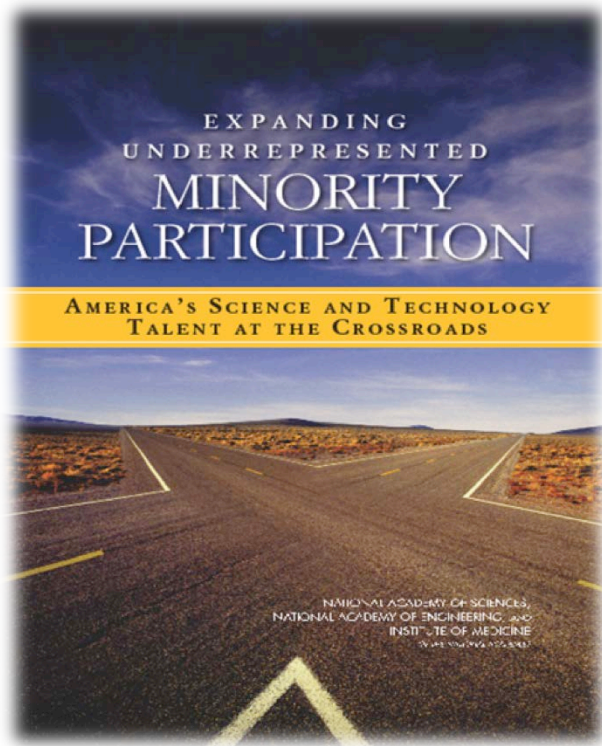


National Consensus Reports



Barriers and Opportunities to 2- and 4-year Undergraduate STEM Degrees: A Pathway Framework

(forthcoming report in 2015)

National Academy of Sciences
National Academy of Engineering



A National Imperative

National Academies (2011) Report *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*

- Most of the growth in the new jobs will require science and technology skills
- “Those groups that are most underrepresented in S&E are also the fastest growing the general population” (National Academies, 2011, p. 3).
- To achieve long-term parity in a diverse workforce, they recommend a near term, reasonable goal of improving institutional efforts to double the number of underrepresented minorities receiving undergraduate STEM degrees.



