Ingredients for Broadening Participation in STEM
Measuring psycho-social stability and integration

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NIGMS
hhmi Howard Hughes Medical Institute
...in diversity there is beauty and there is strength.

Maya Angelou
THE RESEARCH SCIENCE PIPELINE...

BA/BS

Masters

Ph.D.

Post Doctoral Fellow (optional)

Contributing Scientist/Academic
Disparity that grows...

**Share of STEM Degree Attainment Pool by Major Group**

- **STEM Doctorates working as Full/Assoc/Asst Profs in 2yr & 4yr institutions in 2008**
  - URM: 7.3%
  - White: 8.3%

- **STEM Doctorates awarded in 2010**
  - URM: 12.6%
  - White: 8.3%

- **STEM Masters degrees awarded in 2010**
  - URM: 14.7%
  - White: 12.6%

- **STEM Bachelors degrees awarded in 2010**
  - URM: 29.3%
  - White: 14.7%

- **2010 US Population (all ages)**
  - URM: 29.3%
  - White: 14.7%

**Sources:**
Where do we go?

K-12 → Work → High School → 2 Year College → Work → Family

Professional School → 4 Year College → Work

M.D. or D.D.S. etc. → Postdoctoral Fellowship → Practice → University Faculty

Ph.D. or M.D., Ph.D. → Graduate School → Industry

NIH → Etc.

NIH → Etc.
Pipeline or Pathways?
Problems with Existing Data in 2005

1. Programs can “cherry pick” students who are likely to succeed
   - These students are likely to succeed without the program (growing new talent versus harvesting abilities)

2. No control or comparison group

3. Long-term evaluations outside of funding scope

4. No way to examine the “mechanisms” of success

5. Retrospective accounts can be biased
The Science Study

✧ Longitudinal study of underrepresented minority science students who had a strong interest in pursuing a biomedical research career
The Science Study Research Team

- Wesley Schultz (PI)
- Mica Estrada (Co-PI)
- Anna Woodcock
- Paul Hernandez
- Richard Serpe
- Victor Rocha
Overview: The Science Study

From 50 campuses nationwide, 25 of these had RISE programs in 2005 (when study began)
Overview: The Science Study

Matched control group

- For each R.I.S.E. or MARC student, we found a similar student who does not go through the program

- **Matching variables:** ethnicity, gender, major, GPA, intention to become a scientist, enrollment level (LD, UD, Grad)

- **Secondary matching:** age, parental education, community college transfer, English as first language
Survey Data Collection

✧ Data collected twice yearly from students through a secure web interface

✧ 11 years

www.TheScienceStudy.com
Longitudinal Panel

- 72% Female

- Ethnicity/Race:
  - 49% African American
  - 39% Hispanic/Latino(a)
  - 1% Native American

- Major (when began):
  - 63% Biological Sciences
  - 21% Natural Sciences
  - 12% Behavioral & Social Sciences
  - 4% Mathematics & Engineering
RETENTION: Tailored Panel Management

- **Response rates** at each wave range from 86% to 70% (71% in most recent, Spring 2015)
- **Data augmented** with degree attainment from the National Student Clearinghouse
- **Remain in contact** with 97% of panel

*Protocol summarized in Estrada, Woodcock & Schultz, 2014*
Minority Training Programs: NIH RISE Program Elements

- Paid tuition
- Other
- Tutoring
- Graduate school applications
- Summer training/internships
- Academic advising/counseling
- Financial support/stipends
- Seminars/guest speakers
- Conference support
- Research with a faculty member

Note: Results based on survey responses from 25 RISE directors.
Overview of Results

1. Basic effects (summative outcome)
   - Persistence (Intention to become a scientist)
   - STEM career persistence

2. Program elements (mediators)
   - Research experience, faculty mentorship

3. Reasons for success (a process of integration)
   - Self-efficacy, identity, values
Q: To what extent do you intend to pursue a career as a biomedical scientist? (0 – 10)
Initial Model: Change of Intention Over Time

Q: To what extent do you intend to pursue a career as a biomedical scientist? (0 – 10)

C = 1.58
Initial Model: Change of Intention Over Time

Intention to Pursue a Career in the Biomedical Sciences (Modeled)

Wave

RISE
Dropped
Match
Chance students is now in a STEM Career:
RISE EFFECT

Where Are They Now?
(Spring 2014)

- Not in STEM: 64% Control, 52% RISE
- In STEM: 36% Control, 48% RISE
2. Program Elements (Mediators)

- Invited Speakers & Workshops
- Tutoring
- Support to attend professional conferences
- Paid Tuition & Stipends
- Research Experience
- Faculty Mentorship
Mediation: Research Experience

![Diagram showing mediation effects between RISE Status and Intention to Pursue a Career in the Biomedical Sciences through Research Experience.](image)

