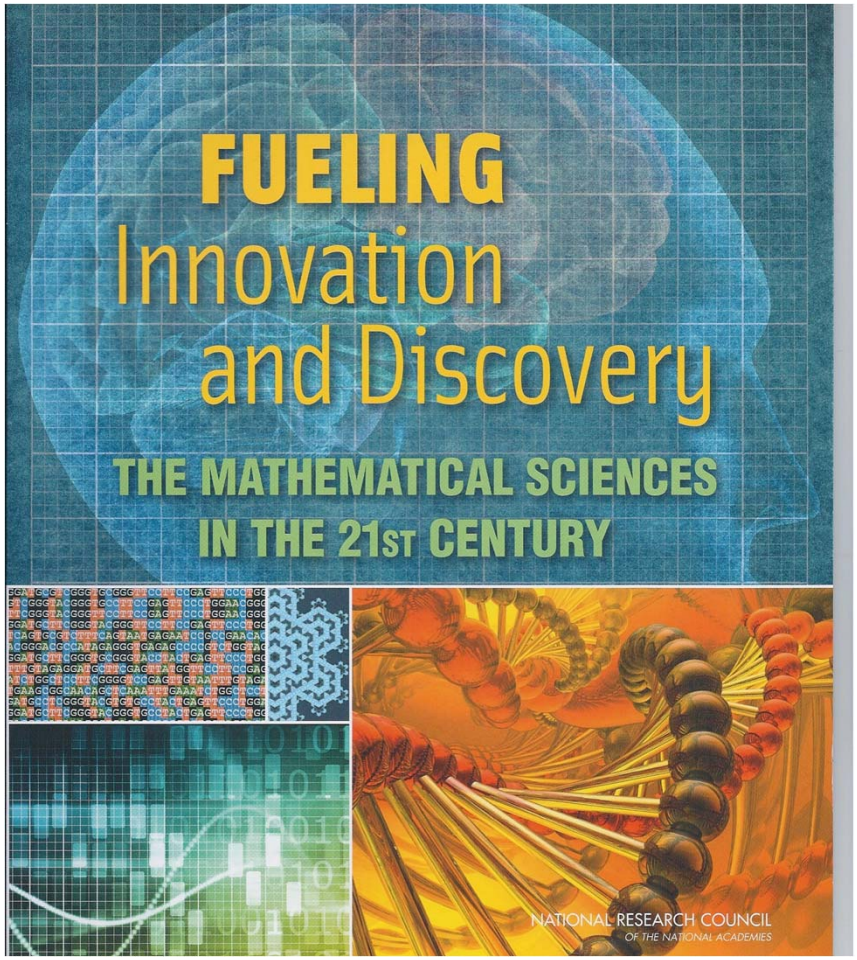
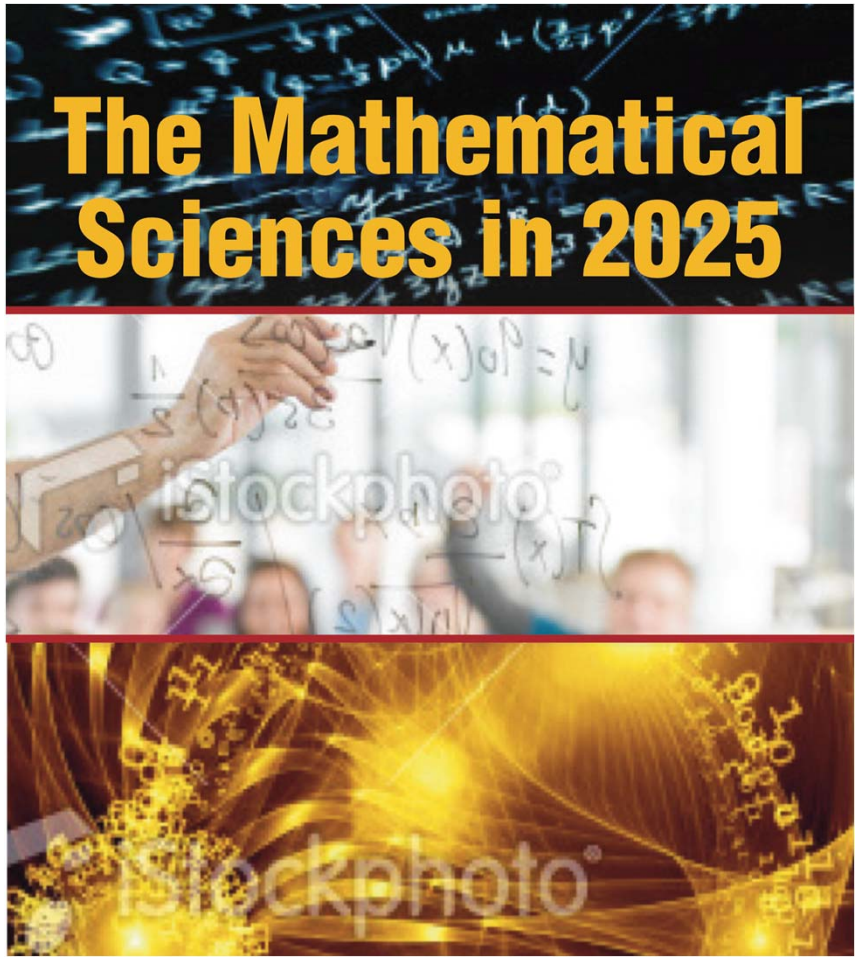
Two Publications