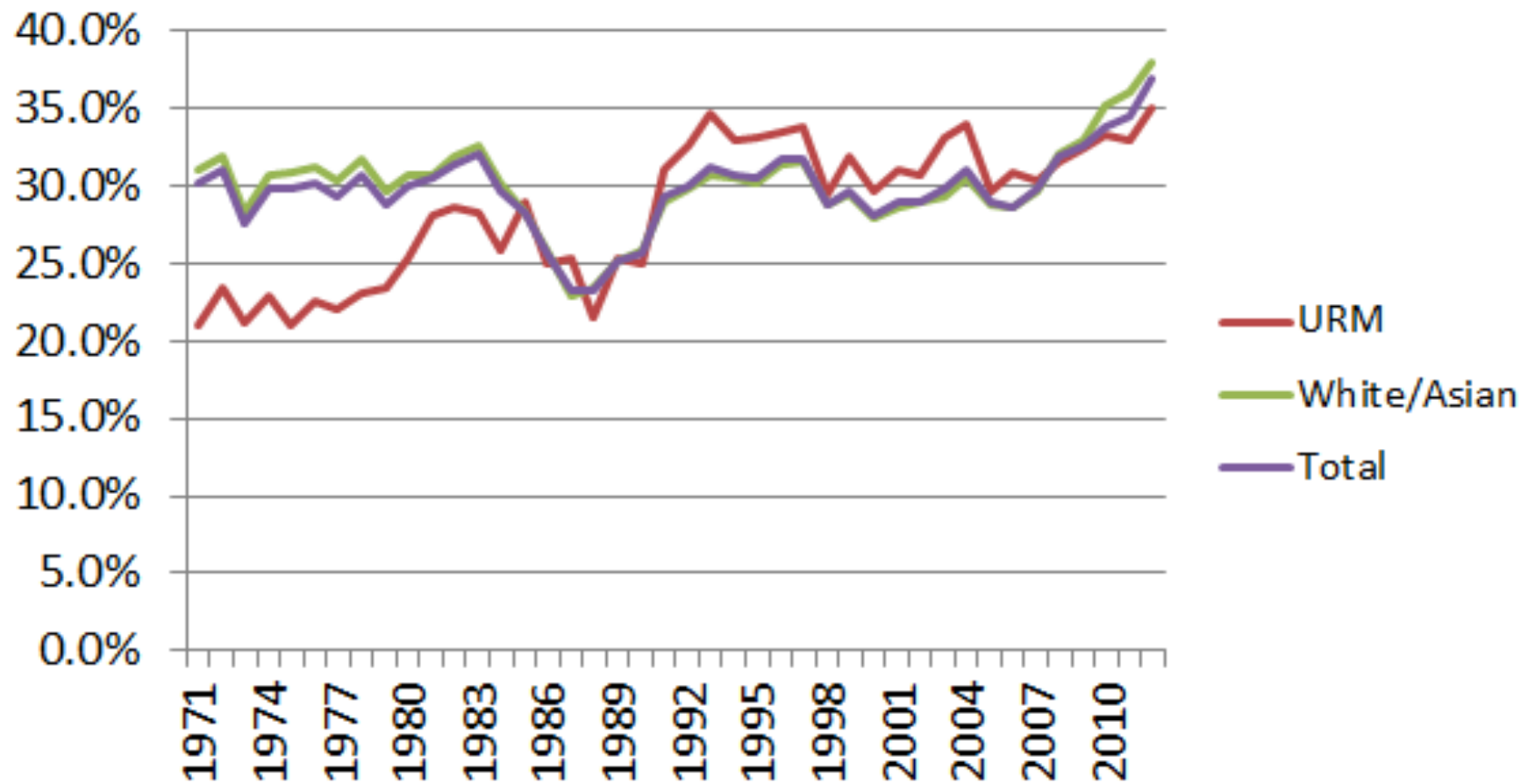
A National Imperative

2012 President's Council of Advisors on Science and Technology (PCAST) Report, *Engage to Excel: Producing One Million Additional College Graduates With Degrees In Science, Technology, Engineering, And Mathematics*

