The Status Quo is Unacceptable: A Common Vision for Improving Collegiate Mathematics and Its Implications for K-12 and Preservice Mathematics Education

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April 14, 2016

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

MATHEMATICAL ASSOCIATION OF AMERICA

MAA100

A Common Vision for Undergraduate Mathematical Sciences Programs in 2025

NCTM Conference

April 14, 2016

Celebrating a Century of Advancing Mathematics

Challenges facing our community

Mathematics and statistics courses function as gateways to many majors and are crucial for preparing scientifically literate citizens. Yet:

- Only **~50%** of students earn a grade of A, B, or C in college algebra courses.
- Women are **almost twice as likely** as men to choose not to continue beyond Calc I, even when Calc II is required for their intended major.

Challenges facing our community

Mathematics and statistics courses function as gateways to many majors and are crucial for preparing scientifically literate citizens. Yet:

- In 2012: 19.9% of **all** bachelor's degrees were awarded to URM students (9.5% to Blacks, 9.8% to Hispanics).

  But only 11.6% of **math** bachelor's degrees were awarded to URM students (4.9% to Blacks, 6.4% to Hispanics).

- Failure rates under traditional lecture are **55% higher** than for more active approaches to instruction

Impetus to change

- *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics* (PCAST, 2012)
- *The Mathematical Sciences in 2025* (NRC, 2013)
- Both reports criticized the collective enterprise of teaching mathematics to undergraduates

Common Vision Project

- National Science Foundation funded the project in 2014 (NSF DUE-1446000).

- To develop a **shared vision** in the mathematical sciences community of the need **to modernize undergraduate mathematics programs**, especially the first two years.

- To catalyze grassroots efforts to address the collective challenges we face.

Common Vision Project

- "Program" comprises:
  - Curricula (courses, topics, electives)
  - Instructional methodologies
  - Support structures
  - Extra-curricular opportunities

Common Vision Project

- "Modernized" programs will reflect:
  - The changing face of our discipline, especially with respect to inclusion of data science, modeling, and computation.
  - The increasingly cross-disciplinary nature of STEM fields.
  - Provide a coherent, intriguing introduction to collegiate mathematics for **all** students.

Common Vision Project

- Representation from the five professional associations who focus on undergraduate mathematical sciences programs as an integral part of their mission
  - American Mathematical Association of Two-Year Colleges (**AMATYC**)
  - American Mathematical Society (**AMS**)
  - American Statistical Association (**ASA**)
  - Mathematical Association of America (**MAA**)
  - Society of Industrial and Applied Mathematics (**SIAM**)

Common Vision Project

- Phase 1 of a 2-part initiative
- Introspective
  - To articulate an internally coherent vision within our community
- Next phase proposed as outward-looking, focused on
  - Grassroots efforts
  - Efforts that build on existing work
  - Dissemination and implementation of modernized curricula and delivery methods
  - Widespread, large-scale

Common Vision Project

- We spent the first six months drafting a report of common themes found in existing curricular guides published by the five associations.
  - *Beyond Crossroads*, AMATYC, 2006 (update of the 1995 publication *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus)*
  - *Guidelines for Assessment and Instruction in Statistics Education College Report*, ASA, 2012
  - *Guidelines for Undergraduate Programs in Statistical Science*, ASA, 2014

Common Vision Project

- We spent the first six months drafting a report of common themes found in existing curricular guides published by the five associations.
  - *2015 CUPM Guide to Majors in the Mathematical Sciences*, MAA, 2015 (update of *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004*)
  - *Partner Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra*, MAA, 2012
  - *Modeling across the Curriculum*, SIAM, 2012
  - *Undergraduate Programs in Applied Mathematics*, SIAM, 2014

Common Vision Report

- Synthesis of the common themes, based on our research and input from project participants and other leaders in our community

- http://www.maa.org/sites/default/files/pdf/common-vision/common_vision_final.pdf

- I have hard copies here today

Common Vision Report

- We intentionally did **not** focus on
  - Developmental/remedial courses
  - K-12 education

  because we had limited time and financial resources.

- We reserved those for Phase 2 efforts.

Common Vision Report

Common Themes in Curricular Guides

- **The status quo is unacceptable**
- More **statistics, modeling, simulation,** and **computation**
- Less traditional lecturing & more '**active learning**' techniques
- **Multiple pathways**:
  - Through **general education (and dev ed)** mathematics and statistics requirements
  - Into and through **majors** in the mathematical sciences
- Increasing role of **two-year colleges**
- Attention to student **transitions** & **transfer** between institutions
- **Technology** to enhance student learning

Common Vision Report

Other Important Themes

- Future teachers
  - The specialized knowledge needed for teaching is distinct from the knowledge needed for other math-intensive professions (**different**, **not less**)
  - 2001 CBMS MET report, 2012 CBMS MET II report
- Failure rates
  - The high rate of failure in post-secondary math classes is an **embarrassment** to our profession
  - Math courses are the most significant barrier to degree completion in **all fields**

Other Important Themes

- Student diversity
  - Our inability to attract and retain a diverse student population in the mathematical sciences is a **dreadful shortcoming that must be remedied**
  - 1998: Stiff & Harvey called the mathematics classroom one of the most segregated places in the U.S.
  - Today: Upper-level mathematics classes remain predominantly white
  - Today: The performance gap in mathematics is evident as early as 4th grade
  - It is **our responsibility** to remove barriers, we **should not** presuppose minorities and women are less capable or less prepared

Common Vision Report

Call to Action

- This work should aim to **narrow the gap** between mathematics as **practiced** in the academy and other employment sectors and mathematics as **experienced in higher education's instructional programs.**
- "Collective action"
  - A coordinated effort supported by major players from all existing sectors is more effective than an array of new initiatives and organizations. (Kania & Kramer, 2011, on "collective impact")

Moving Forward - Build, Collaborate

- The report proposes a path forward for continued collaboration. **Critical to our success.**

- We do **not** view the distinct efforts of various associations as **competing** efforts, but instead as the basis and strong foundation for collective action that is informed by a variety of perspectives.

Building, Collaborating – Principles

- Two profound principles will help ensure our forward progress and success (and are reflected in these recent efforts):

We **must** stop reinventing the wheel.

We **especially** must stop reinventing the flat tire.

Thank you!

Linda Braddy

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References

Kania, J. & Kramer, M. (2011). Collective Impact, Stanford Social Innovation Review, Winter 2011. (Available at http://ssir.org/articles/entry/collective_impact)

National Research Council. (2013). *The Mathematical Sciences in 2025*. Washington, DC: The National Academies Press. (Available at http://www.nap.edu/catalog/15269/the-mathematical-sciences-in-2025)

President's Council of Advisors on Science and Technology. (2012). *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Washington, DC: White House Office of Science and Technology Policy. https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf

References

Saxe, K. & Braddy, L. (2015). *A Common Vision for Undergraduate Mathematical Sciences Programs in 2025.* Washington, DC: Mathematical Association of America. (Available at http://www.maa.org/sites/default/files/pdf/CommonVisionFinal.pdf)

Stiff, L. V., & Harvey, W. B. (1988). On the education of black children in mathematics. Journal of Black Studies, 19(2), 190–203.

