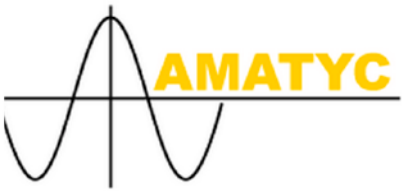
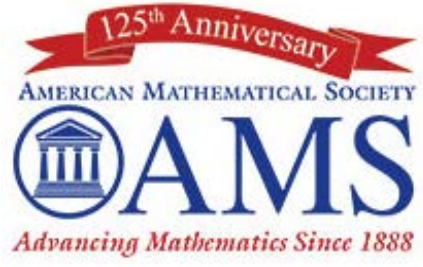




A Common Vision for the Undergraduate Mathematics Program in 2025

Karen Saxe

AMS Committee on Education

October 16-17, 2014

Common Vision 2025
Starting Points

- Freshman and sophomore courses in the mathematical sciences function as gateways to many majors.
- They are crucial to preparing mathematically literate citizens, able to interpret and work with data and computation.
- Diverse stakeholders have made excellent, yet separate, recommendations for improving these courses.
- ***It is time for collective action to coordinate existing and future efforts in such a way that everyone is pulling in the same general direction to leverage the collective power of the whole.***

Common Vision 2025
Starting Points – from the CBMS Forum

- Students are part of *every* post-secondary institution's mission. [Peter March]
- The vitality of the U.S. mathematical sciences enterprise is excellent and their activities are crucial to economic growth, national competitiveness, and national security. Distinctions between "core" and "applied" mathematics increasingly appear artificial; in particular, it is difficult today to find an area of mathematics that does *not* have relevance to applications. [Mark Green]
- While 96% of Chief Academic Officers think they are equipping their graduates for the work force, just 11% of employers strongly agree. [Uri Treisman]

Collective Action
AMATYC, AMS, ASA, MAA, SIAM

- JPBM & AMATYC
- CBMS is an umbrella organization consisting of 17 professional associations all of which have as one of their primary objectives the increase or diffusion of knowledge in one or more of the mathematical sciences.

  AMATYC, AMS, ASA, MAA, SIAM are *exactly* the associations with at least part of their focus on undergraduate teaching.

Common Vision 2025 Leadership team

- John Bailer, ASA
- Linda Braddy, co-PI, MAA Deputy Exec. Director
- Rob Farinelli, AMATYC past President
- Tara Holm, AMS CoE Chair
- Vilma Mesa, MAA & AMATYC
- Karen Saxe, PI, MAA VP2
- Uri Treisman, Dana Center Exec. Director
- Peter Turner, SIAM VP for Education

The AMATYC and undergraduate mathematics curricula

AMATYC is the only organization exclusively devoted to providing a national forum for the improvement of mathematics instruction in the first two years of college. AMATYC's focus is on the introductory courses that come before calculus. Their three key publications are:

- *Crossroads in Mathematics* (original standards document)
- *A Vision: Mathematics for the Emerging Technologies*
- *Beyond Crossroads* (update to the original Crossroads).

The AMATYC and undergraduate mathematics curricula

Basic Principles of *Beyond Crossroads*

- ***Assessment***. *The assessment of student learning in mathematics should be a fundamental tool for the improvement of instruction and student learning.*
- ***Broadening***. *Mathematics courses and programs in the first two years of college should broaden students' options in educational and career choices.*
- ***Equity and access***. *All students should have equitable access to high-quality, challenging, effective mathematics instruction and support services.*

