Issues of the Transition to University Mathematics

David Bressoud
Macalester College
St. Paul, MN

PowerPoint available at
www.macalester.edu/~bressoud/talks

University of British Columbia
Vancouver, BC
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Remarks by President Obama at the National Academy of Sciences, April, 2009:

"… our work does not end with a high school diploma. For decades, we led the world in educational attainment, and as a consequence we led the world in economic growth … But in this new economy, we've come to trail other nations in graduation rates, in educational achievement, and in the production of scientists and engineers."

1. Evidence of a problem in the preparation of mathematicians, scientists, and engineers.

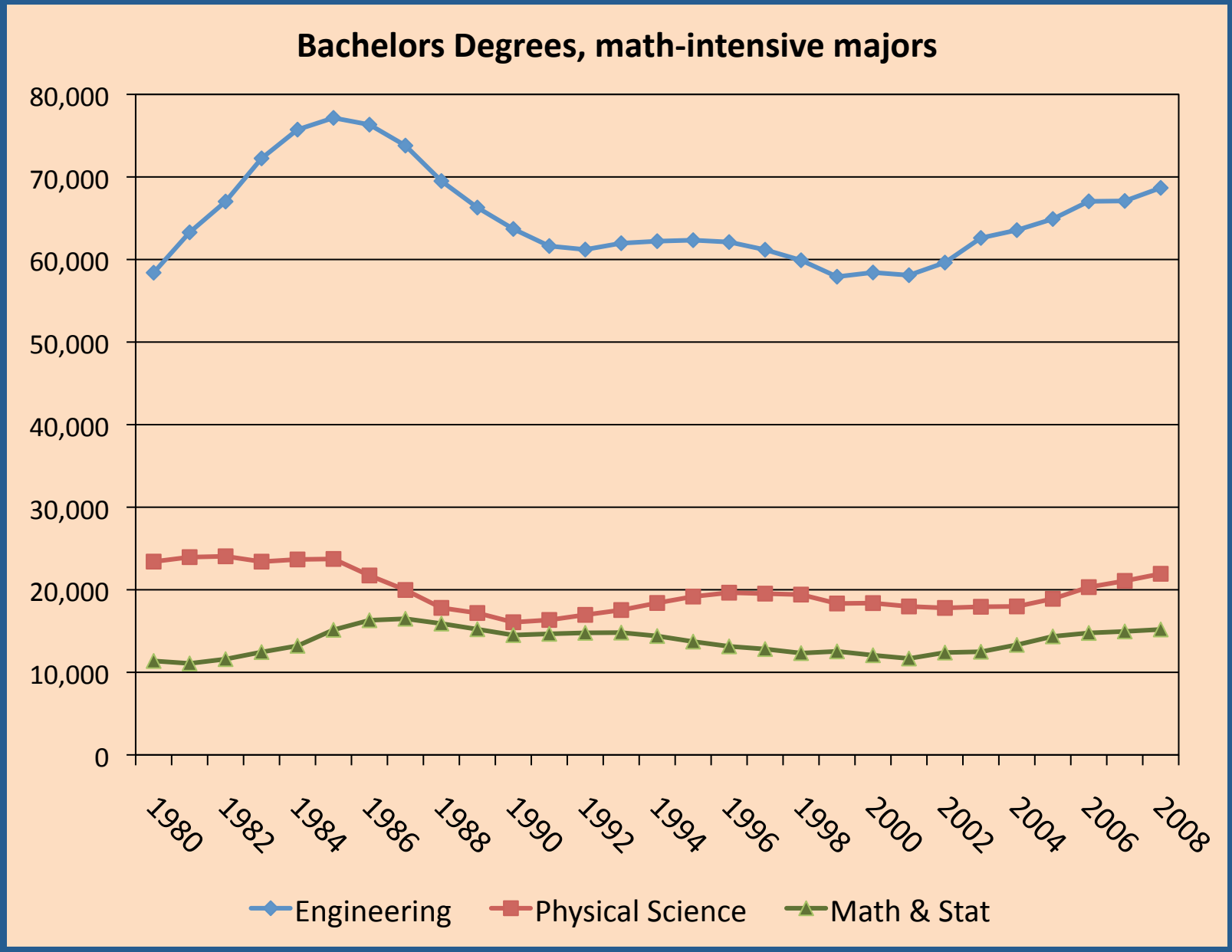
2. The effect of AP Calculus on this problem.

