The APS Bridge Program: Changing the Face of Physics Graduate Education

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Active learning increases student performance in science, engineering, and mathematics

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To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning ($n = 158$ studies), and that the odds ratio for failing was 1.95 under traditional lecturing ($n = 67$ studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. Heterogeneity analyses indicated that both results hold across the STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small ($n \leq 50$) classes. Trim and fill analyses of 225 studies in the published and unpublished literature. The active learning interventions varied widely in intensity and implementation, and included approaches as diverse as occasional group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs. We followed guidelines for best practice in quantitative reviews (\textit{SI Materials and Methods}), and evaluated student performance using two outcome variables: (i) scores on identical or formally equivalent examinations, concept inventories, or other assessments; or (ii) failure rates, usually measured as the percentage of students receiving a D or F grade or withdrawing from the course in question (DFW rate).

The analysis, then, focused on two related questions. Does active learning boost examination scores? Does it lower failure rates?

Results

The overall mean effect size for performance on identical or equivalent examinations, concept inventories, and other assess...
8.2 JOINT DIVERSITY STATEMENT*
(Adopted by Council on November 16, 2008)

To ensure a productive future for science and technology in the United States, we must make physics more inclusive. The health of physics requires talent from the broadest demographic pool. Underrepresented groups constitute a largely untapped intellectual resource and a growing segment of the U.S. population.

Therefore, we charge our membership with increasing the numbers of underrepresented minorities in physics in the pipeline and in all professional ranks, with becoming aware of barriers to implementing this change, and with taking an active role in organizational and institutional efforts to bring about such change. We call upon legislators, administrators, and managers at all levels to enact policies and promote budgets that will foster greater diversity in physics. We call upon employers to pursue recruitment, retention, and promotion of underrepresented minority physicists at all ranks and to create a work environment that encourages inclusion. We call upon the physics community as a whole to work collectively to bring greater diversity wherever physicists are educated or employed.

*Endorsed by APS, NSBP, NSHP
Hispanic American Bachelor Degrees

Pop. Growth

- Population
- Biology
- Engineering
- Chemistry
- Math and Stats
- Physics
- Earth Sciences

Sources: IPEDS Completion survey by race, US Census


0% 2% 4% 6% 8% 10% 12% 14% 16% 18% 20%

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African American Bachelor Degrees

Sources: IPEDS Completion survey by race, US Census
Underrepresented Minority (URM) Physics degrees

Sources: IPEDS Completion survey by race, US Census

Only ~30 students!
### Bachelor and PhD STEM Degrees

<table>
<thead>
<tr>
<th>Field</th>
<th>BS</th>
<th>PhD</th>
</tr>
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<tbody>
<tr>
<td>Computer Science</td>
<td>639</td>
<td>78</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>639</td>
<td>161</td>
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<tr>
<td>Chemistry</td>
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<td>639</td>
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<tr>
<td>Engineering</td>
<td>161</td>
<td>63</td>
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<tr>
<td>Mathematics and Statistics</td>
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<td>6</td>
</tr>
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<td>6</td>
</tr>
<tr>
<td>Astronomy</td>
<td>78</td>
<td>6</td>
</tr>
</tbody>
</table>

Percentage of URM for Bachelor and PhD degrees.
Leadership / Oversight

National Advisory Committee
• J.D. Garcia (Arizona)
• Yolanda George (AAAS)
• Paul Gueye (NSBP)
• Wendell Hill (UMCP)
• Anthony Johnson (Chair, UMBC)
• Brittany Kamai (Grad student)
• Ramon Lopez (UT Arlington)
• Luz Martinez-Miranda (NSHP)
• James Mathis (Grad student)
• Steve McGuire (Southern University)
• Ritchie Patterson (Cornell)

Architect’s Council
• Marcel Agüeros (Columbia)
• Ed Bertschinger (MIT)
• Andreas Bill (CSU Long Beach)
• Simon Capstick (Florida State)
• Cagliyan Kurdak (Michigan)
• Garrett Matthews (USF)
• Jon Pelz (Ohio State)
• Talat Rahman (UCF)
• Kelly Holley-Bockelmann (Fisk/Vanderbilt)
• Jon Urheim (Indiana)

Research / Assessment
• Deepa Chari (FIU-Postdoctoral Assoc.)
• Geoff Potvin (FIU-Research advisor)
• Rachel Scherr (SPU-Project evaluator)

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Bridge Program Design: Underlying Themes

• Focus on underrepresented minorities (Hispanic American, African American, Native American)
• Base components on published scholarship and operational successes of similar programs
• Design program to avoid “rearranging the deck chairs”
• Bring unique position of APS to bear on the problem
• Measurable outcomes must be immediately recognizable by an APS member as having significant value
• Must have significant national impact
APS Bridge Program: Key Features

- **Recruit** students through graduate programs (unaccepted), undergrad programs (promising but uncompetitive, or unsure)

- **Establish** Bridge Sites (6):
  - Year 1: Advanced undergraduate or grad courses, introduction to grad-level research, active mentoring, progress monitoring, social integration into grad school *(Project funds)*
  - Year 2: Take 1st year grad courses, apply to PhD program, research underway *(Department funds)*

- **Place** additional students (at Partnership Institutions):
  - 44 graduate programs looked at “other” applications (2016), recruited additional students; No direct support, some travel
  - “COM approved” Partnership Institutions; national recognition of program