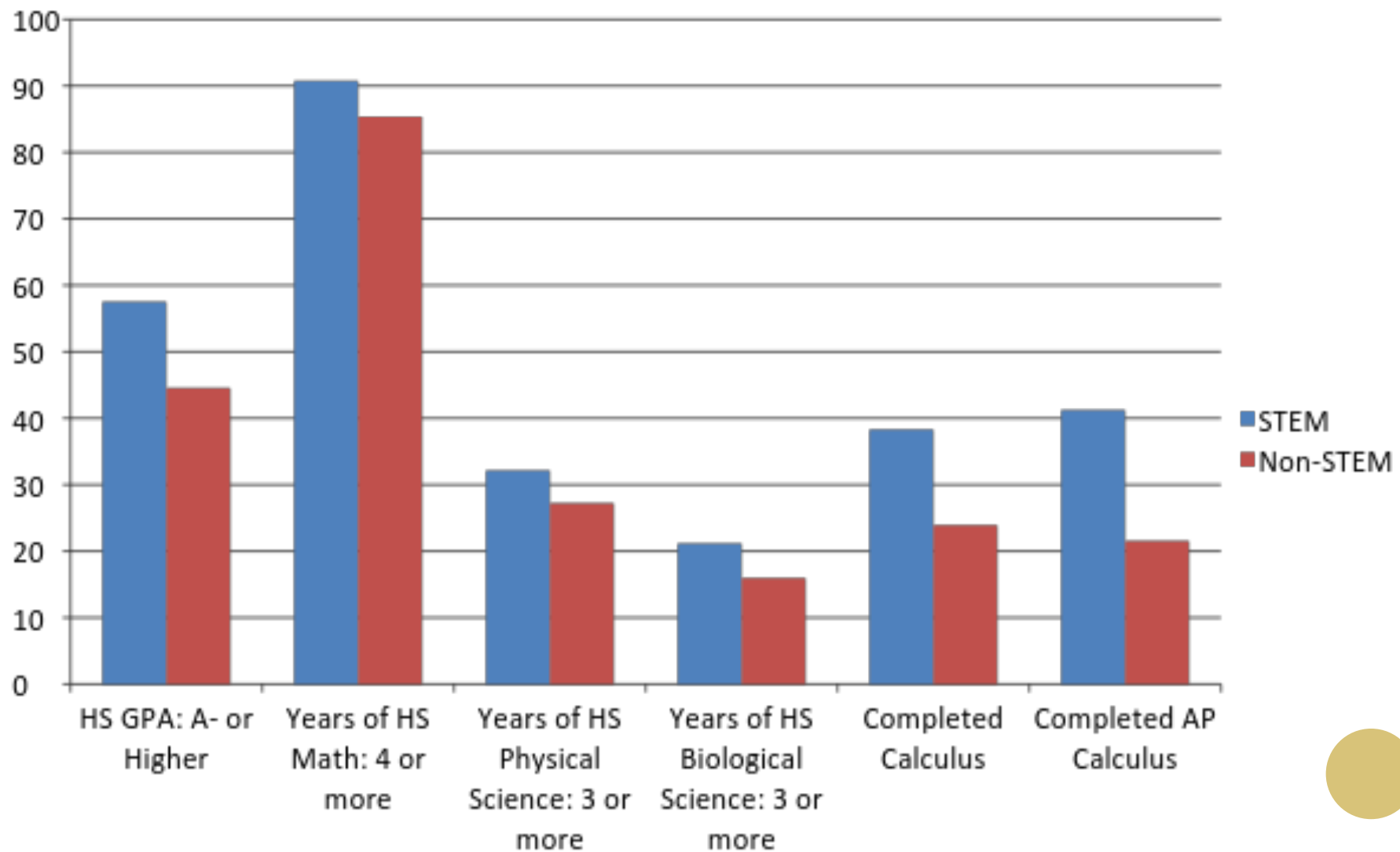
- Increasing STEM degrees from 40% to 50% would, alone, generate three-quarters of the targeted 1 million additional STEM degrees over the next decade
- Retaining more STEM majors is the lowest-cost, fastest policy option to providing the workforce that the nation needs
- Changing productivity levels means changing practices and mindsets from priming the sieve to priming the pump, or talent development



