Drivers of Change in Undergraduate Biology and STEM Education

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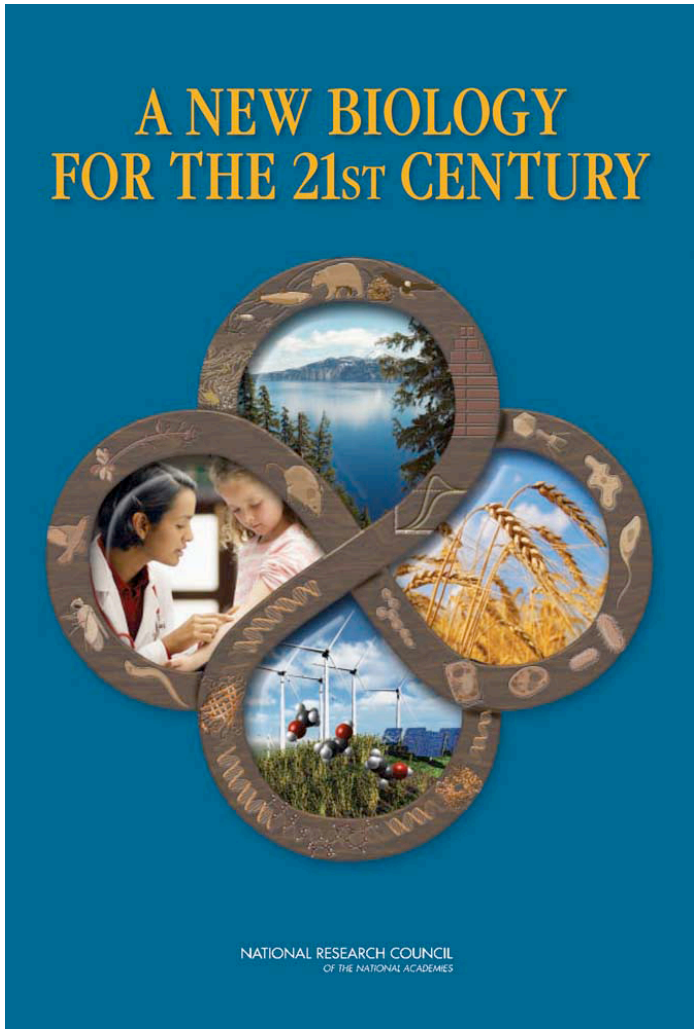
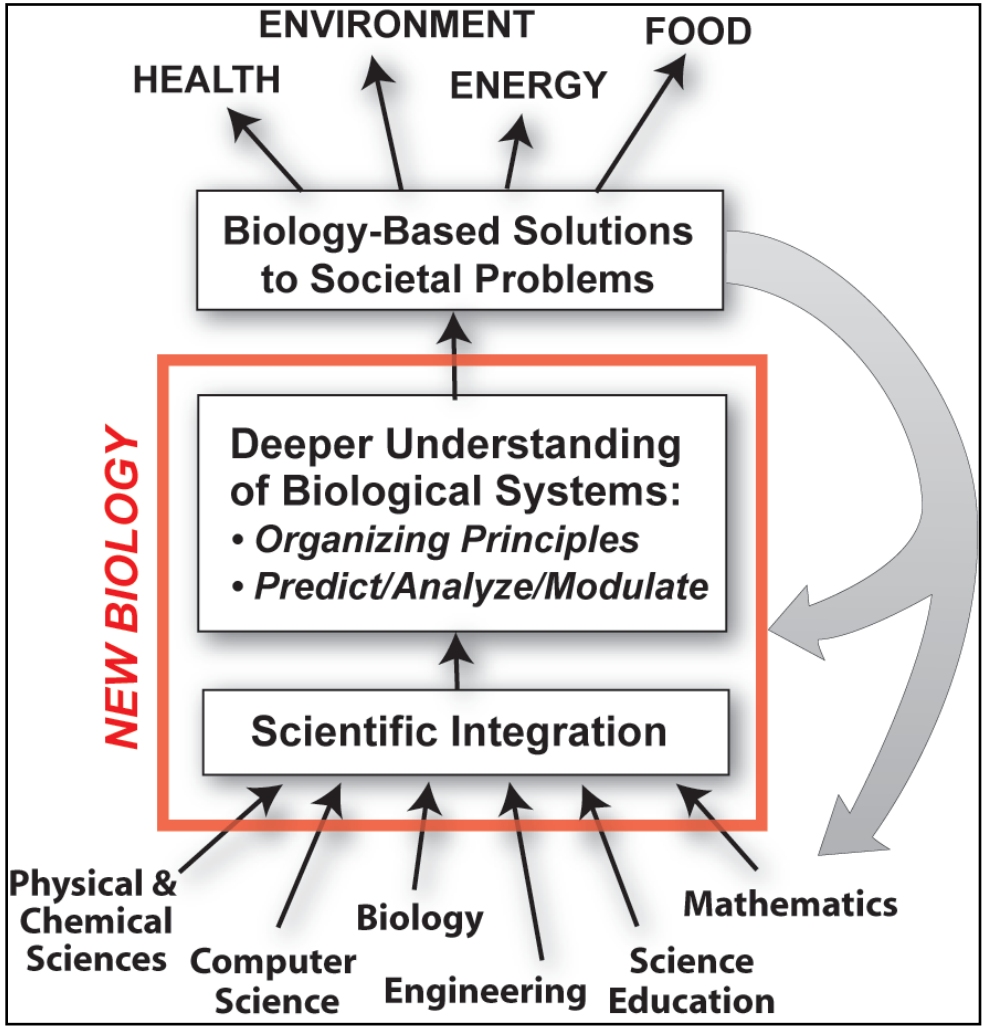
CCAS Annual Meeting
November 3, 2011
Montreal, Canada