3. Components of the solution:

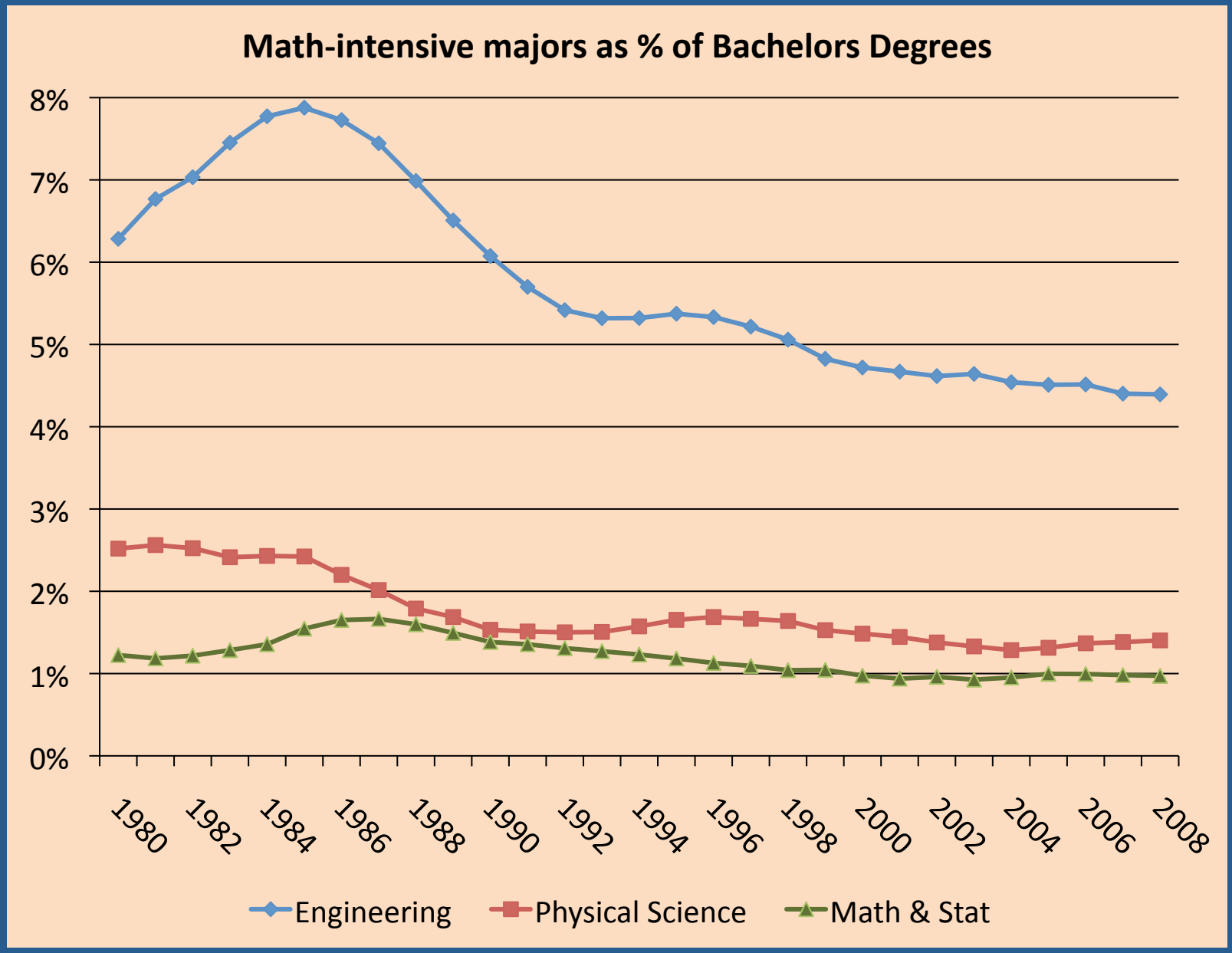
    a) Gather better information about the problem.

    b) Work on PreK-12 mathematics education.

