Photo credits (from left) : U.S. Army Corps of Engineers, Intel Free Press, Kate Ter Haar, Woodley Wonder Works, Ohio Sea Grant, U.S. Army RDECOM, Trevor Prentice

Perspectives from NSF on Undergraduate Mathematics Education

Conference Board of the Mathematical Sciences Forum

The First Two Years of College Math: Building Student Success

Hyatt Regency Hotel, Reston, VA

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Education and Human Resources

Directorate for Education and Human Resources

Now is the time for focus on the first two years of mathematics:

- Mathematics is essential in the preparation of the STEM workforce (*The Mathematical Sciences in 2025*)
- The nature and practice of science is becoming computationally intensive and data-driven across most fields
- New technologies and new understandings about learning and teaching allow new possibilities for instruction

Some concerns:

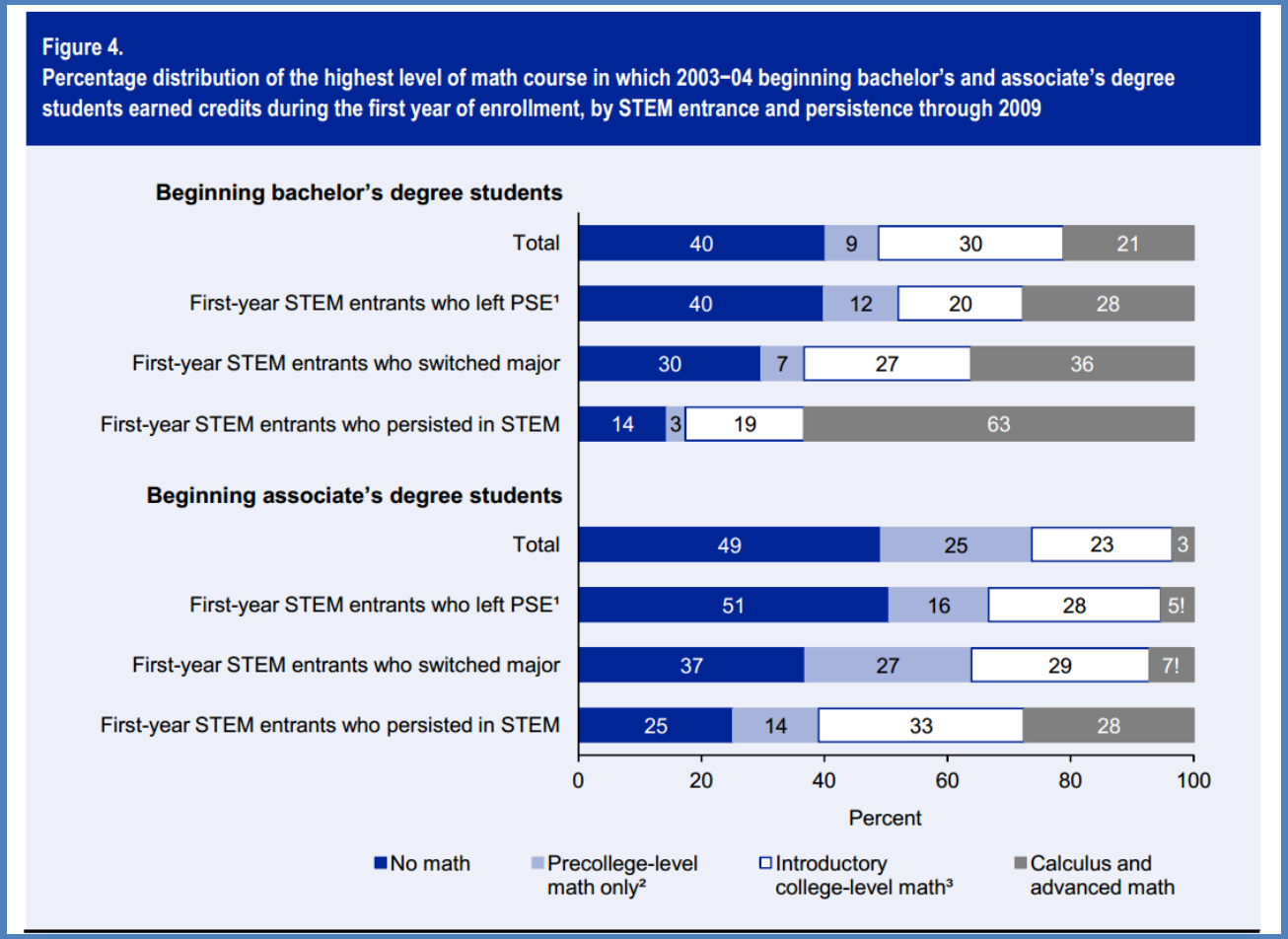
- % of students who arrive at postsecondary education not ready for entry level mathematics: nearly 60%
- % of students who leave STEM and did not take calculus or advanced mathematics in year 1: 33.3%[1]
- % of students who persist in STEM after taking calculus or advanced mathematics in year 1: 66.6%[1]
- % of students requiring special tutoring or remedial mathematics work during college [2] :