Life Sciences (STEM) Education:

So What?

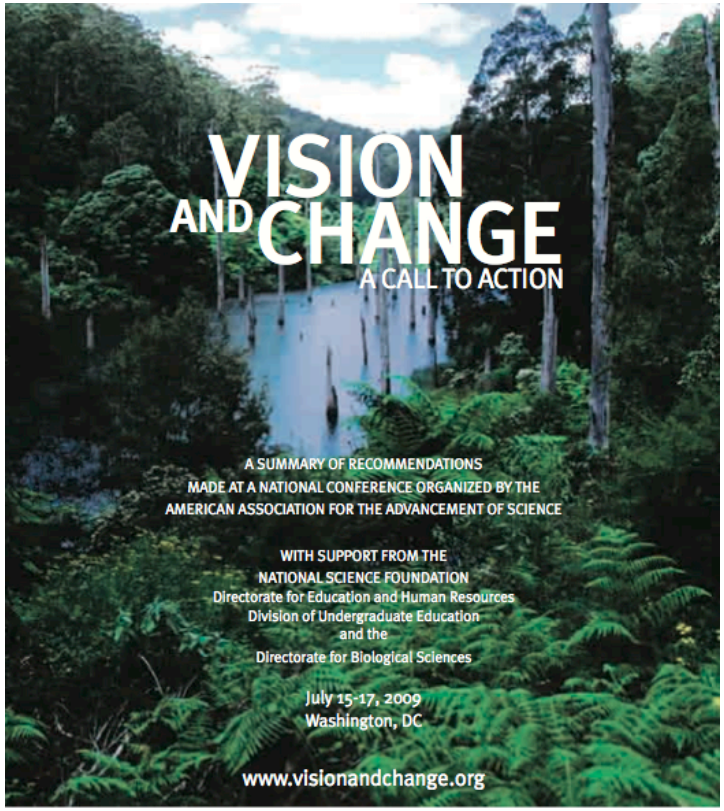
A New Biology for the 21st Century: Interdisciplinarity





http://www.nap.edu/catalog.php?record_id=12764

Vision and Change in Biology Education



- Recommendations for change
  - Learning outcomes
  - Research-based teaching/ learning
  - Authentic assessment
- Note: Revisions to AP Biology (and other sciences)

From the Report: Recommendations

1. Integrate Core Concepts and Competencies throughout the Curriculum
   - E.g., Define learning goals so that they focus on teaching students the core concepts, and align assessments so that they assess the students' understanding of these concepts.
2. Focus on Student-Centered Learning
   - E.g., View the assessment of course success as similar to scientific research, centered on the students involved, and apply the assessment data to improve and enhance the learning environment.
3. Promote a Campus-wide Commitment to Change
   - E.g., Advocate for increased status, recognition, and rewards for innovation in teaching, student success, and other educational outcomes.