Zorn, P., Bailer, J., Braddy, L., Carpenter, J., Jaco, W., & Turner, P. (2014). *The INGenIOuS Project: Mathematics, Statistics, and Preparing the 21st Century Workforce.* Washington, DC: Mathematical Association of America. (Available at http://www.maa.org/sites/default/files/pdf/ingenious/INGenIOuS-report.pdf)

TPSEMath

Transforming Post-Secondary Education in Mathematics

An Update on TPSE Math Activities and Plans

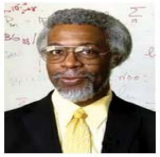
NCTM
April 14, 2016

TPSE Math

Transforming Post-Secondary Education in Mathematics

Phillip Griffiths, IAS

Eric Friedlander, USC



Jim Gates, U. Maryland

Mark Green, UCLA

Tara Holm, Cornell

Uri Treisman, UT Austin

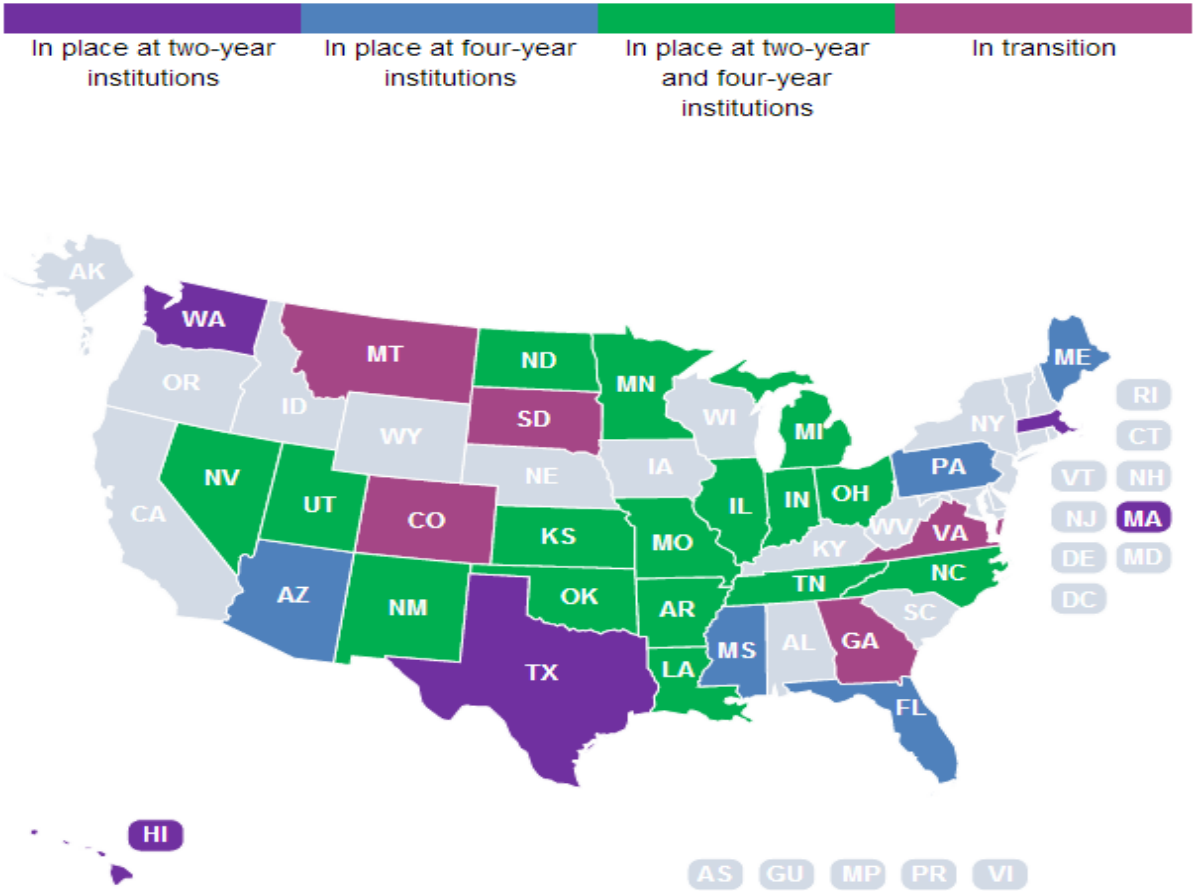
TPSE Math aims to effect constructive change in mathematics education at community colleges, 4-year colleges and research universities. The goal of the first phase of the project is to identify scalable solutions for implementation.

For more information, visit www.tpsemath.org

FORCES SHAPING POST-SECONDARY MATHEMATICS

PERFORMANCE FUNDING AND THE COMPLETION AGENDA

Performance Based Funding for Higher Education



Source: National Conference of State Legislatures

Higher Education Mathematics Course Enrollment

	4 Year Institutions				2 Year Institutions			
	1995	**2000**	**2005**	**2010**	**1995**	**2000**	**2005**	**2010**
College Algebra and below	57%	58%	56%	54%	81%	81%	81%	80%
Calculus	37%	35%	37%	38%	10%	8%	7%	7%
Advanced Courses	7%	6%	7%	8%				
Other Courses (2 Year)					12%	10%	12%	12%
TOTAL Enrollment (in thousands)	1469	1614	1607	1971	1348	1273	1580	1887

Source: Adapted from the CBMS 2010 Census Report, Table S.2

High Rates of Failure in Gateway Courses

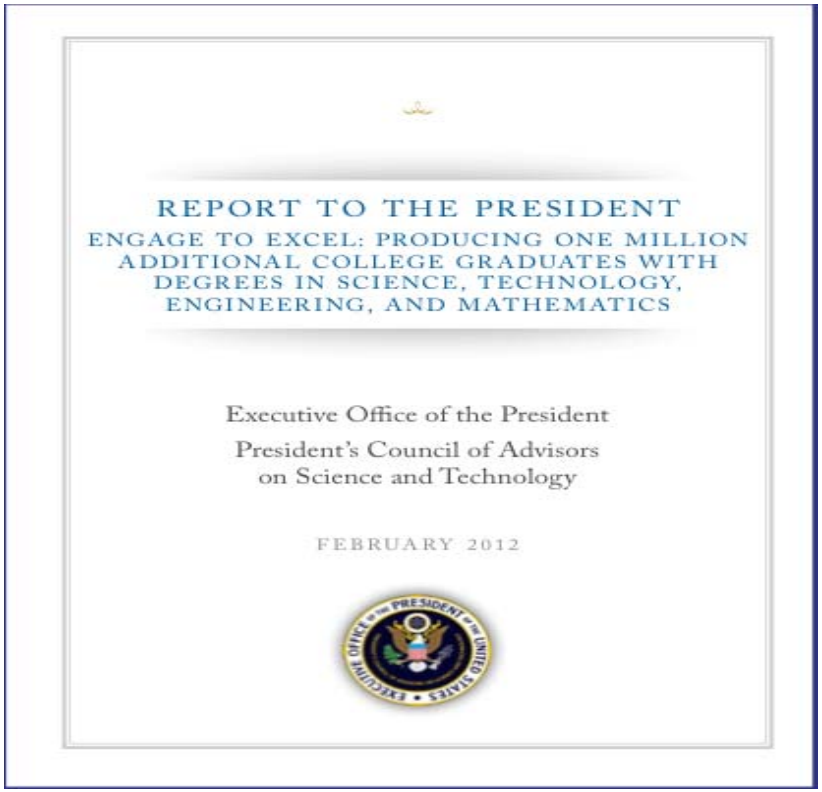
Students Passing a Math Course that Counts Toward an Associate's Degree