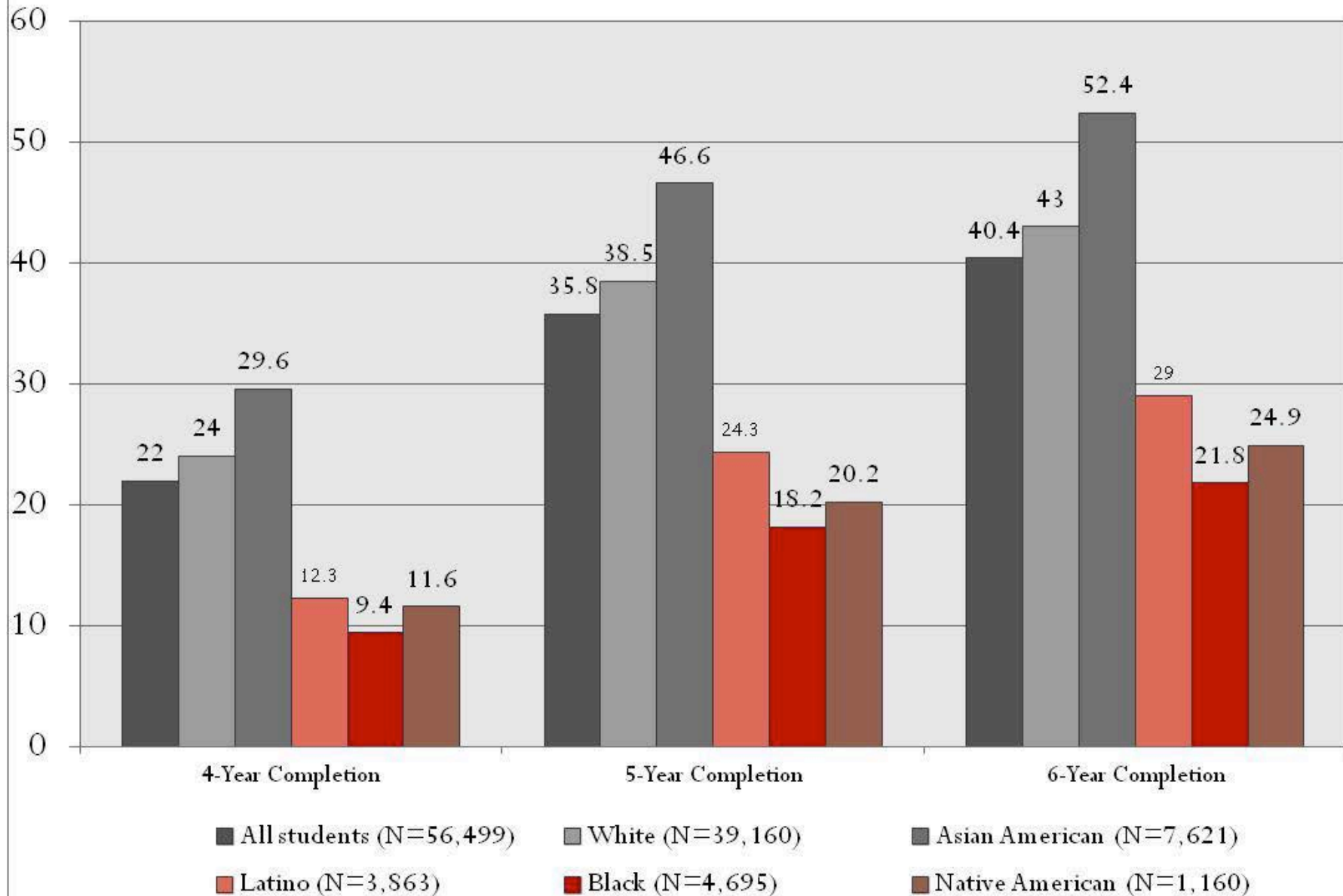
Percentage of Incoming First-Time, Full-Time Freshmen Intending to Major in STEM, 1971-2012



Pre-College Preparation among STEM and non-STEM Aspirants, Fall 2012



Percentage of 2004 STEM Aspirants Who Completed STEM Degrees in Four, Five, and Six Years, by Race/Ethnicity



Factors in Managing Academic Success in the 1st Year

Source: Predicting Transition and Adjustment, *Research in Higher Education* (2007)