The AMATYC and undergraduate mathematics curricula

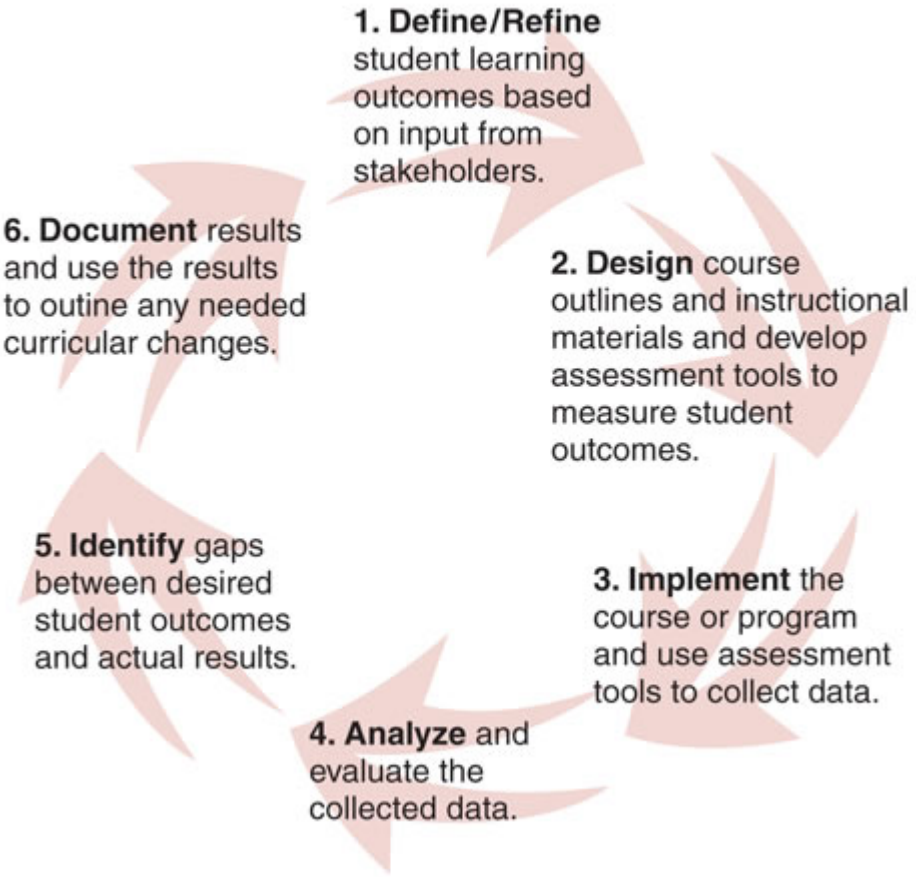
- ***Innovation***. *Mathematics programs should be thoughtfully constructed to approach content and instruction with appropriate use of traditional and innovative methods.*
- ***Inquiry***. *Effective mathematics instruction should require students to be active participants.*
- ***Quantitative literacy***. *Quantitative literacy should be integrated throughout the mathematics program and the college curricula.*

The AMATYC and undergraduate mathematics curricula

- ***Relevance***. *The mathematics that students study should be meaningful and foster their appreciation of the discipline.*
- ***Research into practice***. *The practice of mathematics teaching should be guided by research on teaching and learning.*
- ***Technology***. *Technology should be integral to the teaching and learning of mathematics.*

The AMATYC and undergraduate mathematics curricula

Figure 3 The Curriculum Implementation Cycle



The AMS and undergraduate mathematics curricula

AMS mission focuses on furthering the interests of mathematical research and scholarship, while supporting mathematical education at all levels, and fostering an awareness and appreciation of mathematics and its connections to other disciplines and everyday life.

- This CoE provides a forum for the discussion of mathematics education issues.
- There has been extensive cooperation with other organizations on matters concerning education.
- Several AMS members have been involved with TPSE.
- Prizes and awards: *Programs that Make a Difference Award*
- Workshops and Reports on leading departments

The ASA and undergraduate mathematics curricula

ASA publishes undergraduate guides alone and in collaboration with other associations.

2012 Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report focuses on introductory college courses.

Includes brief history of the intro college course and summarizes the ‘92 report by George Cobb. Results of a survey on the teaching of intro courses are summarized. GAISE offers

- goals for students on what it means to be statistically literate
- 6 recommendations for the teaching of intro statistics

The ASA and undergraduate mathematics curricula

Goals for students to be statistically literate --

- Variability is natural, predictable, and quantifiable
- Understanding of random sampling and extension to conclusions about population
- “Statistical significance” -- what it means if found, what it means if not found
- How to obtain and generate data
- How to communicate results of a stat analysis
- Concepts such as sampling distributions and *p*-values

The ASA and undergraduate mathematics curricula

6 recommendations for the teaching of intro statistics --

- Emphasize statistical literacy and develop statistical thinking
- Use real data
- Stress conceptual understanding
- Foster active learning in the classroom
- Use technology for developing conceptual understanding and analyzing data
- Use assessments to improve and evaluate student learning

The ASA and undergraduate mathematics curricula

- 2014 Guidelines for Undergraduate Programs in Statistical Science
  - majors
  - upper level courses
  - who should/can teach such courses

The MAA and undergraduate mathematics curricula

The MAA's Committee on the Undergraduate Program in Mathematics (CUPM) is charged with making recommendations to guide mathematics departments in designing curricula for their undergraduate students.