- **Monitor** student/site progress

- **Research**

- **Disseminate / Advocate**
Student Eligibility

• Bachelor’s degree in physics or closely related discipline
• US citizen or permanent resident
• Either:
  • Applied but was not accepted
  • Did not apply to graduate program this year
• Be committed to improving diversity in physics
• Meet individual requirements of the institution
• Students may not be currently enrolled in a graduate program

We review applications AFTER April 15
Bridge/Partnership Programs in Physics

APS Sites:
- Cal State Long Beach
- Florida State University
- Indiana University
- Ohio State University
- University of Central Florida
- University of South Florida

Non-APS Sites:
- Bowling Green State University
- Cal State Los Angeles
- Columbia University
- Delaware State University
- DePaul University
- Embry-Riddle Aeronautical University
- Fisk-Vanderbilt
- Florida International University
- MIT
- North Dakota State University
- Princeton University
- Texas State University
- University of Chicago
- University of Cincinnati
- University of Connecticut
- University of Hawai'i at Manoa
- University of Houston, Clear Lake
- University of Michigan
- University of N. Carolina, Chapel Hill
- University of Rochester
- University of Texas, Arlington
Institutional Members

- Member Institutions
  - 108 in 36 states
- Partnership Institutions
  - 27 in 16 states
Bridge Sites and Partnership Institutions

- Admission decisions ("holistic" criteria)
- Financial support (timing)
- Coursework (induction advising critical, allow advanced undergrad courses, alternative plan)
- Progress monitoring (timing, tutors if needed)
- Multiple mentors (intervention, peer involvement)
- Research (appropriate match)
Bridge Program Achievements

Bridge Program Physics PhDs

- 23% Women (20%)
- 93% URM (6%)
  - 64% Hispanic
  - 24% African American
  - 5% Native
- 88% Retention (60%)
What we didn’t know…

1. Aggregating applications is a powerful tool
2. Graduate programs very supportive
3. Admissions data are not what they seem
   • GRE is a big factor
   • No correlations with success…
4. Applications are expensive
5. Importance of graduate student groups
Some reasons students are not admitted

Students:
• Low physics GRE score
• Apply to too few places
• Apply to wrong places
• “Feel” unprepared (self-esteem)
• Inadequate preparation: will fail in grad courses
• Application materials do not tell a predictive story

Admissions Committees:
• Members overwhelmed
• Members unaware of admissions research findings
Research Efforts

• Graduate admissions study
  • Doctoral institutions
  • Master’s institutions

• GRE (and other) admissions data: Correlations with student success; impact on diversity

• Holistic admissions practices: practical use of non-cognitive measures or other practical techniques for use by physics graduate admissions faculty (parallel effort by CGS)

• Student perspective on admissions
Physics GRE: Impact of Cutoff Scores

Enhancing Diversity in Graduate Education

Fraction (White)
Fraction (Hispanic)
Fraction (Black)
Fraction (Asian)

0.09 (Black)
0.34 (Hispanic)
0.44 (White)
0.61 (Asian)

0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

400
500
600
700
800
900
1000

650
Undergraduate GPA as a predictor

Graph showing the relationship between Undergraduate Physics GPA and Core Graduate GPA. The graph includes circles representing Satisfactory, At Risk, and Dropped categories.

- Satisfactory: Green circles
- At Risk: Yellow squares
- Dropped: Red triangles

Axes:
- Y-axis: Core Graduate GPA
- X-axis: Undergraduate Physics GPA

Graph legend:
- Green circle: Satisfactory
- Yellow square: At Risk
- Red triangle: Dropped

Graph values:
- Y-axis: 0 to 4
- X-axis: 0 to 4
Forging Partnerships with MSIs

• New program launching in 2017
• Mini-grants to bring together MSI faculty and researchers at doctoral-granting institutions to build research collaborations
• Funding for travel in both directions for faculty and students
• Contact Erika Brown (brown@aps.org) for more information
Next Steps…

• Partnership Institutions / INCLUDES: Broader implementation of advances made by Bridge Program (admissions, induction, 1st year support, peer and faculty mentoring)

• APS National Mentoring Community (aps.org/nmc)

• Better understand graduate admissions

• Joint Bridge Program / Graduate Education in Physics Meeting: 10-12 February 2017

Happy Physicists ⇒ Great Physics
NMC Benefits

• Locally-based mentoring
• Travel funding to NMC gathering
• APS membership for mentees
• News/information on physics opportunities
• Mentor and mentee training
• Recognition of mentoring as important professional activity
Participant Data

NMC Mentor Registration

Cumulative Number of Mentors

Mentor Registration Date

Future Plans

- Mentee registration
- “Bringing Emergency Aid to Mentees” (BEAM) fund
- Mentoring award
- FAQ sheets
- Multiple mentors
- Get-Togethers at APS March and April Meetings
JOIN THE APS NATIONAL MENTORING COMMUNITY
A program by the American Physical Society

BENEFITS INCLUDE:
△ Access to opportunities and resources
△ Travel awards to NMC Conference
△ Emergency aid fund
△ A supportive mentor to help you navigate your degree
△ Learn about physics careers

The APS NMC program aims to increase the number of African American, Hispanic American, and Native American undergraduates obtaining physics bachelor’s degrees.

SIGN UP
Connect to a local physics mentor.

IT’S FREE!

WWW.APS.ORG/NMC
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