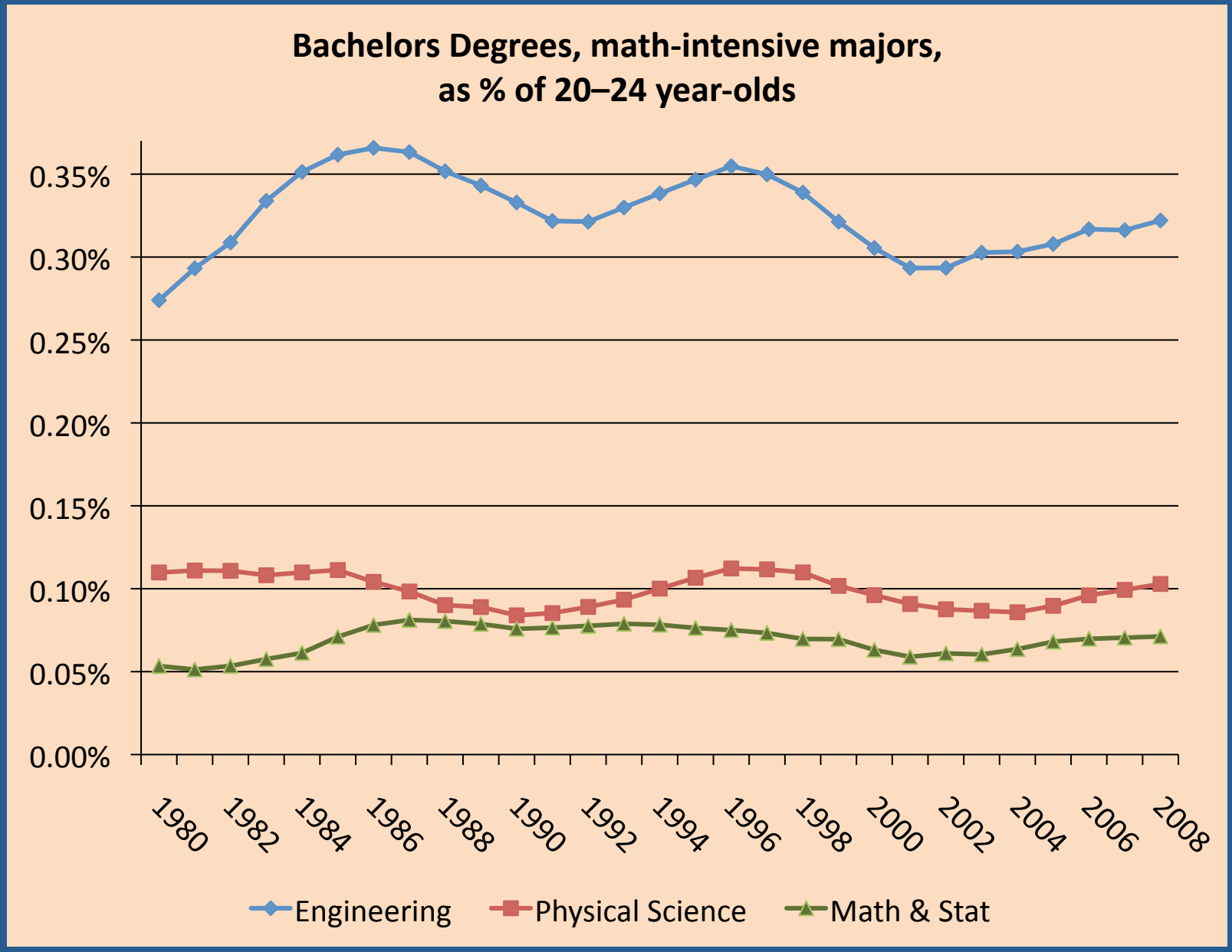
    c) Work on first-year college mathematics.