Fall 2010 enrollments in math courses that students could apply toward a degree	students who remained enrolled until the end of the term	students who received a passing grade
About 17,600 **African American** students	**70%** 12,300 students	**41%** 7300 students
About 108,700 **Hispanic/Latino** students	**75%** 81,900 students	**49%** 53,500 students
About 98,600 **White** students	**80%** 78,500 students	**60%** 58,900 students

source: *Passing when it counts.* EdSource Issue Brief, February 2012
www.edsource.org/pub12-passing-when-it-counts.html

CALLS TO ACTION

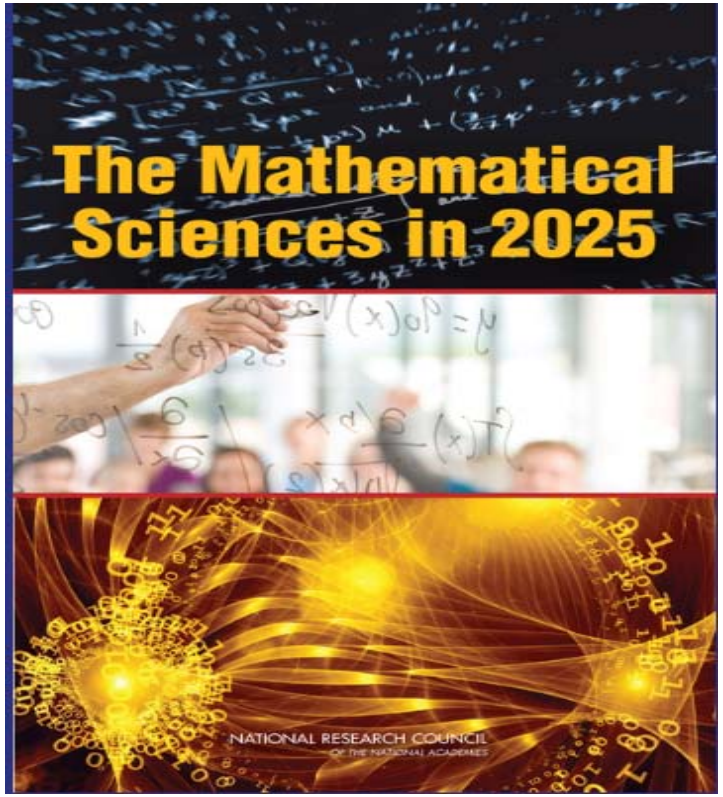
Pivotal reports serve as “calls to action” for two collective efforts to reform undergraduate mathematics education: TPSE Math and Common Vision 2025


REPORT TO THE PRESIDENT

ENGAGE TO EXCEL: PRODUCING ONE MILLION ADDITIONAL COLLEGE GRADUATES WITH DEGREES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

Executive Office of the President
President's Council of Advisors on Science and Technology

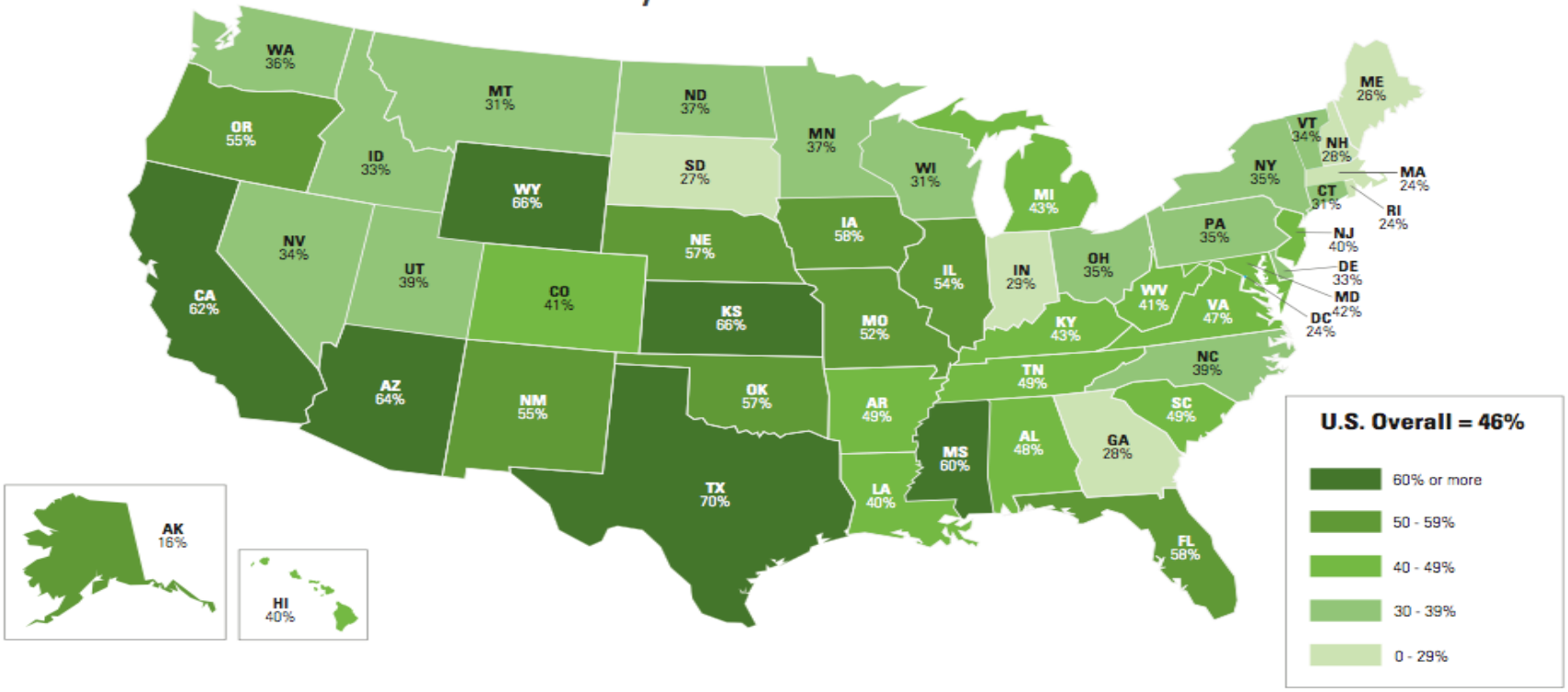
FEBRUARY 2012



CHANGING ENROLLMENT PATTERNS

With data current through October 2014

Percentage of Students Completing Degrees at Four-Year Institutions Who Previously Enrolled at Two-Year Institutions*



*Students were considered enrolled at two-year institutions if they had at least one full-time or part-time enrollment at a two-year institution prior to the four-year completion date.