- $a = 0.36^{**}$
- $b = 2.38^{**}$
- $c = 1.58^{**}$
- $c' = 0.68^*$

Note: $a$, $b$, and $c$ path's are unstandardized coefficients. *$p < 0.05$, **$p < 0.001$

Bootstrapped Indirect Effect: Mean = 0.68, CI$_{99\%}$ = 1.31 to 0.45

Sobel: $Z = 4.67$, $p < .001$
Note: Change over time analyses conducted as a hierarchical linear model, with both linear and quadratic terms. Analyses are based on students who were undergraduates (jr. or sr.) at W0. Propensity score (W0) used as time invariant covariate. RISE = students continuously funded, and MATCH = students never funded by any program and enrolled on a RISE campus. Research is any research experience ever during undergraduate education. Intention to pursue career as biomedical scientist.
Mediation: Faculty Mentor

\[ a = 0.32^{**} \]
\[ b = 0.78^* \]
\[ c = 1.58^{**} \]
\[ c' = 1.33^{**} \]

Intention to Pursue a Career in the Biomedical Sciences

Note: \( a, b \) and \( c \) paths are unstandardized coefficients. \( * p < .05, ** p < .001 \)

Sobel: \( Z = 2.08, p < .05 \)
Why does research experience have such a large impact?
Diversity involves integration...

And it is a two way street...community provides opportunity, inclusion, values...but students are not blank slates...
Building on Kelman’s social influence theory, who integrates into the scientific community?

**Tripartite Integration Model of Social Influence (TIMSI)**

- **Scientific self-efficacy**
  - I can do what scientists do

- **Scientific identity**
  - I am a scientist

- **Internalization of scientific values**
  - I agree with the values of the scientific community.

Integration (persistence)

Estrada et al., 2011
Example of Science Efficacy Questions

Extent to which you are confident you can successfully complete the following tasks...

- Use scientific language and terminology.
- Figure out/analyze what data/observations mean.
- Use scientific literature and/or reports to guide research.
- Use technical science skills (use of tools, instruments, and/or techniques).
- Report research results in a written paper.

Chemers, et. al. (2010).
3. Reasons for Success (process)

Scientific Self-Efficacy (rule)

Research Experience

Intention to Pursue a Career in the Biomedical Sciences

$a = .28^*$

$c = 2.55^{**}$

$c' = 2.28^{**}$

$b = .98^{**}$

Note: $a$, $b$, and $c$ path's are unstandardized coefficients. $^* p < .05$, $^{**} p < .01$

Bootstrapped indirect effect: mean = .27, CI$_{99\%}$ .06 to .56

Note: $R^2 = .26$, $p < .01$
Example of Science Identity Questions

Level of agreement with each statement...

- In general, being a scientist is an important part of my self-image.
- I am a scientist.
- I have a strong sense of belonging to the community of scientists.
- Being a scientist is an important reflection of who I am.

Modification of Chemers, et. al. (2010).
4. Reasons for Success (process)

Scientific Identity (role)

Research Experience

Intention to Pursue a Career in the Biomedical Sciences

\[ a = .56^{**} \]

\[ b = 1.34^{**} \]

\[ c = 2.55^{**} \]

\[ c' = 1.80^{**} \]

Note: a, b and c path’s are unstandardized coefficients. * p < .05, ** p < .01
Bootstrapped indirect effect: mean = .75, CI = .33 to 1.23
Sobel: Z = 4.37, p < .001
Example of Science Value Questions

How much is this person like you?

- A person who thinks it is valuable to conduct research that builds the world's scientific knowledge.

- A person who believes writing up research results to be published in a leading scientific journal is a good use of time.

- A person who feels discovering something new in the sciences is thrilling.

- A person who thinks it is important work to identify truths using the scientific method.

- A person who thinks discussing new theories and ideas between scientists is important.

Estrada, et al. (2011).
4. Reasons for Success (process)

Scientific Values (value)

Research Experience

Intention to Pursue a Career in the Biomedical Sciences

Note: a, b and c paths are unstandardized coefficients. * p < .05, ** p < .01
Bootstrapped indirect effect: mean = .27, CI99% .01 to .60
Sobel: Z = 2.43, p < .01
Tripartite Integration Model of Social Influence (TIMSI)

Undergraduate students

- Self-Efficacy: \(0.60^*\)
- Identity: \(0.54^*\)
- Value: \(0.22^*\)

\[ \rightarrow \quad \text{Scientific Integration} \]

\[ (0.28) \]

Graduate students

- Self-Efficacy: \(-0.11\)
- Identity: \(0.45^*\)
- Value: \(0.16^*\)

\[ \rightarrow \quad \text{Scientific Integration} \]

\[ (0.26) \]