Health Professions Preparation

- Scientific competencies in chemistry, physics, biology, psychology, math for pre-med students
- Implications for forthcoming MCAT revision
- Implications for lower division undergraduate "pre-med" curriculum

From the Report: Competencies

*E1: Apply **quantitative reasoning** and **appropriate mathematics** to describe or explain phenomena in the natural world.*

*E2: Demonstrate understanding of the **process of scientific inquiry**, and explain how scientific knowledge is discovered and validated.*

*E3: Demonstrate knowledge of **basic physical principles** and their **applications to the understanding of living systems**.*

*E4: Demonstrate knowledge of **basic principles of chemistry** and some of their **applications to the understanding of living systems**.*

From the Report: Competencies

*E5: Demonstrate knowledge of how **biomolecules contribute to the structure and function of cells**.*

*E6: Apply understanding of **principles of how molecular and cell assemblies, organs, and organisms** develop structure and carry out function.*

*E7: Explain how organisms **sense and control their internal environment** and how they **respond to external change**.*

*E8: Demonstrate an understanding of how the organizing principle of **evolution by natural selection** explains the diversity of life on earth.*

MCAT Revision

Four test sections and report four scores:

1. Molecular, Cellular, and Organismal Properties of Living Systems
2. Physical, Chemical, and Biochemical Properties of Living Systems
3. Behavioral and Social Sciences Principles
4. Critical Analysis and Reasoning Skills