CUPM began issuing reports in 1953, updating them at roughly 10-year intervals. Their 2015 report is almost in final form.

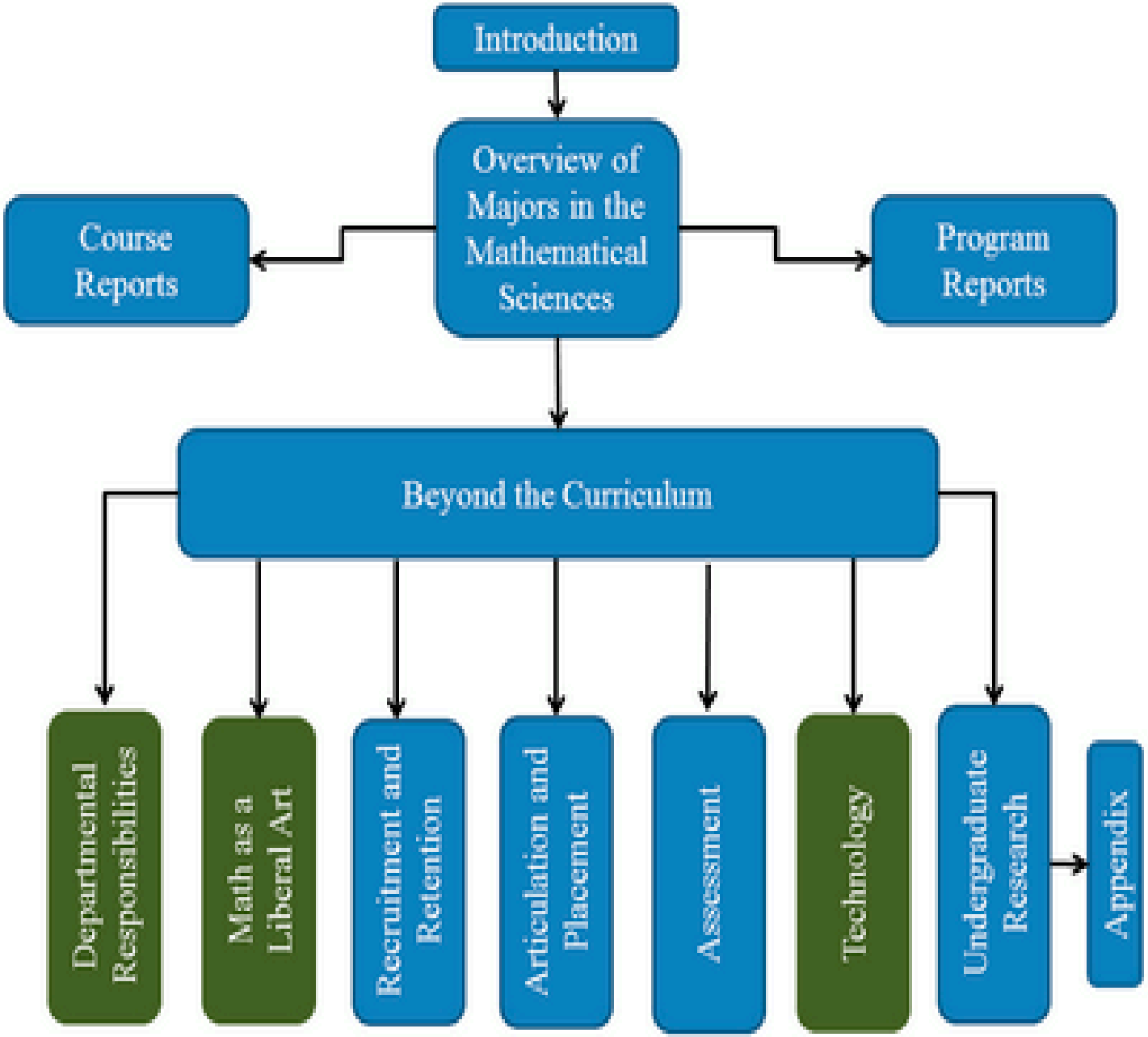
The MAA and undergraduate mathematics curricula