Note: The state shown is the state in which the degree was awarded. The prior two-year enrollments may have occurred in any state. The institution levels are based on 2013 IPEDS institutional characteristics, with the Florida College System being the only exception. The 28 schools in that system offer four-year degrees, but all are categorized as two-year institutions for this analysis, meaning their enrollments are counted as contributing to four-year awards elsewhere, but their own awards are not counted in the denominator. This is in keeping with their traditional role as a primary point of access to higher education.

Many state financial aid programs were designed over 30 years ago to benefit full-time, 4-year college students who enroll immediately after high school. This is no longer the norm.

Today's students are:

On the move

Older

Part time

More diverse

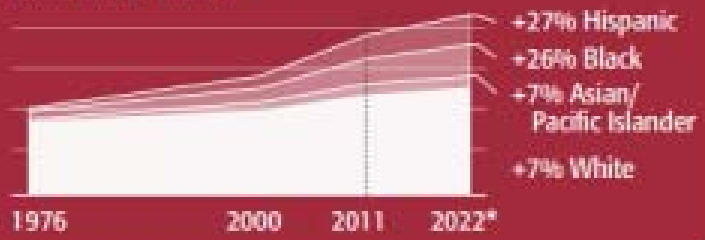
In 2012,
4.6 million
undergraduate students were enrolled in distance education

1/3 of all students
change institutions at some time before earning a degree

Only 19%
of full-time students earn a bachelor's degree in four years

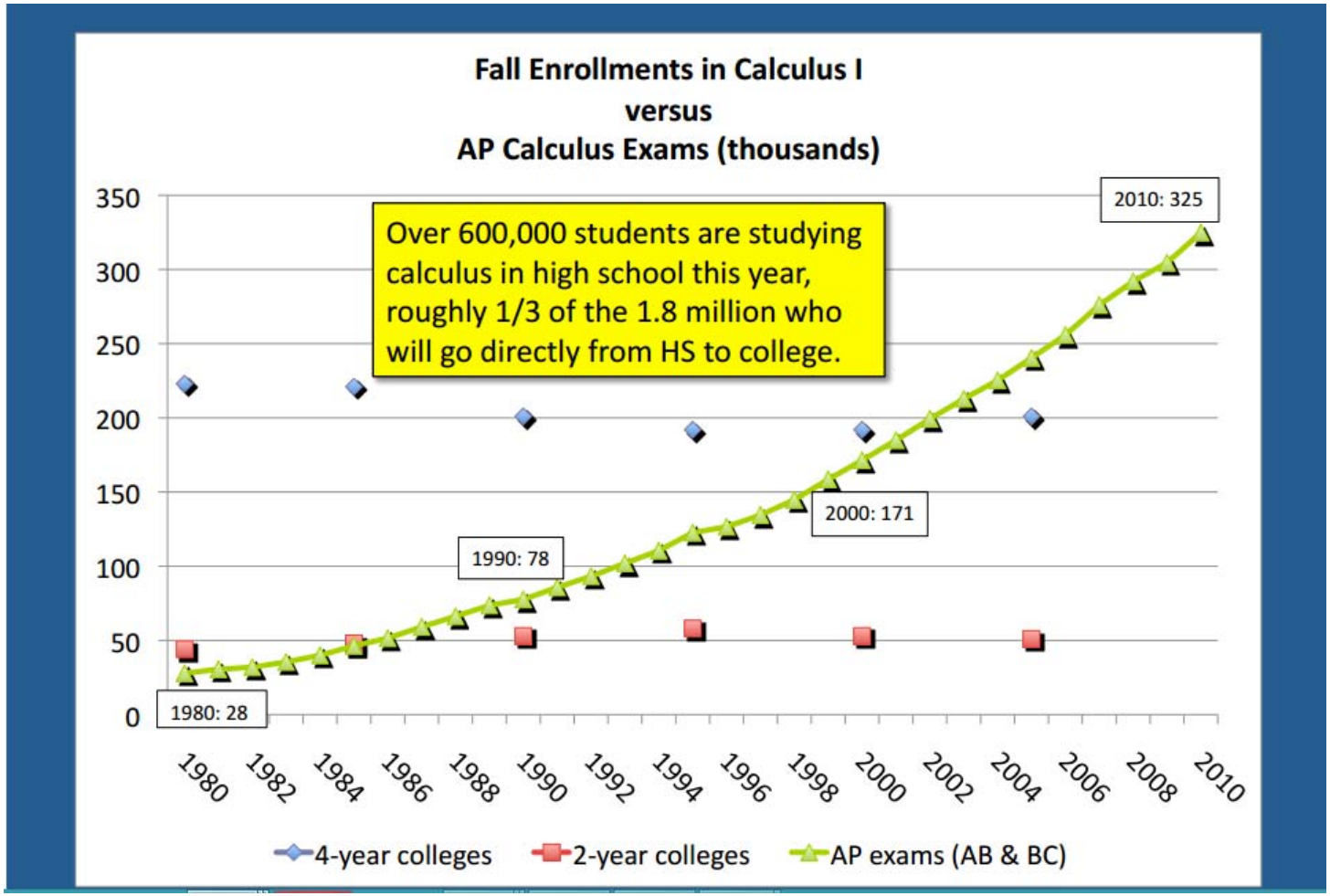
From 2000 to 2011, enrollment of students 25 and older increased
41%