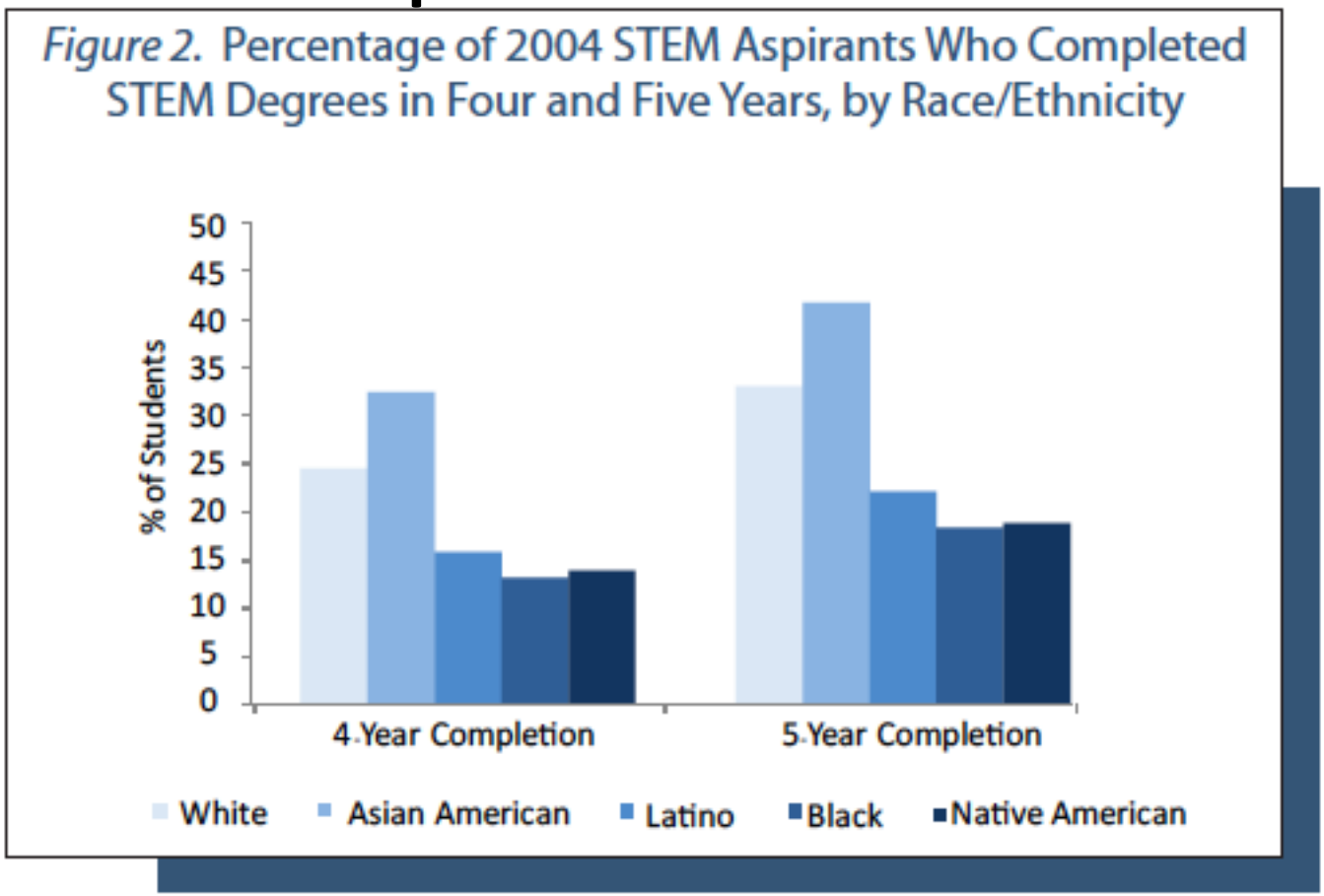
https://www.aamc.org/initiatives/mr5/

MCAT Revision

- Test examinees'
  - *knowledge and use of the* ***concepts in biology, chemistry, physics, biochemistry, cellular/ molecular biology, research methods, and statistics***.
  - *knowledge and use of the* ***concepts in behavioral and social sciences, research methods, and statistics***.
  - *ability to analyze and reason through passages in* ***ethics and philosophy, cross-cultural studies, population health, and a wide range of social sciences and humanities disciplines***.

https://www.aamc.org/initiatives/mr5/

The STEM Pipeline Issue: One View



http://www.heri.ucla.edu/nih/HERI_ResearchBrief_OL_2010_STEM.pdf

Higher Education Research Institute (HERI) STEM Study

The STEM Issue: Another View

- STEM jobs will continue to be in demand, second only to healtcare; but, STEM majors are being diverted to non-STEM jobs
- ***Demand for STEM "talent" will grow in non-STEM professions; those with STEM competencies have increased earning power***
- Women and minorities are still underrepresented in STEM jobs