The Committee by Field

Core Math: LUIS A. CAFFARELLI, MARK L. GREEN (VC), DAVID EISENBUD, PETER W. JONES (applied also), JU-LEE KIM, JOHN W. MORGAN, YUVAL PERES (also industry)

Applied Math: EMMANUEL J. CANDES (Stat also), PHILLIP COLELLA, MARGARET H. WRIGHT

Statistics: JAMES O. BERGER, JUN LIU (Computational Biology also)

Computer Science: YANN LeCUN, EVA TARDOS

Electrical Engineering: THOMAS E. EVERHART (C)

Finance: TANYA S. BEDER

Theoretical Physics: JUAN MALDACENA

Education/Math/CS: JOE B. WYATT

A Word About Me

- Trained as a pure mathematician
- Directed a start-up institute focused on fostering interactions of mathematics with other fields. This proved to be a life-changing experience

The Story in Brief

- The role and impact of the mathematical sciences in other fields has expanded enormously
- This has educational implications at all levels
- The business model of universities is changing due to technology and cost pressures
- There is a once-in-a-generation opportunity for positive change

Expanding Role

- More types of mathematics and statistics are used and more types of people use them
- The curriculum has not kept pace
- Partnerships with other disciplines can help to meet these new needs
- Expanded role means math is needed by--and thus potentially a barrier for--a growing group of students

Goal: From Barrier to Gateway

- Motivation: Motivate math by how it is used
- Incorporate multiple modes of mathematical thinking
- New entry-points and new pathways
- Partner with other disciplines to create a compelling menu of lower-division courses
- Diversify teaching methods, engage with online education
- A community-wide effort to bring successful experiments to scale

Unifying Theme: Motivating Mathematics by How It Is Used

- Research shows this is key for K-12 students
- Addresses the 27% with high math skills and low STEM interest
- Impacts the dropoff in STEM majors over college years
- Faculty and grad students need to know how math is used
- K-12 teacher training needs to incorporate it

Modes of Thinking in the Mathematical Sciences

- Formal manipulation
- Logical reasoning, proof
- Modeling and simulation
- Algorithms
- Probabilistic and statistical thinking

Goals: Expose students at all levels to a variety of modes of thinking.

Foster the ability to deal with problems that are not precisely formulated.

New Majors, New Programs, New Pathways are Needed

- The educational offerings of typical departments in the mathematical sciences have not kept pace with the large and rapid changes in how the mathematical sciences are used in science, engineering, medicine, finance, social science, and society at large.
- This entails a need for new courses, new majors, new programs, new educational pathways and new educational partnerships with those in other disciplines, both inside and outside universities.

A Community-Wide Effort at Change is Needed

- Many mathematics and other STEM departments still tend to use calculus as the gateway to higher-level coursework, and that is not appropriate for many students.
- Different pathways are needed for students who may go on to work in bioinformatics, ecology, medicine, social science, computing…
- It is not enough to rearrange existing courses to create alternative curricula; a redesigned offering of courses and majors is needed.
- Although there is an abundance of promising experiments, a community-wide effort is needed in the mathematical sciences to make its undergraduate courses more compelling to students and better aligned with the needs of user departments.