Projected % *increases* in student enrollment from 2011–2022:*



38.3%
of students were enrolled part time in 2012

21.76%
of American adults have some college credits but no college degree

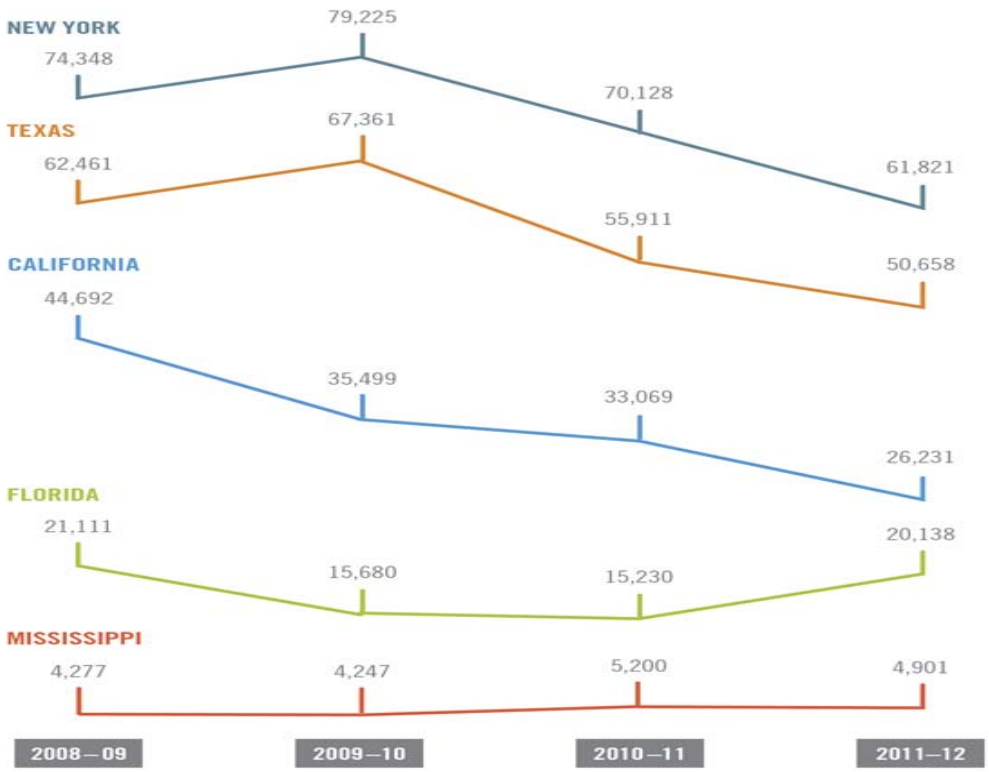


Source: David Bressoud - http://www.macalester.edu/~bressoud/talks/2011/portland-apcalc.pdf

THE COMMON CORE STATE STANDARDS AND THE UNDERSUPPLY OF TEACHERS OF MATHEMATICS

TEACHER-PREP ENROLLMENT TRENDS BY STATE

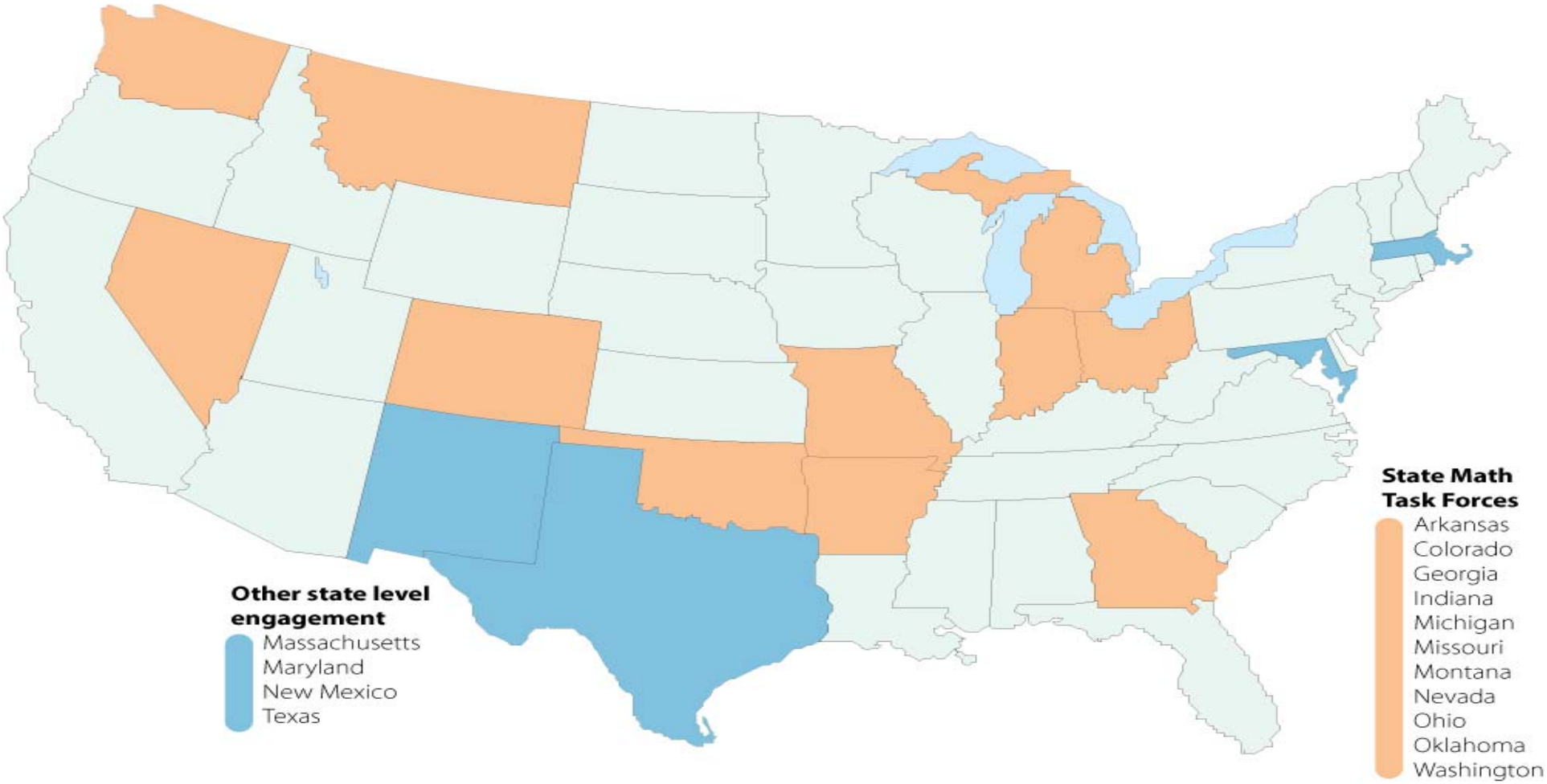
Enrollments in teacher-preparation programs (including alternative-route options) have fallen dramatically in some states in recent years, while holding steady in others.



SOURCE: U.S. Department of Education, Higher Education Act Title II Data Collection

EDUCATION WEEK

THE EMERGENCE OF STATE MATH TASK FORCES


Other state level engagement
Massachusetts
Maryland
New Mexico
Texas
State Math Task Forces
Arkansas
Colorado
Georgia
Indiana
Michigan
Missouri
Montana
Nevada
Ohio
Oklahoma
Washington

SELECTED TPSE THEMES

HONOR AND BUILD ON THE PROFESSION'S STRENGTHS

Rather than obsess about its perceived weaknesses

MODERATION AND MODERNIZATION

COHERENCE WITHOUT UNIFORMITY

One size does not fit all

SCALING

Changing normative practice

CHANGING THE ROLES OF MATHEMATICS IN POST-SECONDARY EDUCATION

High-level goals for post-secondary mathematics

1. Math can become a partner discipline, rather than a service discipline.
2. Math can become the discipline best at curricular modernization and relevance, which requires working with peer disciplines.
3. Math can be seen as the most responsible discipline in supporting student success—and the easiest to work with.
4. Mathematics can become the exemplar among disciplines in improvement, in identifying areas of consensus in a highly heterogeneous higher education landscape, and in developing and scaling innovation.

