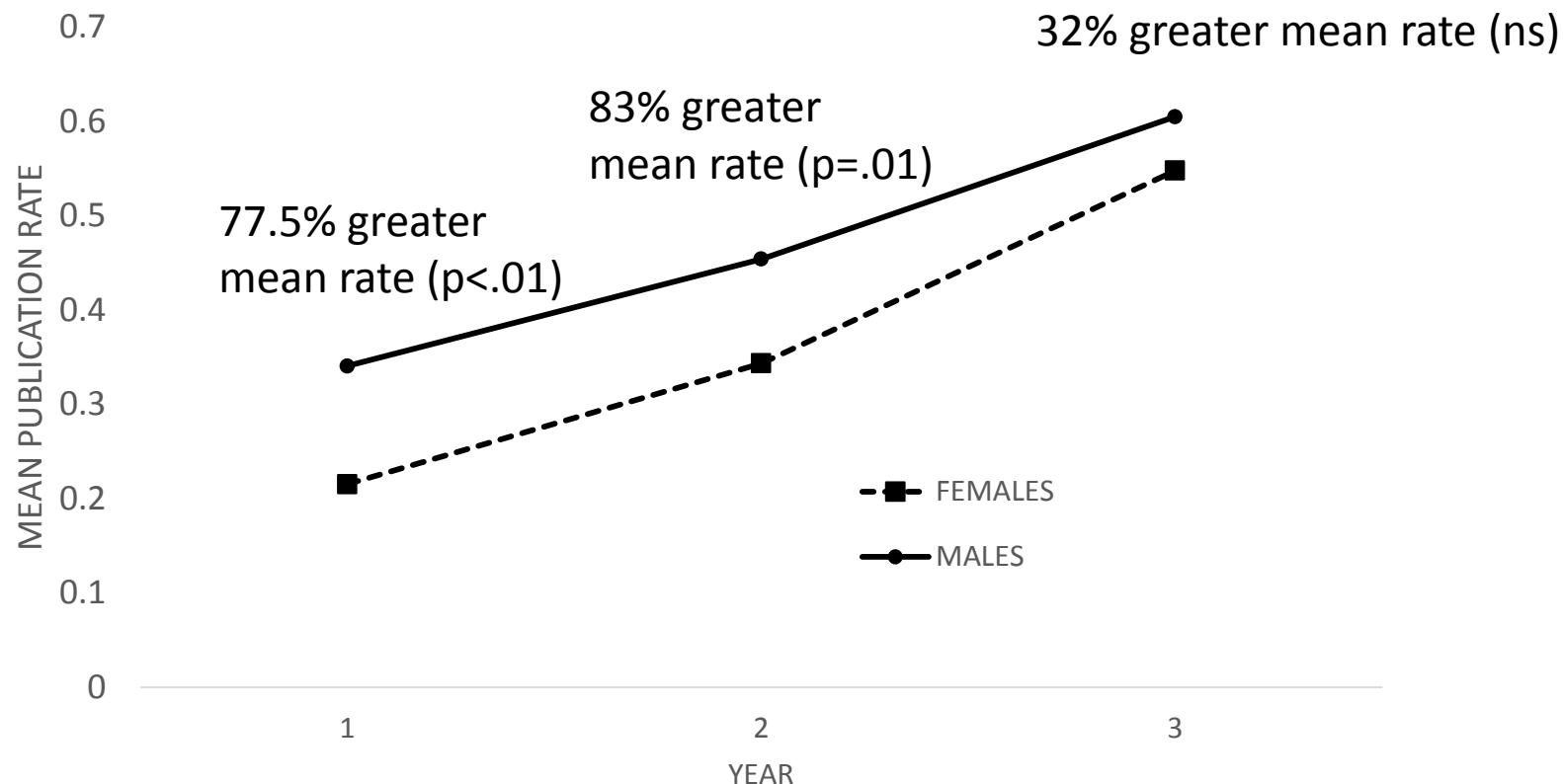
(Feldon et al., 2017, *CBE-Life Sciences Education*)