- Every department and every school has a unique mission
- Planning curricular offerings for any department should be a group effort, informed by local knowledge of students, faculty, resources, administration, and, where appropriate, governmental restrictions and support
- Mathematics is more than curriculum

The MAA and undergraduate mathematics curriculum

Every course should

- Incorporate activities that will help all students progress in developing analytical, critical reasoning, problem-solving, and communication skills and acquiring mathematical habits of mind
- Promote awareness of connections to other subjects (both in and out of the mathematical sciences) and strengthen each student's ability to apply the course material to these subjects
- Introduce contemporary topics from the mathematical sciences and their applications, and enhance student perceptions of the vitality and importance of mathematics in the modern world


Introduction
Overview of Majors in the Mathematical Sciences
Course Reports
Program Reports
Beyond the Curriculum
Departmental Responsibilities
Math as a Liberal Art
Recruitment and Retention
Articulation and Placement
Assessment
Technology
Undergraduate Research
Appendix

The MAA and undergraduate mathematics curricula

CRAFTY is a subcommittee of CUPM charged with monitoring ongoing developments and making general recommendations concerning the first two years of collegiate mathematics. The recent focus of CRAFTY has been on determining the mathematical needs of partner disciplines and on the College Algebra course.

These efforts have culminated in two publications

- *Curriculum Foundations Project: Voices of the Partner Disciplines*
- *Partner Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra*

The MAA and undergraduate mathematics curricula

CRAFTY summary recommendations are to emphasize

- conceptual understanding
- problem solving skills
- mathematical modeling
- communication skills
- balance between perspectives

The MAA and undergraduate mathematics curricula

CRAFTY prioritizes offering, in the first two years:

- non-calculus-based descriptive statistics and data analysis
- discrete mathematics and mathematical reasoning (without calculus as prerequisite)
- calculus and linear algebra, making the curriculum more appropriate for the needs of the partner disciplines
- Replace traditional college algebra courses with courses stressing problem solving, mathematical modeling, descriptive statistics, and applications in the appropriate technical areas. Deemphasize intricate algebraic manipulation.

The SIAM and undergraduate mathematics curricula

SIAM regularly writes curricula guides and makes further recommendations on education policy and curricula in areas relevant to applied and computational mathematics.

- *Undergraduate Degree Programs in Applied Mathematics (May 2014)*
- *Modeling across the Curriculum*

The SIAM and undergraduate mathematics curricula

- Add more hands-on experiences in first year
- Teach the students you have
- Create multiple entryways
  - A non-calculus track for freshman modeling
  - Use of computation/ discrete calculus
  - Data-based models as well as “physics-based” models
- Develop a repository of materials for math modeling instruction and understanding

The SIAM and undergraduate mathematics curricula

A modern math sciences undergraduate education should include at least some introduction to

- Algorithms and Analysis
- Distributed Computing and Big Data
- Data Analytics
- Modeling with Probability and Stochastic Processes
- Bayesian Statistics and Machine Learning
- Dynamical Systems
- Optimization and Control