Association of Mathematics Teacher Educators

"The Status Quo Is No Longer Acceptable."

- How is AMTE connected to this Common Vision?
- What is AMTE's Role and addressing the challenges of a "Status Quo No Longer Acceptable?"

Who are we?

- AMTE is the largest professional organization devoted to the improvement of mathematics teacher education.

- AMTE's Membership includes professors, researchers, teacher-leaders, school mathematics coordinators, policy experts, graduate students, and others.

Future Teachers

Attending to the preparation of future K–12 mathematics and statistics teachers is critical to the future of our profession, and mathematics departments should work with schools of education to ensure pre-service teachers are well-prepared for the classroom.

The Common Vision is calling upon the community to

(1) update curricula,

(2) articulate clear pathways between curricula driven by changes at the K–12 level and the first courses students take in college,

(3) scale up the use of evidence-based pedagogical methods,

(4) find ways to remove barriers facing students at critical transition points (e.g., placement, transfer) and

(5) establish stronger connections with other disciplines.

Catalyst for a "Common Vision"

- Member organization of the Conference Board of Mathematical Sciences
- Writing of the MET II (Mathematical Education of Teachers II)

Current Initiatives

Statement on Active Learning

AMTE is collaborating with several member organizations of CBMS in the crafting of a statement of support for the use of active learning techniques in mathematics education. It is anticipated this statement will serve as a clear public message that the mathematical community is striving to improve the mathematical learning of all students

Current Initiatives

AMTE is working with AMATYC in crafting the next version in the Crossroads series that will impact the teaching and learning of mathematics in the first two years of college.

Current Initiatives

AMTE is hosting an upcoming webinar (date to be announced) focusing on the ***Guidelines for Assessment and Instruction in Mathematical Modeling Education*** (GAIMME report). This is a project of SIAM and COMAP with the cooperation of NCTM. The AMTE webinar will be presented by Rachel Levy of SIAM.

Current Initiatives

Opening Session for the AMTE 2017 Annual Conference: Invited panel focusing on *teaching the content* with respect to teacher preparation and professional development in Statistics, Mathematical Modeling and Mathematics.

Current Initiatives

AMTE is developing Standards for Mathematics Teacher Preparation PK-12 to disseminate broadly a well-articulated vision of what it means to prepare teachers of mathematics.

THE MTP Standards

- The MTP Standards will describe a national vision for the initial preparation of mathematics teachers PK-12
- Guide the improvement of individual teacher preparation programs (no matter their accrediting agency)
- Promote national dialogue and action related to mathematics teacher preparation
- Are aspirational, advocating for practices that support candidates in becoming high quality teachers who guide student learning

Association of Mathematics Teacher Educators

Leadership Team

Pk-2 Doug Clements

3-5 Nadine Bezuk

6-8 Jennifer Bay-Williams

9-12 Gary Martin

Association of Mathematics Teacher Educators

Writing Group
Pk-12 Mathematics Educators and Mathematicians

PK-2 Team

Dorothy White	University of Georgia
Nicole Rigelman	Portland State University
DeAnne Huinker	University of Wisconsin, Milwaukee
Doug Clements	University of Denver

Association of Mathematics Teacher Educators

3- 5 Team

Karen Karp	Johns Hopkins University
Tim Boerst	University of Michigan
Julia Aguirre	University of Washington, Tacoma
Nadine Bezuk	San Diego State University
Kristin Umland	University of New Mexico

6-8 Team

Ed Dickey	University of South Carolina
Travis Olson	University of Nevada Las Vegas
Elizabeth Hughes	University of Northern Iowa
Jennifer Bay-Williams	University of Louisville
Jim Lewis	University of Nebraska

9-12 Team

Rochelle Gutierrez	University of Illinois
Marilyn Strutchens	Auburn University
Randy Philipp	San Diego State University
W. Gary Martin	Auburn University
Beth Burroughs	University of Montana

Engage in the Review Process

- All organizations in CBMS
- The ASA-NCTM joint committee on statistics education
- Accreditation organizations (AACTE, CAEP)
- Other teacher education organizations (ASTE, ATE, NAEYC)
- Teacher Focus Groups
- Other stakeholders

AMTE Association of Mathematics Teacher Educators

We Invite You to Become Involved

- If not a member, become a member of AMTE
- Our next annual conference is in Orlando, Florida, February 9-11, 2017
- Visit our website to submit a proposal www.amte.org; proposal deadline is May 15th

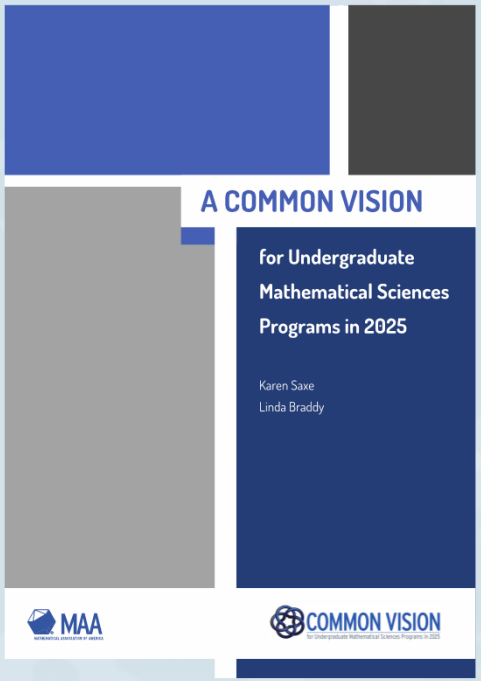
The Implication of Common Vision for K-12 Mathematics Education

Diane J. Briars
President
National Council of Teachers of Mathematics
dbriars@nctm.org
April 14, 2016

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

A Common Vision for Undergraduate Mathematical Sciences in 2025

"The status quo is unacceptable."