http://cew.georgetown.edu/STEM/

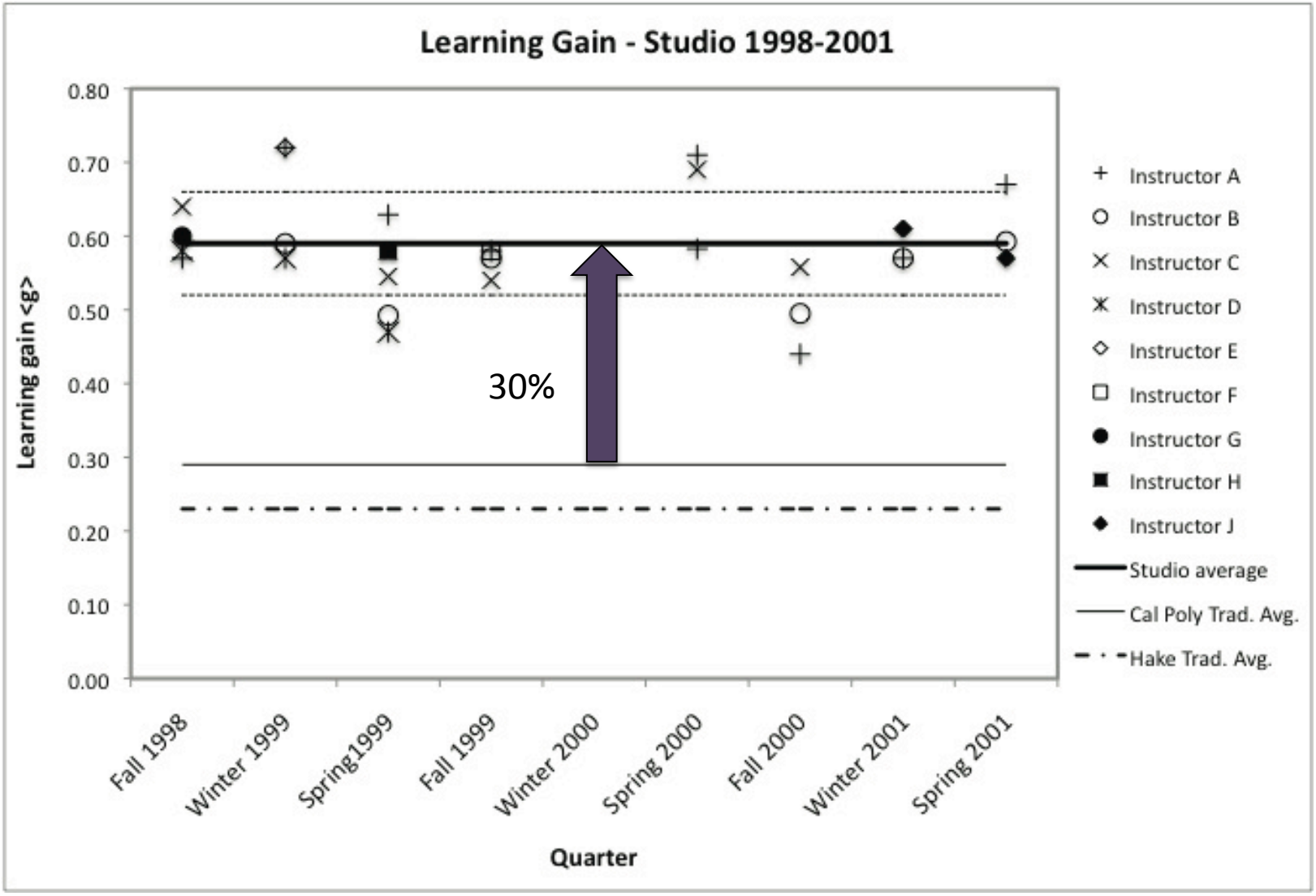
The Bigger Picture: Pretty Bleak

- **Math proficiency of college students marginal**
  - 5% of freshmen proficient; 10% of seniors (ETS data)
  - Math proficiency doesn't change (CAAP test data)
- **Attitudes regarding quantitative literacy increase moderately**
  - 36% increase in positive attitude; 53% no growth or decline (Wabash National Study)
- **Desire to contribute to sciences doesn't change much**
  - 21% increase over four years (Wabash National Study)
  - 16.9% of freshmen; 20% of seniors (College Senior Survey)
- **Measures of reading, writing and critical thinking are not any better** [see also, *Academically Adrift* (Arum & Roksa, 2011)]

[Source: Finley, A. (2011) *Making Progress?: What Assessment Data Tells Us About Liberal Education Outcomes*. Washington, DC: AAC&U]

"The largest gain in learning productivity in STEM will come from convincing the large majority of STEM faculty that currently teaches by lecturing to use any form of active or collaborative instruction."

-- James Fairweather (2009) Report to the National Academies Board on Science Education

