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
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 Undergraduate Programs in Statistical Science*, ASA, 2014
Common Vision Project

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  • 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


- 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 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
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
Common Vision Report

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
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


An Update on TPSE Math Activities and Plans

NCTM
April 14, 2016
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](http://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

<table>
<thead>
<tr>
<th></th>
<th>4 Year Institutions</th>
<th>2 Year Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Algebra and below</td>
<td>57%</td>
<td>58%</td>
</tr>
<tr>
<td>Calculus</td>
<td>37%</td>
<td>35%</td>
</tr>
<tr>
<td>Advanced Courses</td>
<td>7%</td>
<td>6%</td>
</tr>
<tr>
<td>Other Courses (2 Year)</td>
<td></td>
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<tr>
<td>TOTAL Enrollment (in thousands)</td>
<td>1469</td>
<td>1614</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Fall 2010 enrollments in math courses that students could apply toward a degree</th>
<th>students who remained enrolled until the end of the term</th>
<th>students who received a passing grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>About 17,600 African American students</td>
<td>70% (12,300 students)</td>
<td>41% (7,300 students)</td>
</tr>
<tr>
<td>About 108,700 Hispanic/Latino students</td>
<td>75% (81,900 students)</td>
<td>49% (53,500 students)</td>
</tr>
<tr>
<td>About 98,600 White students</td>
<td>80% (78,500 students)</td>
<td>60% (58,900 students)</td>
</tr>
</tbody>
</table>

*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
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.

U.S. Overall = 46%

- **60% or more**
- **50 - 59%**
- **40 - 49%**
- **30 - 39%**
- **0 - 29%**
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:

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:

- 27% Hispanic
- 26% Black
- 7% Asian/Pacific Islander
- 7% White

38.3% of students were enrolled part time in 2012.

21.76% of American adults have some college credits but no college degree.
Over 600,000 students are studying calculus in high school this year, roughly 1/3 of the 1.8 million who will go directly from HS to college.
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.

NEW YORK
74,348
79,225
70,128
61,821

TEXAS
62,461
67,361
55,911
50,658

CALIFORNIA
44,692
35,499
33,089
26,231

FLORIDA
21,111
15,680
15,230
20,138

MISSISSIPPI
4,277
4,247
5,200
4,901


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

EDUCATION WEEK
THE EMERGENCE OF STATE MATH TASK FORCES
SELECTED TPSE THEMES
HONOR AND BUILD ON THE PROFESSION’S STRENGTHS

Rather than obsess about its perceived weaknesses
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.
“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)
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.
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.
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.
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

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<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Dorothy White</td>
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<tr>
<td>Nicole Rigelman</td>
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<td>DeAnne Huinker</td>
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<td>Doug Clements</td>
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<tr>
<td>Name</td>
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<tr>
<td>Karen Karp</td>
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<td>Tim Boerst</td>
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<td>Julia Aguirre</td>
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<td>Nadine Bezuk</td>
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<td>Kristin Umland</td>
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<td>Name</td>
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<td>Ed Dickey</td>
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<td>Jim Lewis</td>
<td>University of Nebraska</td>
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### 9-12 Team

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<tbody>
<tr>
<td>Rochelle Gutierrez</td>
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<td>Marilyn Strutchens</td>
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<td>Randy Philipp</td>
<td>San Diego State University</td>
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<tr>
<td>W. Gary Martin</td>
<td>Auburn University</td>
</tr>
<tr>
<td>Beth Burroughs</td>
<td>University of Montana</td>
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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
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
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April 14, 2016
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

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4. Remove barriers at critical transition points

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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
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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?

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.

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

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.

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.
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Thank You!

Diane Briars
dbriars@nctm.org