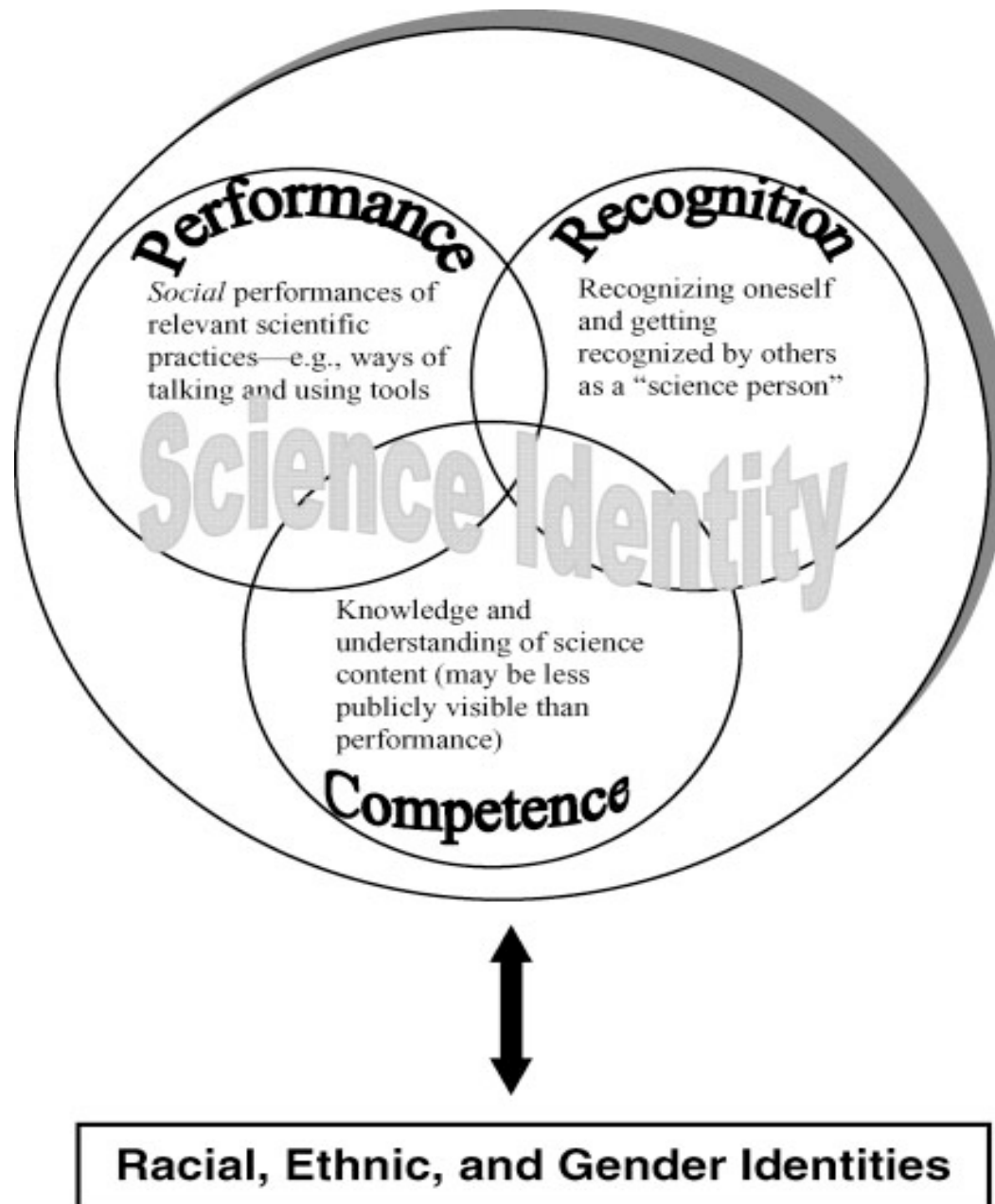
* Indicates effect is stronger for URM STEM students

NEGATIVE EFFECTS

- Interfering family responsibilities
- Concern about financing college*
- Perceptions of a competitive environment *
- Perceptions of a hostile racial climate*
- Institutional selectivity
- Academic advice from a freshman peer *

POSITIVE EFFECTS

- Self-rated ability to manage time
- Best guess they will communicate with faculty
- High proportion of degrees in science
- Worked with an academic advisor to select courses
- Academic advice from a junior/senior and major/preprof clubs*
- Change in ability to conduct research



Source: Carlone & Johnson. (2007). *Journal of Research in Science Teaching*, 44 (8).

Findings: Becoming a Scientist

Recognition

I had a good experience with my PIs [principal investigators] just because they made me feel like...as an undergrad, you kind of feel like on the bottom of the food chain and they kind of believe in you and say, “Yes, you can do this. I’m giving you this project to do and I know you can do it.” *So it kind of builds your confidence and just them believing in you makes you feel like you can actually complete the project because you can.* (female)



Expanding Theory With Findings: Context Matters

Source: Focus groups of students in programs reported in *Diversifying Science, Research in Higher Education* (2009)


Competence

Students talk about science differently in the classroom, in a professor's project, or in a structured research program (peers, dedicated faculty)

Recognition

- Institutional ethos – “We do science here”
- Peer culture
- Proximal contexts, faculty belief in students' potential and determination to succeed