Lower-Division Partnerships With Other Disciplines

- The needs of 21st century students call for a truly compelling menu of creatively taught lower-division courses in the mathematical sciences.
- The mathematical sciences have a critical role in educating a broad range of students, including from other STEM disciplines.
- Partnerships with mathematics-intensive disciplines in designing such courses are eminently worth pursuing.

Diversification of Teaching Methods

- A large and growing body of research indicates that STEM education can be substantially improved through a diversification of teaching methods.
- Change is unquestionably coming to lower-division undergraduate mathematics, and the mathematical sciences community should be at the center of these changes and not at the periphery.
- Online education is rewriting the rules, potentially transformative but requiring a new business model.
- Technology offers an opportunity to redesign developmental math courses to have a more individualized focus.

K-12 Education is Central to the Pipeline

- How much the pipeline of students preparing for mathematical science-based careers can be enlarged is fundamentally limited by the quality of K-12 mathematics and statistics education.
- The nation's well-being is dependent on a strong flow of talented students into careers in STEM fields, but college students cannot even contemplate those careers unless they have strong K-12 preparation in the mathematical sciences.
- The K-12 pipeline is an Achilles heel for U.S. innovation.

Distinguishing Between Issues

- Problem of inadequate preparation vs problem of teaching and motivating postsecondary students who have embarked on STEM programs
- Issue of preparing K-12 math teachers in universities, getting them ready for the Common Core

Bringing Reform to Scale

- The stick: Change is coming no matter what, business model is unsustainable
- The carrot: Putting mathematics education on a sustainable and exciting course that will serve the country well for the next 15 years
- Steps: Mobilize the stakeholders, provide tools for a community wide effort, involve those with experience in bringing successful reform efforts to scale

Why It's Hard

- Involves culture change
- Faculty need to venture out of their comfort zone
- Occurs at a time of intense cost pressures and of major changes in how universities and colleges operate
- Represents a large scale, rapid change

Nevertheless, a once-in-a-generation opportunity for positive change

Follow-up Activities (The Ones I Am Involved In)

- Convening at Carnegie Corp of NY in Feb 2013
- Presidents' Committee of the National Academies has provided funding to send the full report to every math and stat dept in the country and for 4 regional follow-up meetings
- Small group including Phillip Griffiths, Eric Friedlander, Uri Treisman and myself has approached two foundations for funding to run meetings launching a postsecondary mathematics education reform effort

A Role for PCAST in 2025 Follow-up

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Thank you very much!

Some Relevant Recommendations and Findings from MathSci 2025

A Deep Rethinking is Needed

Recommendation: Mathematics and statistics departments, in concert with their university administrations, should engage in a deep rethinking of the different types of students they are attracting and wish to attract, and must identify the top priorities for educating these students. This should be done for bachelor's, master's, and Ph.D.-level curricula. In some cases, this rethinking should be carried out in consultation with faculty from other relevant disciplines.

University administrations can play a role as honest brokers in moving this forward.

Motivating Mathematical Sciences Ideas by How They are Used

Recommendation: In order to motivate students and show the full value of the material, it is essential that educators explain to their K-12 and undergraduate students how the mathematical science topics they are teaching are used and the careers that make use of them. Modest steps in this direction could lead to greater success in attracting and retaining students in mathematical sciences courses. Graduate students should be taught about the uses of the mathematical sciences so that they can pass this information along to students when they become faculty members. Mathematical science professional societies and funding agencies should play a role in developing programs to give faculty members the tools to teach in this way.

Underrepresentation

Recommendation: Every academic department in the mathematical sciences should explicitly incorporate recruitment and retention of women and underrepresented groups into the responsibilities of the faculty members in charge of the undergraduate program, graduate program, and faculty hiring and promotion. Resources need to be provided to enable departments to monitor and adapt successful recruiting and mentoring programs that have been pioneered at many schools and to find and correct any disincentives that may exist in the department.

Getting Ahead of the Curve

Recommendation: Academic departments in mathematics and statistics should begin the process of rethinking and adapting their programs in order to keep pace with the evolving academic environment and to be sure they have a seat at the table as online content and other innovations in the delivery of mathematical science coursework are created. The professional societies have important roles to play in mobilizing the community in these matters, through mechanisms such as opinion articles, online discussion groups, policy monitoring, and conferences.