Race	African American	American Indian	Asian	Hispanic	Multiple Races	White
Percent	43.4	29.8	22.0	38.5	29.8	20.0

[1] Figures have been rounded. Source: *STEM Attrition: College Students' Paths Into and Out of STEM Fields*, Xianglei Chen and Matthew Soldner, Institute for Education Statistics , National Center for Education Statistics, U.S. Department of Education, November 2013.

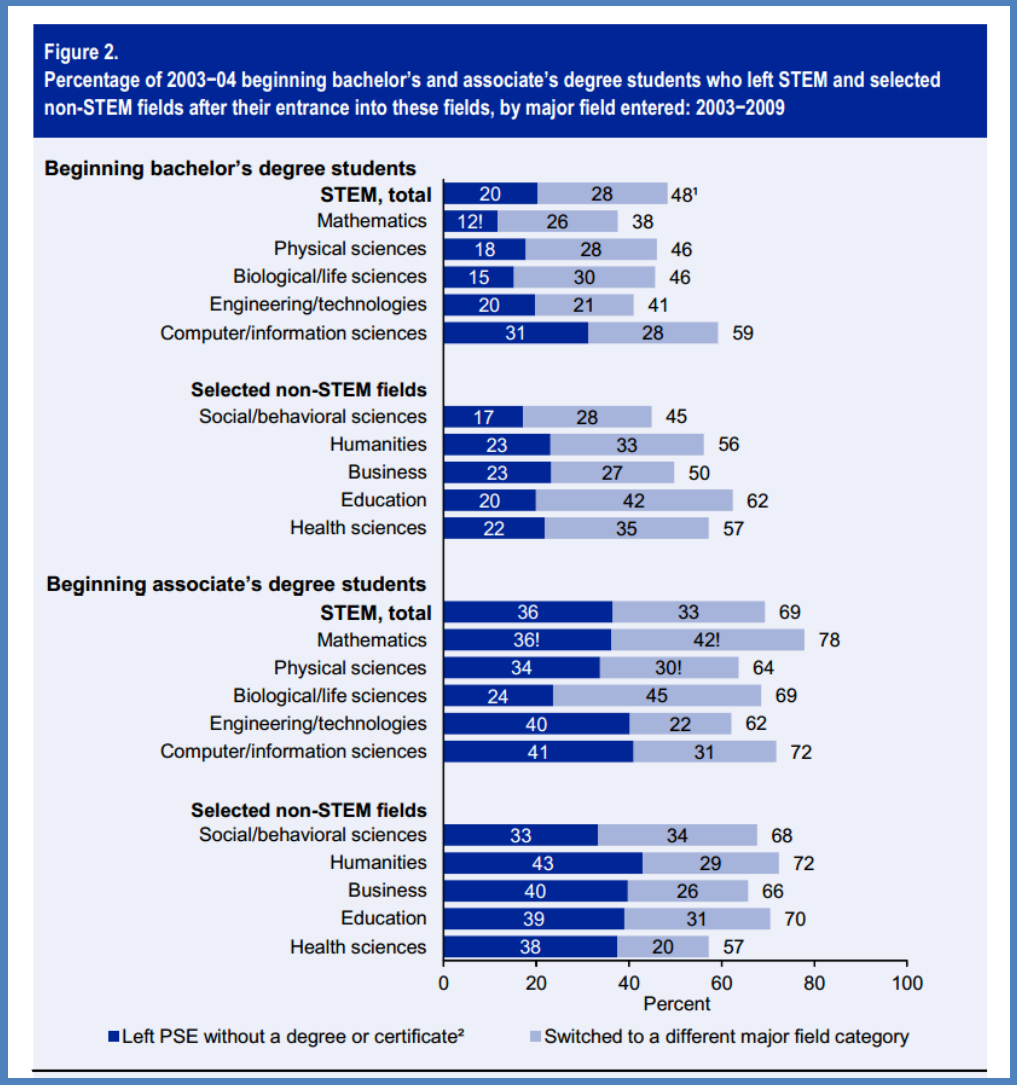
[2] *The American Freshman: Forty Year Trends*, John H. Pryor, Sylvia Hurtado, Victor B. Saenz, Jose Luis Santos, and William S. Korn, Cooperative Institutional Research Institute, University of California, Los Angeles, 2007.