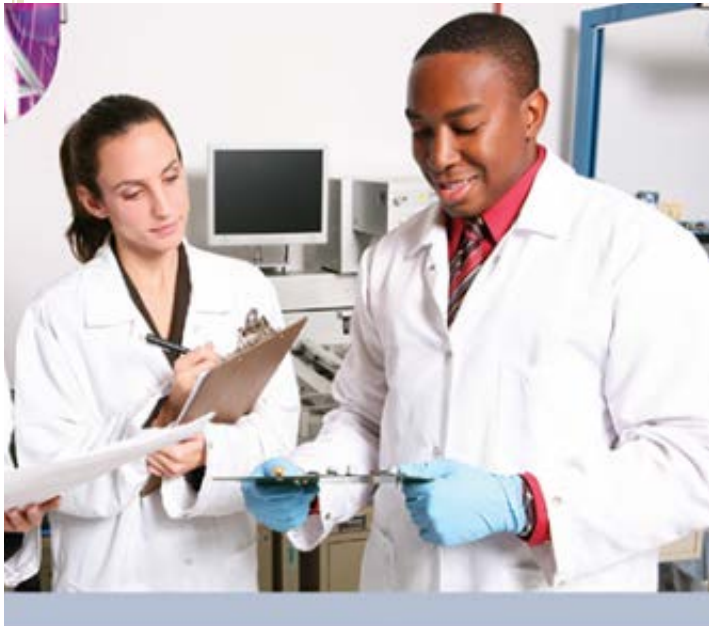
Emergent Results

- Knowledge/content is to be mastered (memorized) versus knowledge can be discovered and “owned”
 - Science is competitive, getting right answers vs. collaborative using both challenge and support
 - More ways of demonstrating competence
 - Failure in scientific work is OK Rethink and try again until one succeeds
 - Validation from faculty and peers
- 

Retention in STEM: First Year

Source: Three different studies, one student dissertation, listed on project website

- URM students with a high level of science identity were 4 times more likely to persist than their counterparts who reported moderate level of identification, 8 times more likely than those with the weakest level of identification
- However, those with high science identification and hostile racial climate perceptions were among students less likely to persist in the first year



- Black students were 4 times more likely to participate in first year research if a structured program existed on a campus
- Selective institutions negatively affect persistence in the first year of college
- Women of color persisted in STEM to the fourth year if they joined student organizations, discussed course content outside of class, and participated in undergraduate research programs

Changing Mindsets: Who has talent

Every single one of those students in my [introductory biology] classroom had the potential to succeed, I absolutely believe that's the case and some had farther to go to succeed than other students in the class...[And] whether a student gets through the class or not... those all get accumulated into institutional success, which is frequently measured by retention rates.

– *Female Biological Science Professor
and Dean of Science*



Changing Behavior: Teaching Practices Focused on Improved Learning

I wasn't happy with the learning gains [my students] were making. I knew some people were getting it but I wanted almost *everybody* to get it. I think it was only after I started going to [the discipline-based education research meetings] that I started reading [about undergraduate STEM education reform and research] and started going to [the Center for the Advancement of Teaching] workshops. I started moving further and further away from lecture ... my golden chance came when I got the HHMI Fellowship and [the dept. gave me] my own learning assistants. At that point I said, 'okay this is my opportunity to show that if the learning assistants are there in class every single day, it can mean a huge difference.' And it did.

– *Female Chemistry Professor*



Changing Teaching Culture

Faculty reflect on their teaching techniques:

- Focus on learning instead of the volume of information
 - Think, 'What do I want my students to be able to do after they take this course?' instead of, 'What amount of info can I cram into them?' - Female Biology professor
- Focus on the relevance of coursework to problems that matter (e.g. improving the health of minority communities)
- Collaborate across departments so that the curriculum in foundational courses supports student progress (e.g. what are the courses that affect the progress of BBS students or URM students in particular?)