Left

- Self-Efficacy: \(0.60^*\)
- Identity: \(0.49^*\)
- Value: \(0.05\)

\[ \rightarrow \quad \text{Scientific Integration} \]

\[ (0.21) \]

Estrada et al. (2011)
Tripartite Integration Model of Social Influence (TIMSI)

Estrada et al. (2011)
Gift it Forward Study: Researching UC Berkeley’s Biology Scholars Program

Lilibeth Flores¹. John Matsui²
University of California San Francisco¹ &
University of California Berkeley²
Biology Scholars Program (BSP)
UC Berkeley

- 23 year program
- Consistent “beating the odds” results
- Provides academic advising, social support, research opportunities, mentorship, seminars and workshops, community.
- National recognition for its success
BSP Demographics

<table>
<thead>
<tr>
<th>BSP Participant</th>
<th>Biological Sciences Intended Freshmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>74%</td>
</tr>
<tr>
<td>Underrepresented Minority</td>
<td>58%</td>
</tr>
<tr>
<td>First Generation College</td>
<td>69%</td>
</tr>
<tr>
<td>HS API Rank 1 to 5</td>
<td>52%</td>
</tr>
<tr>
<td>Weighted HS GPA 3.5 to 4.0</td>
<td>22%</td>
</tr>
<tr>
<td>SAT Math 200 to 600</td>
<td>58%</td>
</tr>
</tbody>
</table>
Biological/Biomedical Sciences Persistence – URM

Note: 2002-2008 entering freshmen cohorts, intended biological and biomedical sciences majors
Beyond outcomes...

What is happening?
BSP Gift It Forward Study

- Began in Fall 2014 (currently have 5 waves of data)
- 72 Participants (2014 cohort)
  - 74.3% females
  - 44.3% Hispanic/Latino/Chicano; 8.6% African American; 4.3% Native American/Alaskan Native.
  - 75% of the participants were first generation college students
  - 43.7% first year, 31% second year, 15.5% third year, 2.8% 4th year, and 4.2% 5th year or more at UCB
Biology Scholars
Integration into Science Community

No significant change for BSEP students.
Psychosocial and Outcome Variable: BSP compared with Bio1A/Chem 1A Students (Fall 2015)

- Life Satisfaction
- Stress
- Stereotype Threat
- Science Values
- Science Identity
- Science Efficacy
- Intentions

Legend:
- Biology Scholars
- Science Students High Intention
- Science Students Low Intention

Understanding why programs work

5/17/17

UCSF
Psychosocial and Outcome Variable:
BSP compared with Bio1A/Chem 1A Students (Fall 2015)

- Life Satisfaction
- Stress
- Stereotype Threat
- Science Values
- Science Identity
- Science Efficacy
- Intentions

Biology Scholars
Science Students High Intention
Science Students Low Intention
Psychosocial and Outcome Variable:
BSP compared with Bio1A/Chem 1A Students (Fall 2015)
Example of Stereotype Threat Questions

How often do you feel that because of your ethnicity...

- Some people believe that you have lower ability than other students.
- People assume that you are not good enough, even if you are similar to other students.
- If you do poorly on a test, people act like that is normal.
- Your intelligence is not fairly evaluated.
### BSP 2015 Participation and Integration

#### Spring 2015

<table>
<thead>
<tr>
<th></th>
<th>Science Efficacy</th>
<th>Science Identity</th>
<th>Science Values</th>
<th>Social Climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutoring</td>
<td>-.27</td>
<td>-.16</td>
<td>-.05</td>
<td>-.11</td>
</tr>
<tr>
<td>BSP Participation</td>
<td>.21</td>
<td>.12</td>
<td>.13</td>
<td>.19</td>
</tr>
<tr>
<td>Events Attended</td>
<td>.27*</td>
<td>.29*</td>
<td>.01</td>
<td>.36**</td>
</tr>
<tr>
<td>Appointments Attended</td>
<td>.40**</td>
<td>.26</td>
<td>-.08</td>
<td>.20</td>
</tr>
<tr>
<td>Total Events Attended</td>
<td>.40**</td>
<td>.28*</td>
<td>.19</td>
<td>.29*</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
BSP Integration into Science Community
(compared with TheScienceStudy)

Baseline | Mid | End
--- | --- | ---

Sci Identity - BSP
Science Study STEM BA
Science Study non-STEM BA
Key Points

1. There are ways to evaluate and conduct research to see if a programs are effective at increasing persistence
   
   Collect longitudinal data

   Prospective (as it happens)

   Have comparison groups when feasible

   Utilize institutional data to track short- and long-term impacts

2. There are ways to start to understand why programs work

   Measure psychosocial variables -- such as science efficacy, identity and values -- that are related to persistence.

   Looks at well-being, stereotype threat and stress as well.
THANK YOU

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