Entry-Level Mathematics Performance and STEM Persistence



Source: *STEM Attrition: College Students' Paths Into and Out of STEM Fields*, Xianglei Chen and Matthew Soldner, Institute for Education Statistics , National Center for Education Statistics, U.S. Department of Education, November 2013.

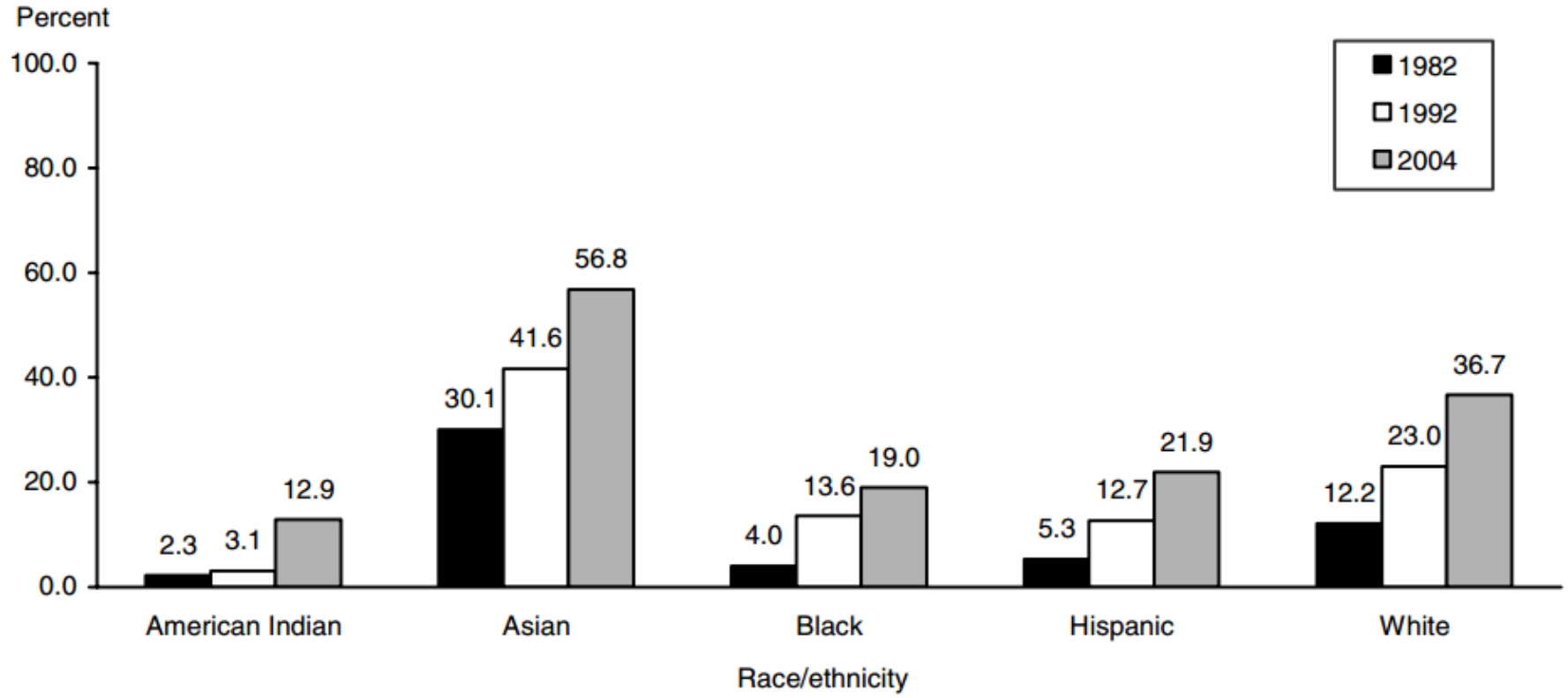
Attrition



Source: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Lack of Preparedness

Figure C. Percentage of high school graduates who completed precalculus or calculus, by race/ethnicity: 1982, 1992, and 2004



Note: Black includes African American, Hispanic includes Latino, Asian includes Native Hawaiian or Other Pacific Islander, and American Indian includes Alaska Native

Source: U.S. Department of Education, National Center for Education Statistics, High School and Beyond Longitudinal Study of 1980 Sophomores (HS&B-So:80/82), "High School Transcript Study"; National Education Longitudinal Study of 1988 (NELS:88/92), "Second Follow-up, Transcript Survey, 1992"; and Education Longitudinal Study of 2002 (ELS:2002), "First Follow-up, High School Transcript Study, 2004."

NSF Investment in Mathematics Focused on the First 2 Years: Several NSF Programs

- Advanced Technological Education (ATE)
- Cyberlearning and Future Learning Technologies
- Education and Human Resources Core Research (ECR)
- Historically Black Colleges and Universities Undergraduate Program (HBCU-UP)
- Improving Undergraduate STEM Education (IUSE)
- Cybercorps: Scholarships for Service (SFS)
- Scholarships for STEM (S-STEM)
- Research Experiences for Undergraduates (REU)

Improving Undergraduate STEM Education: EHR

IUSE seeks to address immediate challenges and opportunities facing undergraduate STEM education focusing on two program tracks, as "exploration" or "design and development" projects:

- *Engaged Student Learning*
- *Institutional and Community Transformation*

Photo Source: Widdowquinn (Flickr)

Funding Distribution

- Mathematics funding in EHR overall:

  between 12 and 15% of proposals

- Most recent IUSE competition:

  ~6%

Send in more proposals, consider the full range of programs!

Opportunities