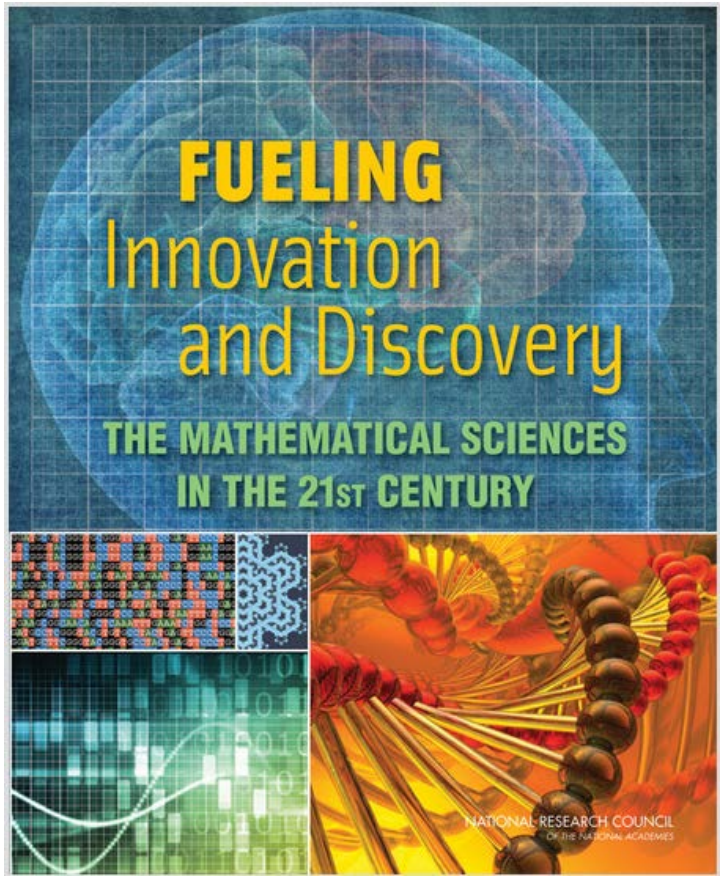
Common Themes?
Guides all touch on

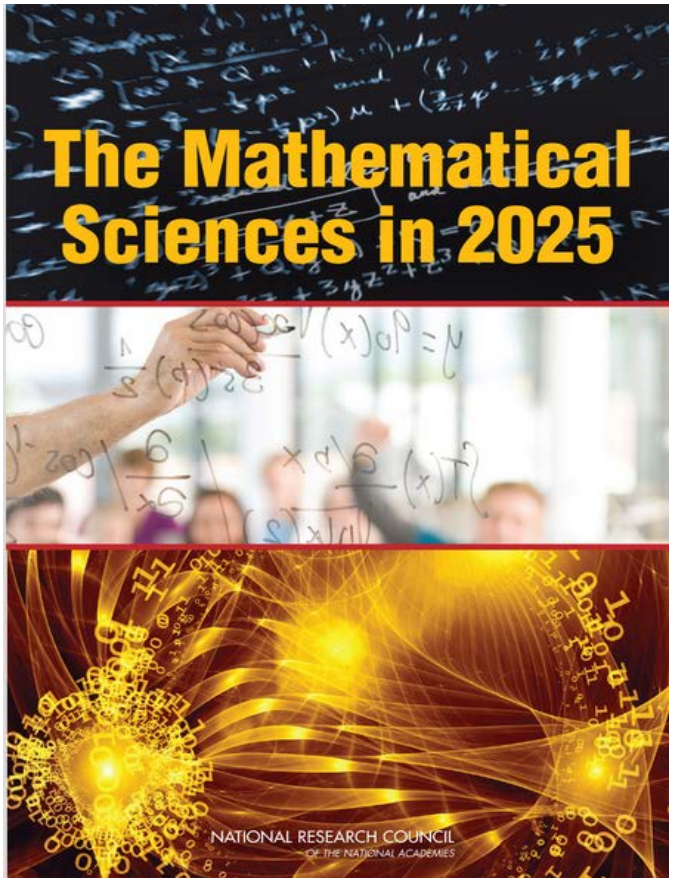
- Course content
- Course structure and pedagogy, including delivery models
- Student supports
- Faculty development
- Scale and resources

We must, always

- Improve interdisciplinary cooperation
- Increase participation
- Emphasize the use of appropriate technology
- Emphasize the use of appropriate assessment
- Consider sustainability