# Publication Rates by Gender

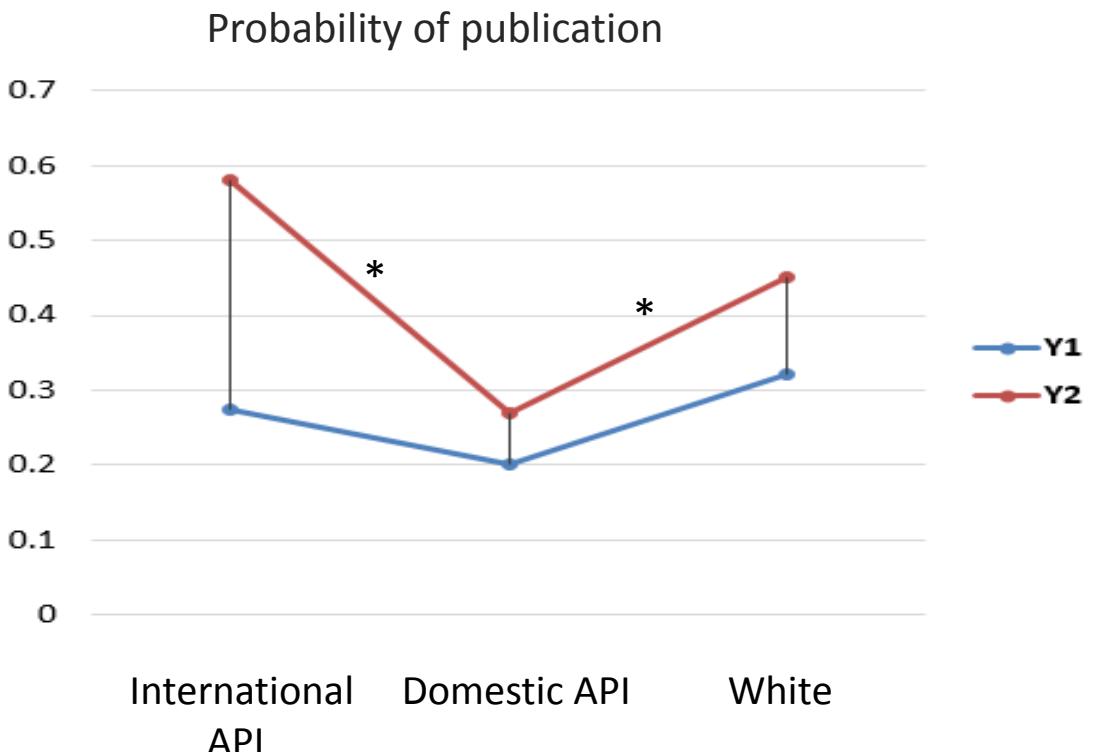
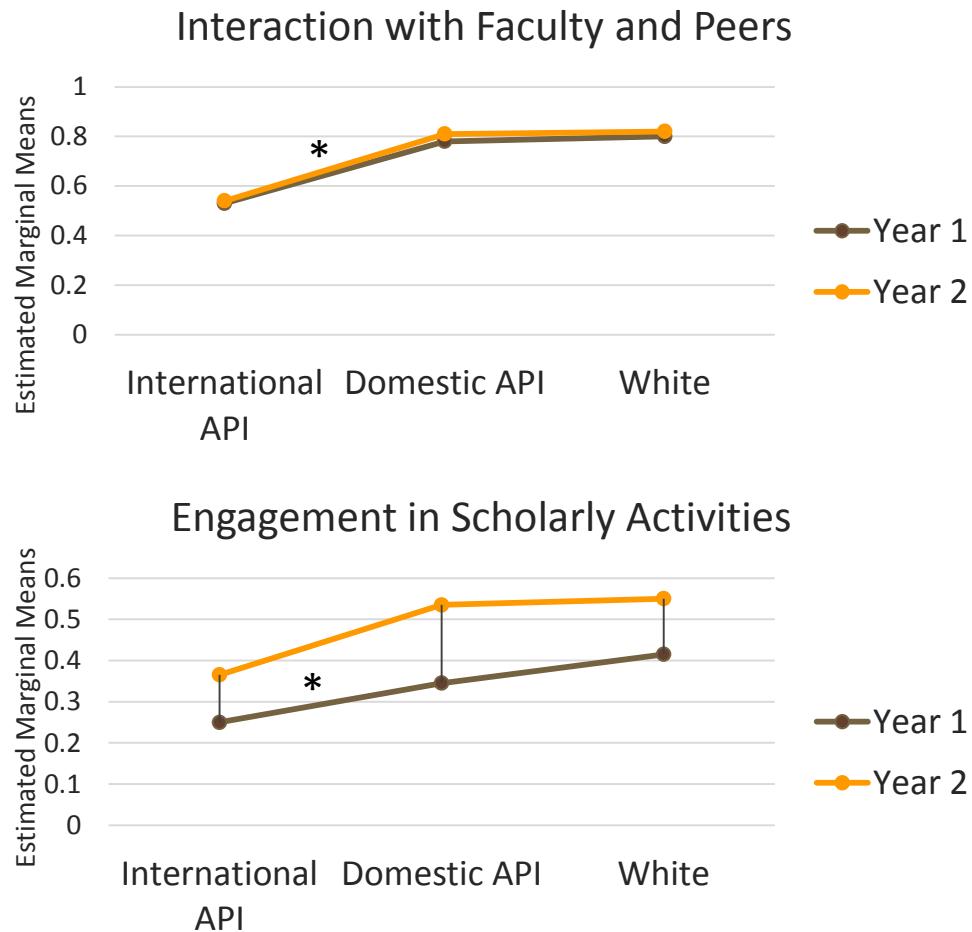
(Feldon et al., in preparation)