1. Transition from secondary school to undergraduate education
2. Implementation of active learning-oriented instruction
3. Engagement of of students from groups traditionally underrepresented in STEM
4. Learning supported by technology
5. Mathematics through authentic STEM research experiences
6. New curriculum, data science and computational approaches

Opportunities in the first two years

Opportunity	Program(s)
Transition from secondary school to undergraduate education	ATE, LSAMP, DRK-12
Implementation of active learning-oriented instruction	IUSE
Engagement of students from groups traditionally underrepresented in STEM	S-STEM, LSAMP, HBCU-UP, TCUP
Learning supported by technology	Cyberlearning
Mathematics through authentic STEM research experiences	REU sites and supplements
New curriculum, data science and computational approaches	IUSE, SFS

NSF commitment to investing in the improvement of undergraduate mathematics education in the first two years:

- Research and development to improve mathematics learning environments
- Direct support to students and faculty to improve success
- Research experiences for students
- Preparation for the STEM workforce

Research and Development

- Sian Bielock, University of Chicago, CAREER: stereotype threat operates in working memory to impair test performance for women
- Chris Hirsch, Western Michigan University, DRK-12: Transition to College Mathematics and Statistics
- Ulrike Genshel, Iowa State University, GSE: Exploring the STEM Gender Gap: Introductory College Mathematics and Statistics Instruction and its Association with Self-Efficacy

Research and development

Thomas Griffiths and Anna Rafferty, University of California, Berkeley and Carleton College: Diagnosing misconceptions about algebra using Bayesian inverse reinforcement learning

- Online math tutor to help high school and college students learn algebra
- Program will collect large amounts of data on algebra problem solving that will be used to refine the technological approach, develop computational models of student learning, optimize the design of tests, and identify effective strategies for online learning and teaching