Changing Faculty-Student Interactions

An ethic of care means being accessible, responsive, and intrusive advising:

We have this expected high touch component. I would describe it as reaching out to students. Especially students who have fallen behind and who have kind of withdrawn from the course – for whom that extra connective experience will make a difference in their performance and in their learning. So it is usually it is similar to calling and texting [the student]. Some [faculty] do it different ways. Like one of my colleagues she has a certain time every week like an hour or two, and she just does it then. For others, it is not as regular or as needed.. I don't think many other departments are [doing this]... We are kind of trying to institutionalize this. [Students' response to this high touch approach is] usually very positive... I text, for example, which I switched to as my primary mode of communication [with students] for nothing else then because they respond. They are very thankful, they are very grateful. [Just] yesterday I connected [with a student] and he said I was the first professor in his post-secondary life to ever contact him.

– *Male Instructor in Math and Statistical Science, HSI*

Changing Mindsets: Grading Practices

Dismantling the bell curve mentality in higher education and shifting to a student-centered approach to learning:

One of the biggest challenges...what I saw early in my career here is people said that my job was to 'profess' and students would learn or they wouldn't. And it's breaking that mindset—that **we are here to facilitate learning, not just teach... Because if you think about a bell curve, it makes teaching improvement irrelevant because the same proportion of students are going to fail or get a C, no matter what you do... So, if you're really measuring what students learn and have a sense of what they should know at the end of a class** – there should be grades actually improving through time... those are things that remain challenges in some pockets here... it's so ingrained in, "This is how we grade" or "This is what we do".

– *Biology Professor and Dean of Sciences*



Long Term Impact of Practices

(Quasi-experimental, Longitudinal Study)

- **Supplemental instruction as a way to establish a community of practice**
 - Strengthens students' STEM identity; particularly beneficial for URM STEM identity development
 - Boosts grades in introductory STEM courses
 - Increases likelihood to plan to enroll in STEM graduate programs
- **Faculty Mentorship and Support**
 - Improved performance in STEM courses
 - Mentorship even more impactful for URM students' STEM identity development
 - Increases students' intentions to enroll in graduate school
 - Benefits of mentorship extend even after accounting for the types of students likely to receive or seek out mentorship



Long Term Impact of Practices

(Quasi-experimental, Longitudinal Study)

UNDERGRADUATE RESEARCH PROGRAMS

- Increases students' confidence and skills as a researcher
- Significantly increases student intentions to enroll in graduate school and pursue a STEM career. Has added benefit for URM students with respect to GPA

MAJOR RELATED CLUBS

- Provides skills transferrable to the job market
- Participating URM students have a continued interest in a STEM career



Effect of Research Participation on STEM Graduate/Professional School Enrollment

(controlling for propensity to participate in research)

	Change in probability
All students: Structured program	0.09
All students: Research with faculty	0.14
All students: Any research	0.14
URM students: Structured program	0.15
URM students: Research with faculty	0.14
URM students: Any research	0.17

Conclusion

In order to produce 1 million more STEM degrees, we have to address diversity and equity in attainments and improve access to STEM careers

Contexts Matter!

Selective institutions can improve productivity. They promote degree completion and graduate school aspirations, but students are not more likely to complete in STEM degrees. More work is now occurring in changing classroom practices to actively engage students and be more inclusive.



Conclusion

Supportive Environments Work!

- Having an undergraduate research program has an effect on retaining minority students in STEM (and quicker degree completion)

Pre-med Phenomenon

- Students who are pre-med majors are more likely to complete in STEM, but less likely at selective institutions; high % of pre-meds causes students to switch from STEM among four year completers—presumably a talented group



Conclusion

Call for evidence-based teaching practices in STEM

- Student centered pedagogy was important to staying in STEM for high-achieving minority students.
- More faculty across universities are “flipping classrooms”, introducing learning assistants, and studying the effect of these innovations.

New initiatives by associations and foundations indicate great interest in “demonstration campuses” that can make transformations to increase productivity of STEM degrees.



Resources

HERI

Research

For the latest papers, presentations, and findings please visit heri.ucla.edu/nih

Practice

Transformations: Approaches to College Science Teaching (Allen & Tanner, 2007)

Attend

Summer STEM Institute, UCLA for research and practices in STEM



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Papers and reports are available for download from project website:

<http://heri.ucla.edu/nih>

Project e-mail: herinih@ucla.edu

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