Calls on the community to:

1. Update curricula
2. Articulate clear pathways between curricula driven by changes in K-12 and the first courses students take in college
3. Scale up the use of evidence-based pedagogical methods
4. Remove barriers at critical transition points
5. Establish stronger connections with other disciplines

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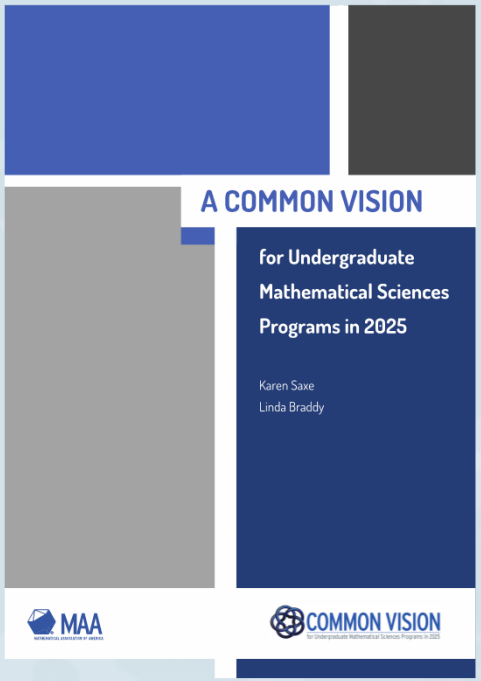

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Update Curricula

Provides support for:

- Increasing the emphasis on modeling, statistics, and discrete mathematics.
- Emphasizing conceptual understanding.
- Providing adequate time for students to develop proficiency in the Standards for Mathematical Practice/Process Skills.
- Moving to integrated high school mathematics courses

A Common Vision for Undergraduate Mathematical Sciences in 2025

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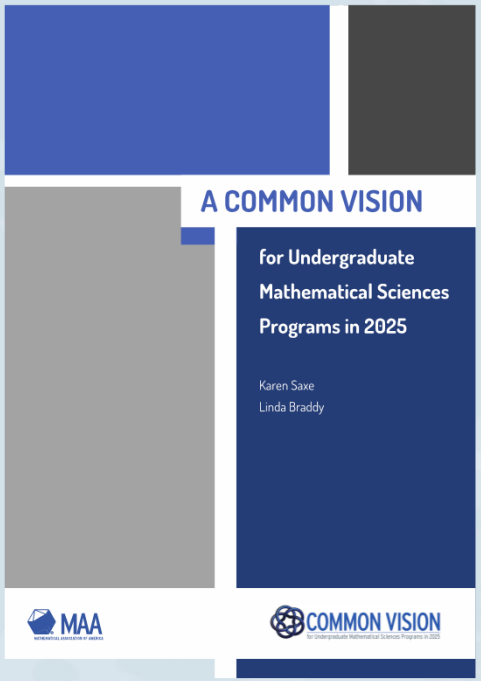

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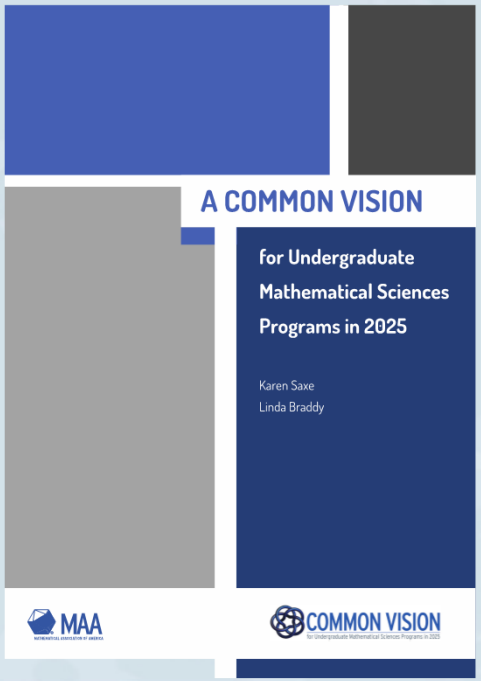

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NCTM | NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

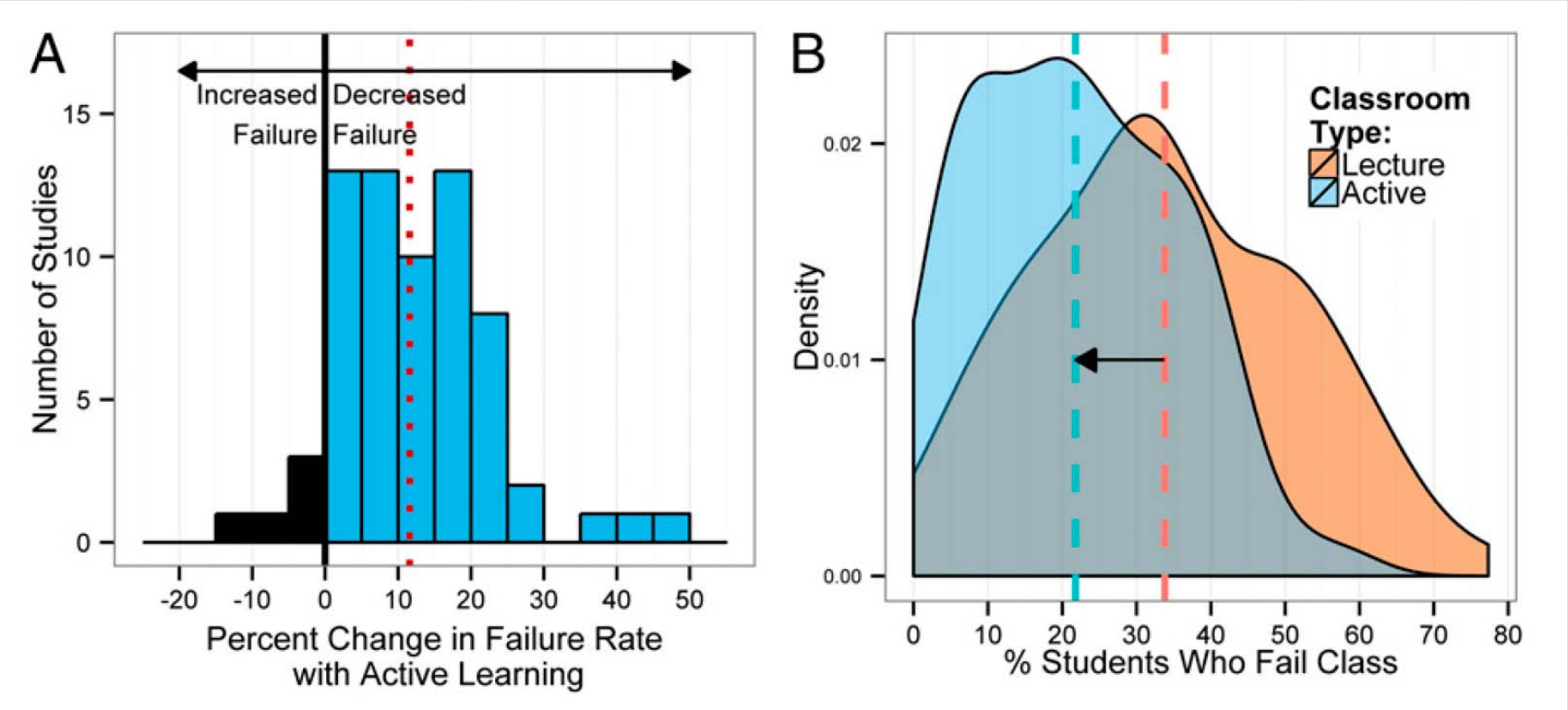
Active Learning Increases Student Performance in Science, Engineering, and Mathematics

- Meta-analysis of 225 studies comparing student performance in undergraduate science, technology, engineering, and mathematics (44 studies) (STEM) courses under traditional lecturing versus active learning.
- Active learning interventions included:
  - occasional group problem-solving,
  - worksheets or tutorials completed during class,
  - use of personal response systems
  - studio or workshop course designs.
- Research questions:
  - Does active learning boost examination scores?
  - Does it lower failure rates?