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# Socialization Does Not Drive Productivity

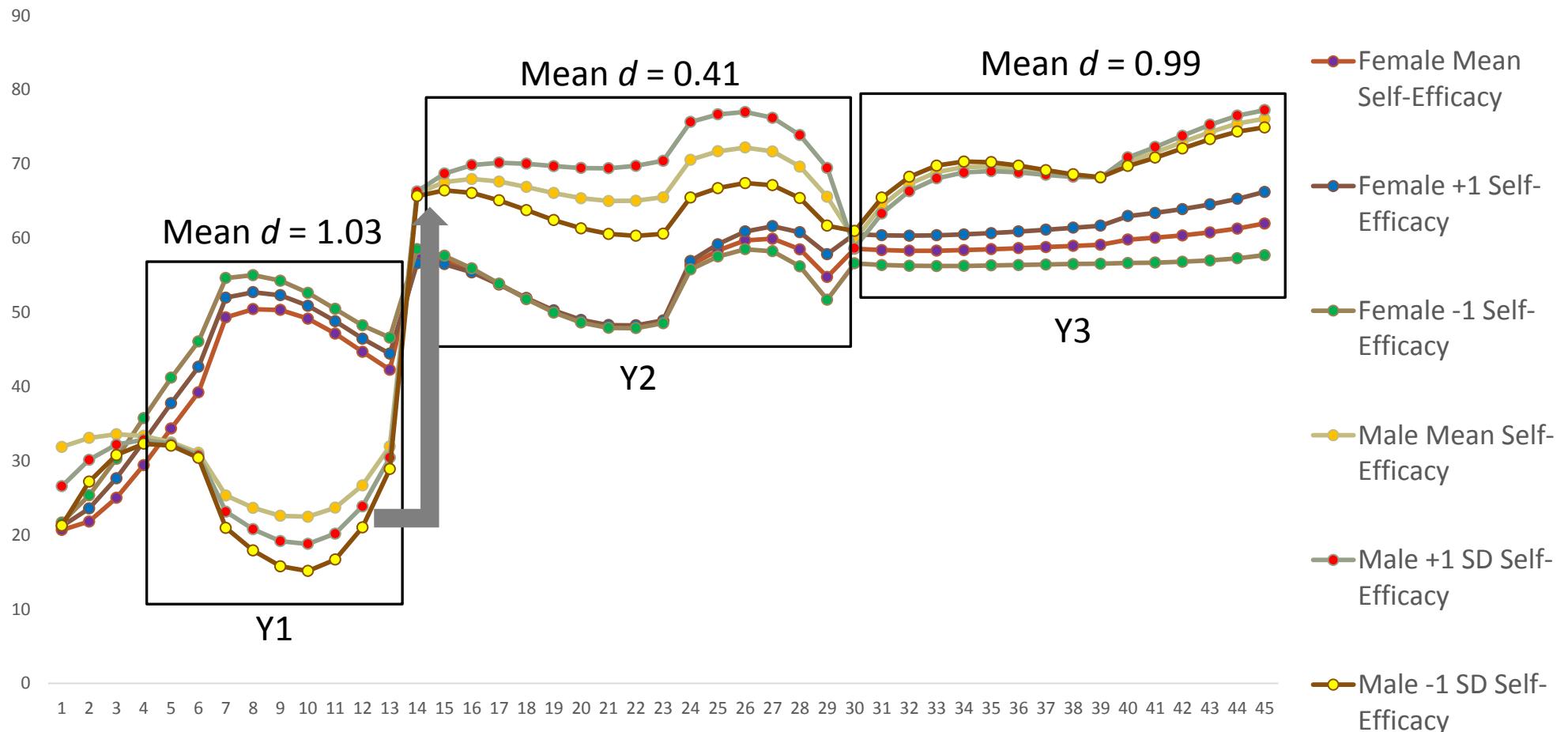
(Roksa et al., in press, *RSE*)



# Organizational Career

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# Lab Time by Gender Over 3 Years



# Laboratory Rotations as a Target of Future Inquiry (Maher et al., 2017, *JCSR*)

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During exit interviews with students withdrawing from Ph.D. programs during the first 2 years of study (n=18), 33% reported “Rotation 180”

- Positive interactions and experiences during rotation, negative interactions after placement
- 5 of 6 were female
- Supervising faculty of both genders

# Acknowledgements

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