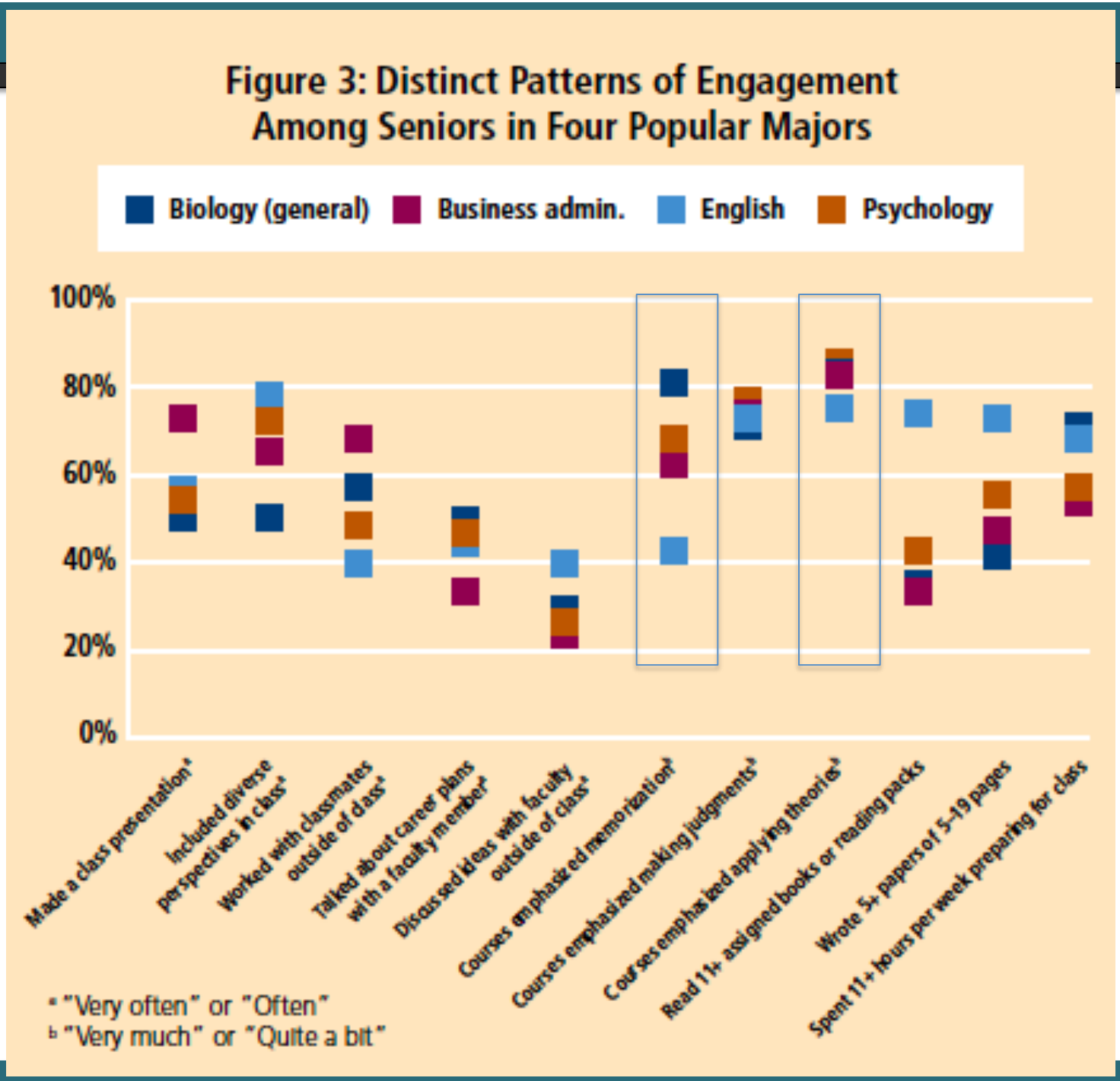


Hoellwarth and Moelter (2011) American Journal of Physics 79 (5): 540.

NSSE STEM/non-STEM Analysis

- **Good News:** Parity with non-STEM students in active/collaborative learning and student-faculty interactions
- **Bad News:** STEM students report fewer experiences with higher order, integrative and reflective learning than non-STEM counterparts

[Source: Nelson Laird, *et al.* (2011) Peer Review 13(3): 23-26]



NSSE 2010 Annual Report:

http://nsse.iub.edu/html/annual_results.cfm

Discussion I: So What? Drivers

- Which of these issues are relevant drivers for advancing life science and STEM education on your campus?
- What are other important drivers?
- Where are the gaps or missed opportunities for working to improve undergraduate education?

Life Sciences (STEM) Education:

Now What?

CHALLENGE OF EXISTING EFFORTS

"Most efforts to reform undergraduate STEM education (MISTAKINGLY) start from a presumptive reform model, one based primarily on in-classroom innovation, that individual faculty member improvements will lead to aggregate change."

-- James Fairweather (2009) Report to the National Academies Board on Science Education

CHALLENGE OF EXISTING EFFORTS

STEM reform requires active intervention by academic leaders at the departmental, college and institutional level. It requires efforts to encourage a culture within academic programs that values teaching.

(Fairweather, 2009, *Report to the National Academies Board on Science Education)*

On Leadership, Management and Change

"Strong leadership can help create the vision,
set the tone of the climate,
emphasize the values that are most critical,
and build trust among people.
Strong management ensures that the appropriate
execution of functions and follow-through
are enabled through assessment.
However, changing the culture is the engine that drives transformation."

Source: FREEMAN A. HRABOWSKI III, JACK SUESS, AND JOHN FRITZ
Assessment and Analytics in Institutional Transformation
EDUCAUSE Review Magazine, Volume 46, Number 5, September/October 2011