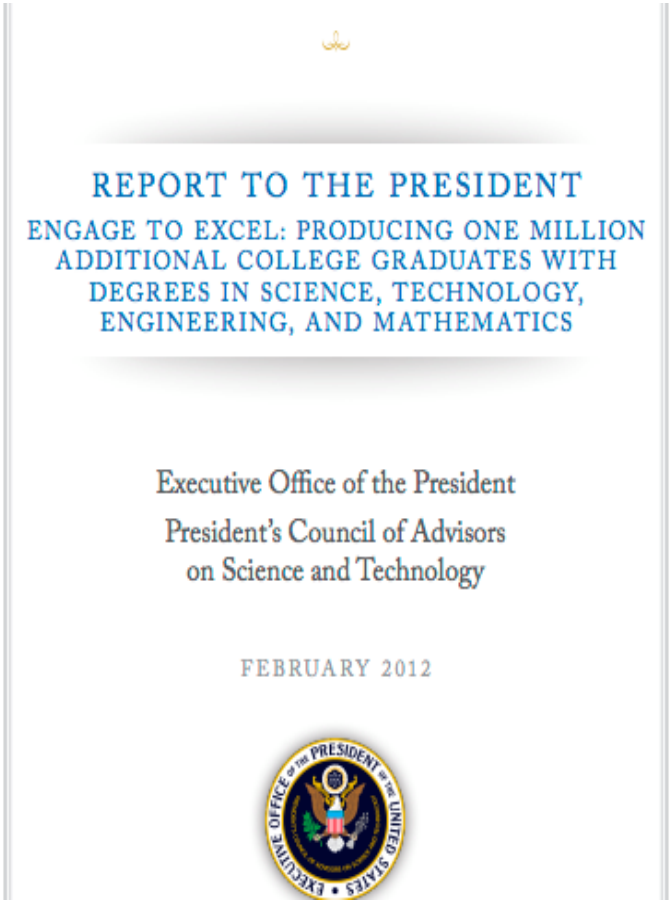
Common Vision 2025 done in context of “calls to action”



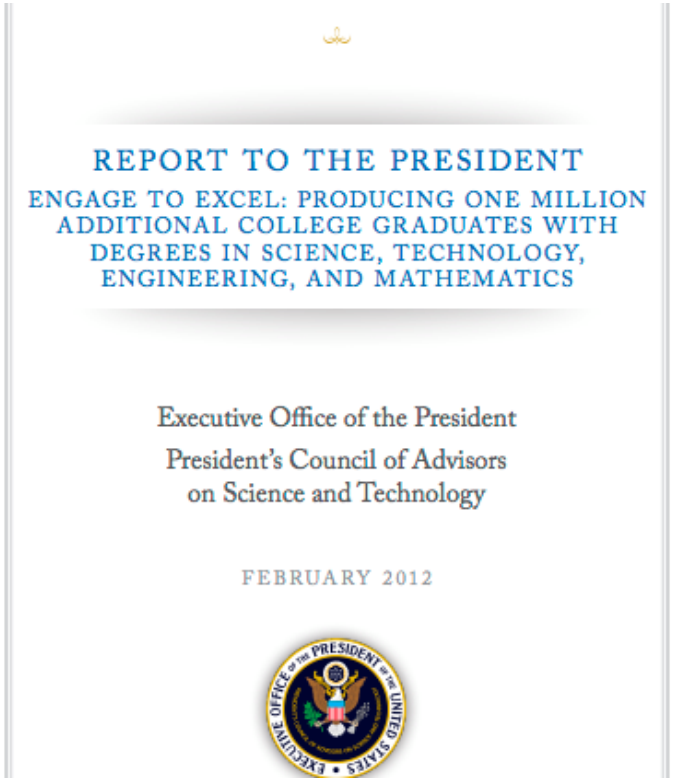


Common Vision 2025 done in context of “calls to action”

President’s Council of Advisors of Science and Technology (PCAST) “Engage to Excel”



Many other resources…



Common Vision “Deliverables”

- Executive summary of the associations’ guides
- Joint statement and implications for associations
  - collection of 5 statements
    - embracing common themes and goals,
    - encouraging broad community engagement and effort,
    - building on existing successful or promising efforts, and
    - call to avoid reinvention and acting without adequate understanding of prior work across the community.
  - An article written for each association’s news magazine and on each website putting the joint statement(s) in context of that target audience.

