Revitalizing Graduate STEM Education for the 21st Century: Skills, Motivation, and Structure

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Premises of the PhD

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

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**THE AUTHOR LIST: Giving Credit Where Credit is Due**

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

- **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 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 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.
Cognitive Career
Research Skills Develop Sequentially

Timmerman et al. (2013), SHE
Equity-Trajectory Interaction

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

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*)

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)

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
Time-to-Credit Gender Inequities in Publication
(Feldon et al., 2017, CBE-Life Sciences Education)

\[ d = 1.2 \ 0.9 \ 1.1 \ 1.7 \ 1.0 \ .68 \ .63 \]

+1 S.D. Female Research Self-Efficacy
Mean Female Research Self-Efficacy
-1 S.D. Female Research Self-Efficacy

+1 S.D. Male Research Self-Efficacy
Mean Male Research Self-Efficacy
-1 S.D. Male Research Self-Efficacy

PROBABILITY OF ARTICLE PUBLICATION

MEAN-CENTERED HOURS SPENT ON RESEARCH (in hundreds)
Publication Rates by Gender
(Feldon et al., in preparation)

- 32% greater mean rate (ns)
- 83% greater mean rate (p=.01)
- 77.5% greater mean rate (p<.01)
Socialization Does Not Drive Productivity
(Roksa et al., in press, RSE)
Organizational Career
Lab Time by Gender Over 3 Years

- Female Mean Self-Efficacy: Mean $d = 0.99$
- Male Mean Self-Efficacy: Mean $d = 0.41$
- Female +1 SD Self-Efficacy: Mean $d = 1.03$
- Male +1 SD Self-Efficacy: Mean $d = 0.99$
- Female -1 SD Self-Efficacy: Mean $d = 0.41$
- Male -1 SD Self-Efficacy: Mean $d = 1.03$

Y1, Y2, Y3
Laboratory Rotations as a Target of Future Inquiry (Maher et al., 2017, JCSR)

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
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