Photo Source: Andrew Ostrovsky

Research and development

Mathematical Association of America, Progress through Calculus

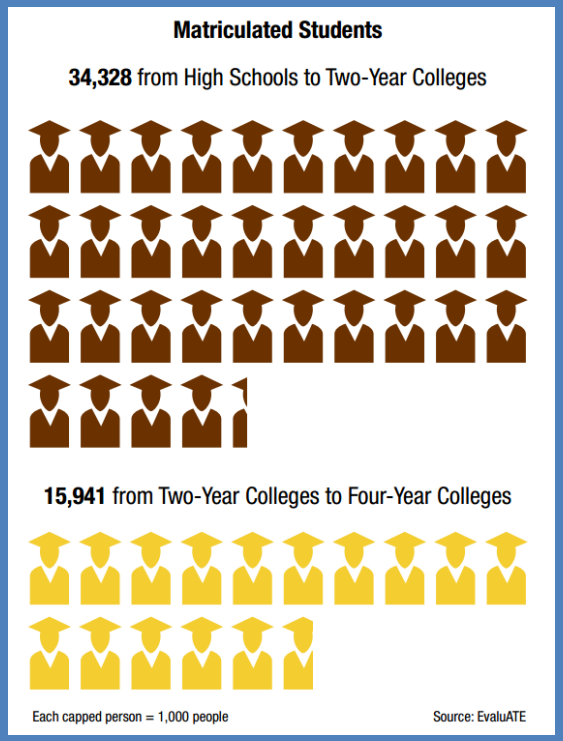
This national project will explore the factors influencing student success over the progression of introductory mathematics courses that begins with precalculus and continues through the full year of single variable calculus.

1) What are the programs and structures of the pre-calculus to calculus sequence as currently implemented? How common are the various programs and structures? How varied are they in practice? What kinds of changes have recently been undertaken or are currently underway?

2) What are the effects of structural, curricular, and pedagogical decisions on student success in pre-calculus to calculus?

Photo Source: Widdowquinn (Flickr)

Direct support to students and faculty to improve success



Donna Milgram, National Institute for Women in Trades, Technology, and Science (IWITTS), Alameda, California: Strategies include teaching time management skills, teaching mathematics in the context of STEM workplace activity, and extended lab hours.

Source: *ATE@20: Two Decades of Advancing Technological Education, A report on the Transformation of Technician Education by the National Science Foundation's Advanced Technological Education Program,* Madeline Patton and Internet Scout Research Group, 2013

Research experiences for students

- Scott Annin and Angel Pineda Fortin, CSU Fullerton, Graduate Readiness and Access in Mathematics Program (DMS and DUE): comprehensive preparation for undergraduate students aspiring to graduate study in mathematics and a model for other HSIs

Research experiences for students

Brenda Allen, Mamudu Yakubu, Winston Salem State University, Achievement in Mathematics and Science Programs (RAMS). Engages students in research on and off campus throughout their undergraduate career. Program provides the following support:

- Faculty mentorship
- Research project
- Professional development
- Monthly stipend

Photo Source: Jeremy Wilburn (Flickr)