Common Vision “Deliverables”

- Public relations & ‘marketing’
  - Letters to policy makers
  - newspaper letters & editorials
  - Science magazine, Scientific American letters
  - Template one-pagers for association reps to bring to lawmakers (state and federal) or other stakeholders (deans, industry partners)
- Framework/guide for writing Phase II grants
- Annotated list of successful initiatives

Phase II, preliminary ideas

- Center for the Advancement of Mathematical Sciences Education to Expand STEM Capacity
  - Communicate with other STEM disciplinary societies and higher ed associations to improve alignment of curricula
  - Develop online guides for faculty exchanges and postdoc programs aimed at developing and supporting new faculty to teach modernized curriculum using effective pedagogical methods
  - Facilitate field visits for faculty to visit schools to aid in implementing new curriculum and/or pedagogical efforts
  - Work with NCTM, and other K-12 groups
  - Host mtgs of CoE chairs from associations

Grant Period Timeline

Until JMM 2015

JMM 2015

Between JMM 2105 and May Workshop

May Workshop

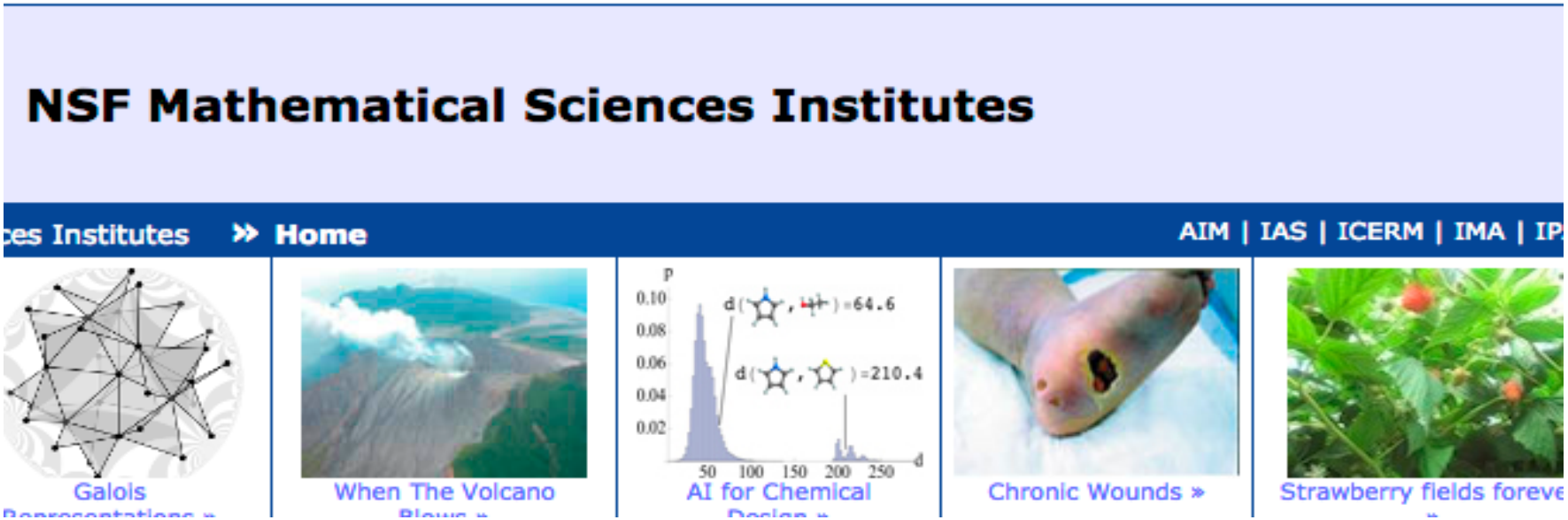
Between May Workshop and September 2015

Summary

- Mathematical sciences courses function as gateways to many majors and – for all – they prepare citizens who are able to interpret and work with data and computation
- Diverse stakeholders have made excellent, yet separate, recommendations for improving these courses

Common Vision 2025 is a collective action to highlight and identify common themes in these efforts.

We do not view conflict among our separate efforts, rather a strong feeling that collective actions are going to benefit all components and allow all flavors to be well represented



- We need research mathematicians to help inform undergraduate curriculum
  - As individual researches
  - Through departmental structure
  - Through the institutes
- How best can mathematical research & research mathematicians help inform undergraduate curriculum?
- What would you like to see out of a Center for UG Math.? How can you imagine AMS CoE engaging with Center or with process of developing center?