NCTM NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Freeman, S. et al, Proceedings of the National Academy of Sciences, June 10, 2014, vol. 111 no. 238410-8414.

Changes in Failure Rate Lecture vs Active Learning



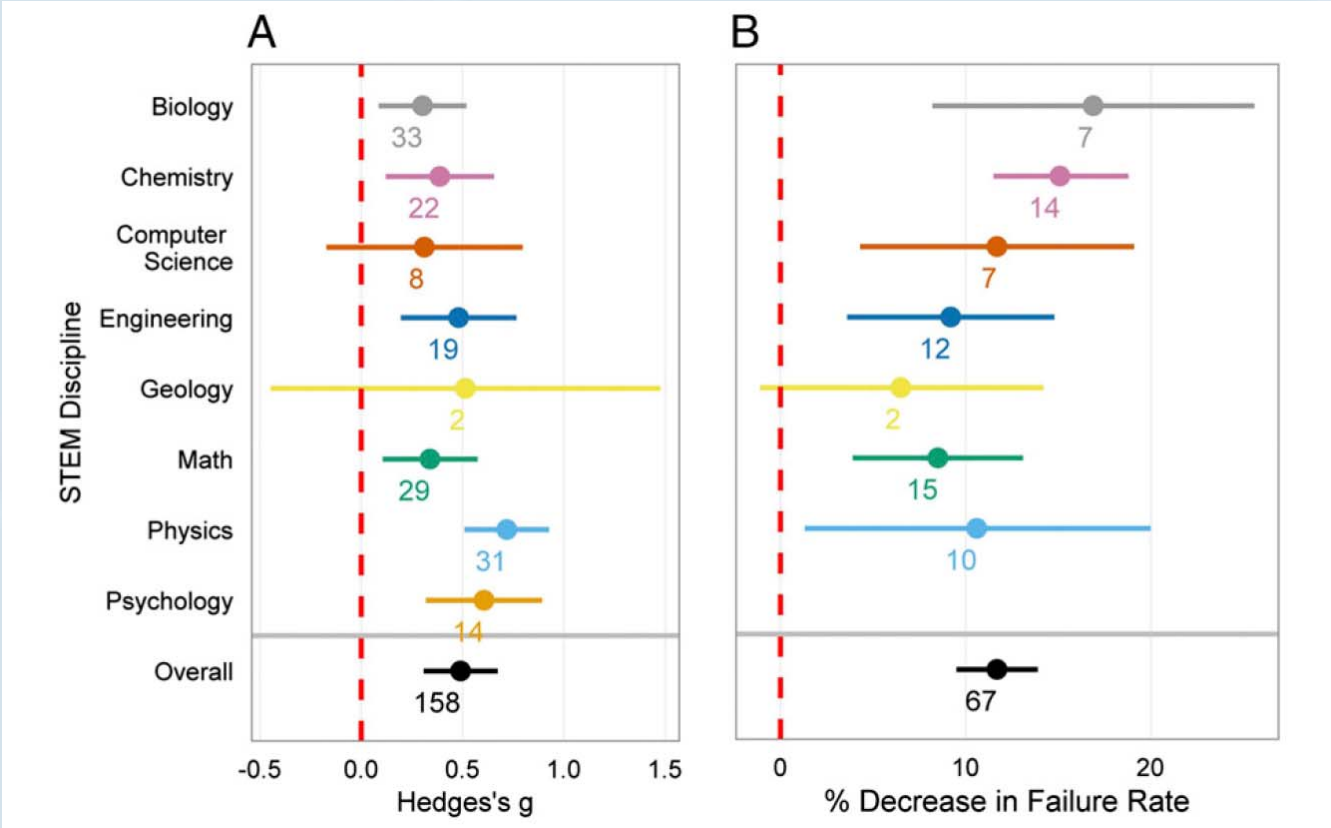
(A) The mean change (12%) is indicated by the dashed vertical line.

(B) Kernel density plots of failure rates under active learning and under lecturing. The mean failure rates under each classroom type (21.8% and 33.8%) are shown by dashed vertical lines.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Freeman et al., 2014

Changes in Assessment Performance and Failure Rate
Lecture vs Active Learning



(A) Data on examination scores, concept inventories or other assessments

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Freeman et al., 2014

Active Learning Increases Student Performance in Science, Engineering, and Mathematics

- Active learning confers disproportionate benefits for STEM students from disadvantaged backgrounds and for female students in male-dominated fields;

- The results raise questions about the continued use of traditional lecturing as a control in research studies, and support **active learning as the preferred, empirically validated teaching practice in regular classrooms**.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Freeman et al, 2014

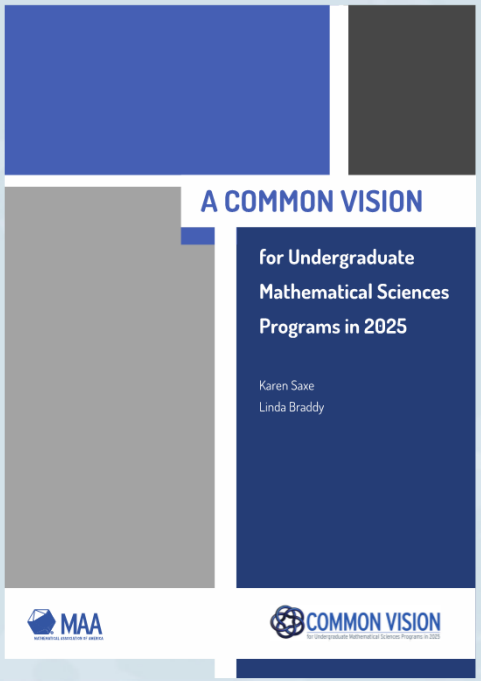
Effective Mathematics Teaching Practices

1. Establish mathematics **goals** to focus learning.
2. Implement **tasks** that promote reasoning and problem solving.
3. Use and connect mathematical **representations.**
4. Facilitate meaningful mathematical **discourse**.
5. Pose purposeful **questions**.
6. Build **procedural fluency** from conceptual understanding.
7. Support **productive struggle** in learning mathematics.
8. **Elicit and use evidence** of student thinking.

NCTM | NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

A Common Vision for Undergraduate Mathematical Sciences in 2025

"The status quo is unacceptable."



Calls on the community to:

1. **Update curricula**
2. **Articulate clear pathways between curricula driven by changes in K-12 and the first courses students take in college**
3. **Scale up the use of evidence-based pedagogical methods**
4. Remove barriers at critical transition points
5. Establish stronger connections with other disciplines

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Thank You!

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