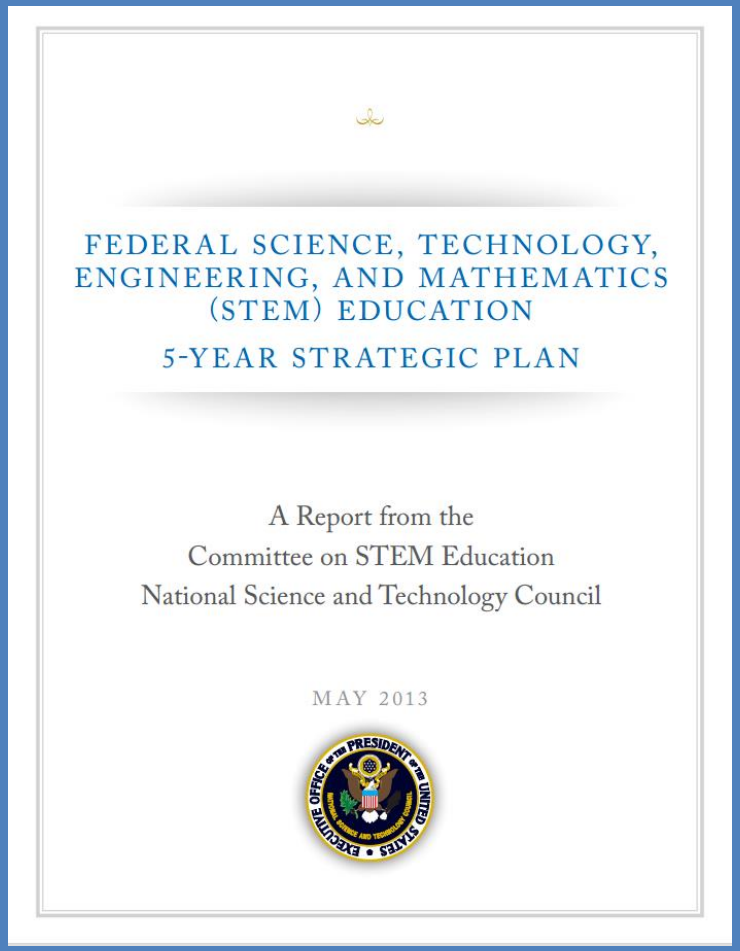
Preparing the STEM Workforce

Florian P. Buchholz and Hossain Heydari, Scholarship for Service: Digital Forensics and Undergraduate Information Security, James Madison University

- Undergraduate students in the program earn a Bachelor of Science degree in computer science.
- Provides students with skills needed in the federal workforce
- 150 undergraduate students have earned a Committee on National Security Systems certificate

Photo Source: Infocrux Technologies (Flickr)

Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan



FEDERAL SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) EDUCATION

5-YEAR STRATEGIC PLAN

A Report from the
Committee on STEM Education
National Science and Technology Council

MAY 2013

"We want to make sure that we are exciting young people around math and science and technology and computer science. We don't want our kids just to be consumers of the amazing things that science generates; we want them to be producers as well. And we want to make sure that those who historically have not participated in the sciences as robustly — girls, members of minority groups here in this country — that they are encouraged as well. We've got to make sure that we're training great calculus and biology teachers, and encouraging students to keep up with their physics and chemistry classes.... It means teaching proper research methods and encouraging young people to challenge accepted knowledge."

President Barack Obama
National Academy of Sciences
April 2013

Federal STEM Education 5-Year Strategic Plan

Priority Areas	*Strategic Goals*
Improve STEM Teacher Training	**Support a 50% increase in the number of youth who have authentic STEM experiences each year**
Increase and Sustain Youth and Public Engagement in STEM	**Graduate 1 million additional students with degrees in STEM fields over a decade**
Enhance STEM Experience of Undergraduate Students	**100,000 new K-12 STEM teachers by 2020 and support existing STEM teacher workforce**
Better Serve Groups Historically Underrepresented in STEM Fields	**Increase the number of underrepresented minorities graduating with STEM degrees and improve women's participation in areas of STEM where they are significantly underrepresented**
Design Graduate Education for Tomorrow's STEM Workforce	**Provide basic research expertise, professional development, and specialized skills development to graduate-trained STEM professionals**

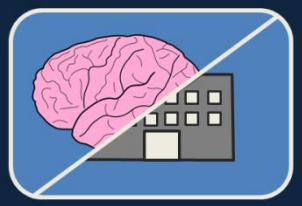
Priority Area: Undergraduate Education

Co-Leads: NSF and TBD

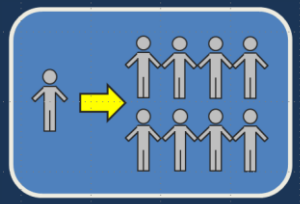
Strategic Objectives to Achieve Impact

- Implementation of evidence-based instructional practices and innovations
- Improve STEM education at 2-year colleges and transfer to 4-year colleges
- Support the development of university-industry partnerships to provide relevant and authentic experiences
- Address high failure rates in introductory undergraduate mathematics

Education and Human Resources Themes



Learning & Learning Environments



Broadening Participation

Workforce Development

Thank You!

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