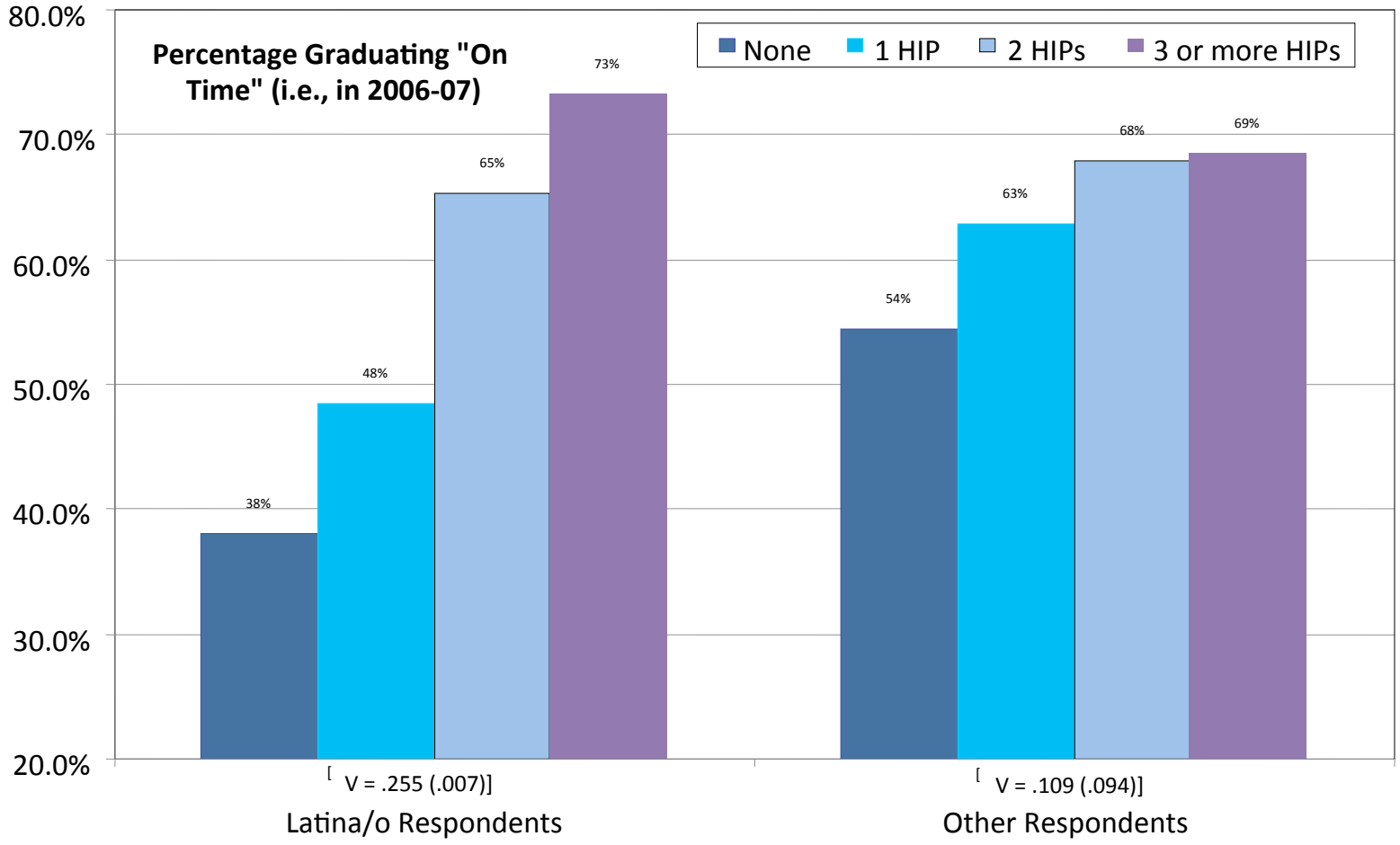
Life Sciences (STEM) Education:

Strategies for Moving Forward

How do you plan for Success in STEM?

- Align institutional goals and priorities with respect to STEM learning and student success/ integration with campus strategic plan or other campus-wide initiatives
- Characterize current progress toward goals, including analysis of institutional data; current strategies
- Identify gaps or missed opportunities and areas of future work
- Identify best practices that help you make progress

Impact of Participation in High-Impact Practices on Percentage of Senior NSSE Respondents Graduating on Time, by Racial and Ethnic Background



Source: *Does Participation in Multiple High Impact Practices Affect Student Success at Cal State Northridge?* by Bettina Huber (unpublished paper, 2010).

What are the characteristics of "STEM-engaged"?

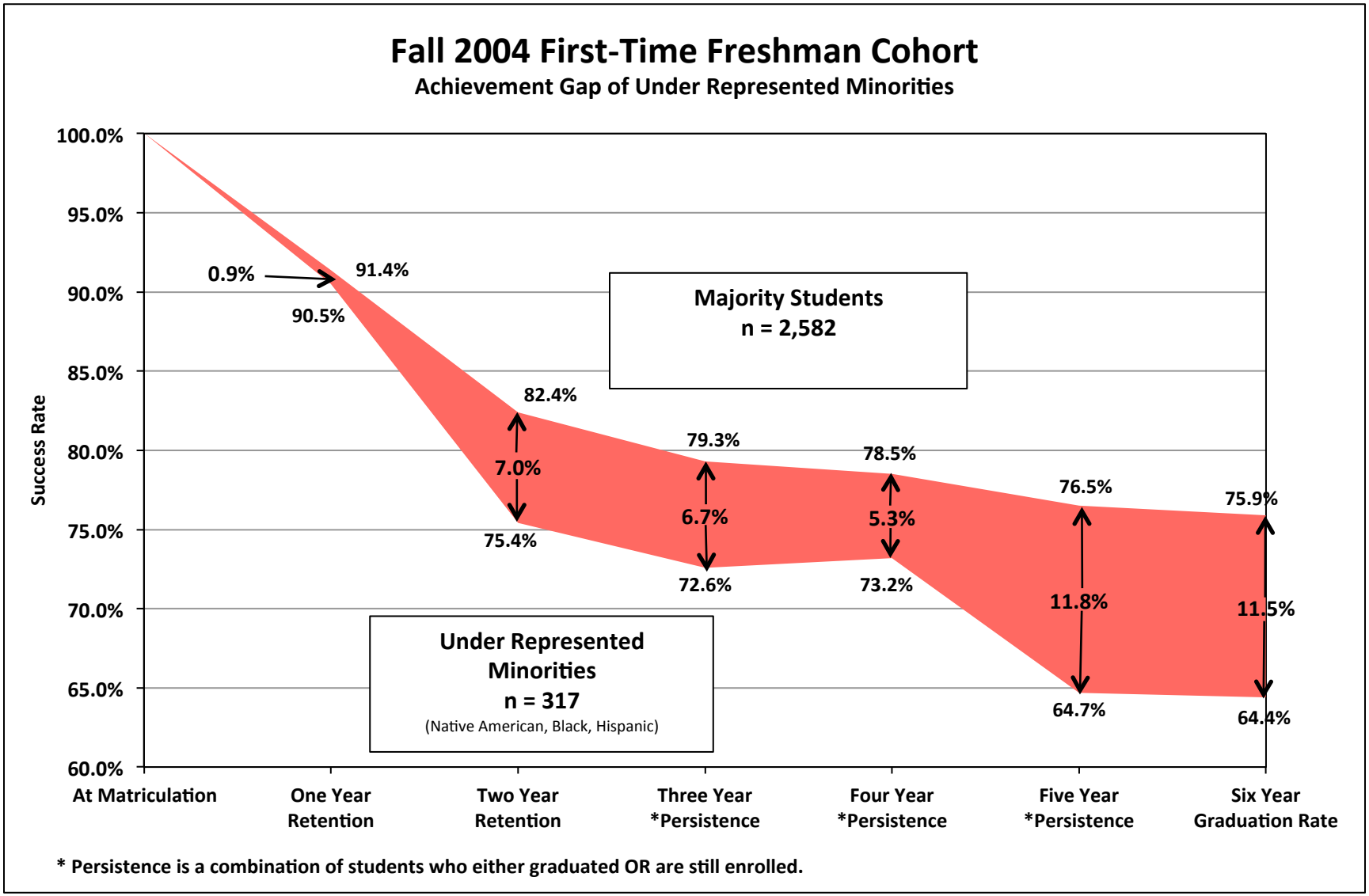
- Institutional goals for STEM learning (specified outcomes) and student success (retention, progression and completion)
- Focus on and documentation of student learning and success
- Effective learning environments (teaching, spaces); assessment
- Continuous program improvement that is linked to institutional goals and priorities

Note: See AAAS V&C Report, among others

How can success be measured?

- Student learning data (pre/post tests, use of rubrics to assess learning/projects)
- Rubric for assessing effective and engaged STEM teaching; guidelines for faculty review, tenure and promotion
- Student success/retention data – first year courses, sophomore gateway courses
- Program completion data – percentages of students who graduate, disaggregated
- National Survey of Student Engagement data

Institutional Retention Data



Discussion II: Now What? Strategies

- What characteristics would describe a “STEM engaged” campus?
- What benchmarks might be used to measure “STEM engagement” or success?
- What data should be used to measure success in STEM education?

Project Kaleidoscope (PKAL)

- National organization dedicated to "advancing what works in undergraduate STEM education"
- Cross disciplinary community of nearly 7,000 people at over 1,000 colleges, universities, and organizations
- Association of American Colleges & Universities (AAC&U) affiliation

http://www.aacu.org/pkal