Bachelors Degrees, math-intensive majors
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Engineering
Physical Science
Math & Stat

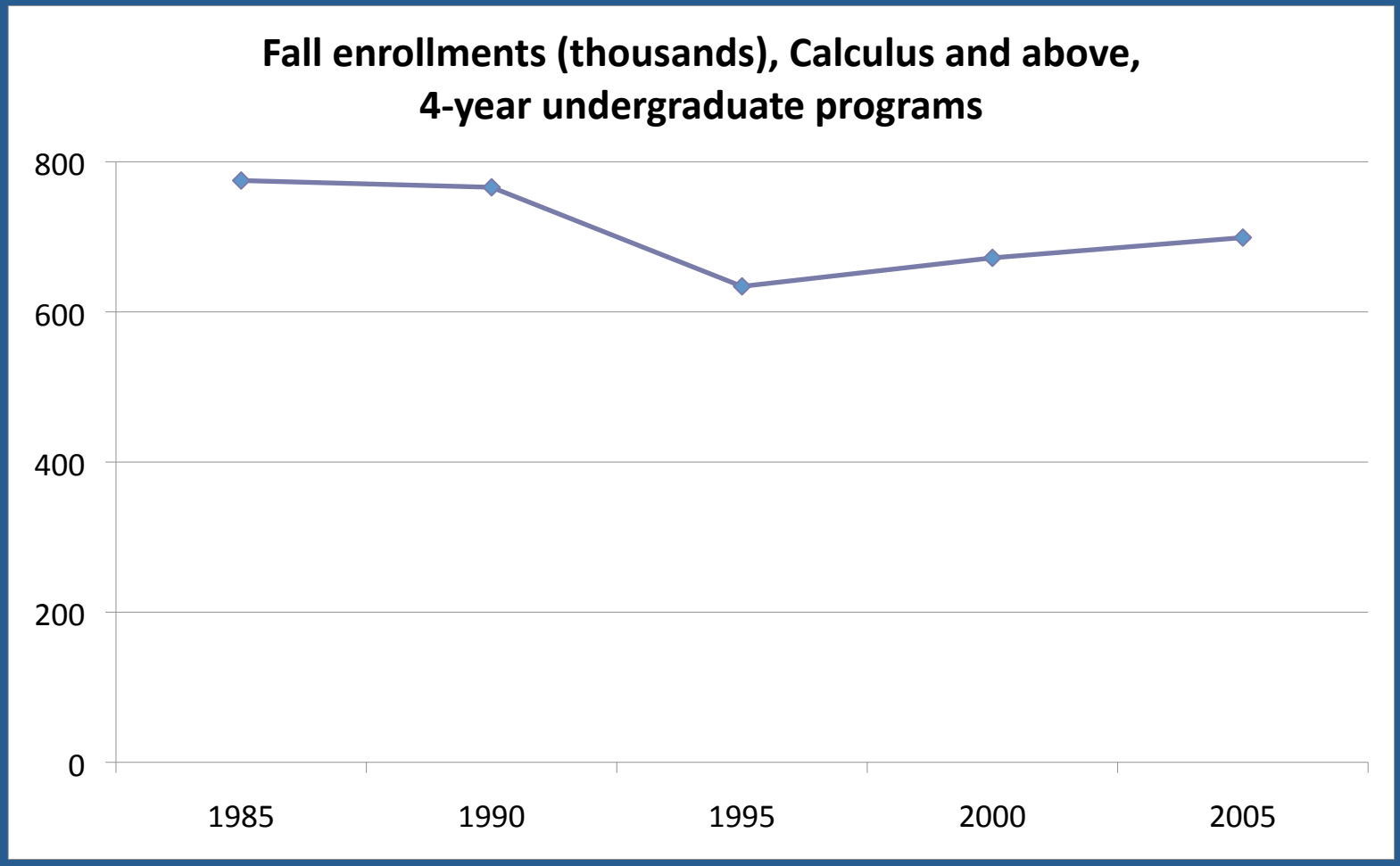
NCES data


Math-intensive majors as % of Bachelors Degrees
8%
7%
6%
5%
4%
3%
2%
1%
0%
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Engineering
Physical Science
Math & Stat

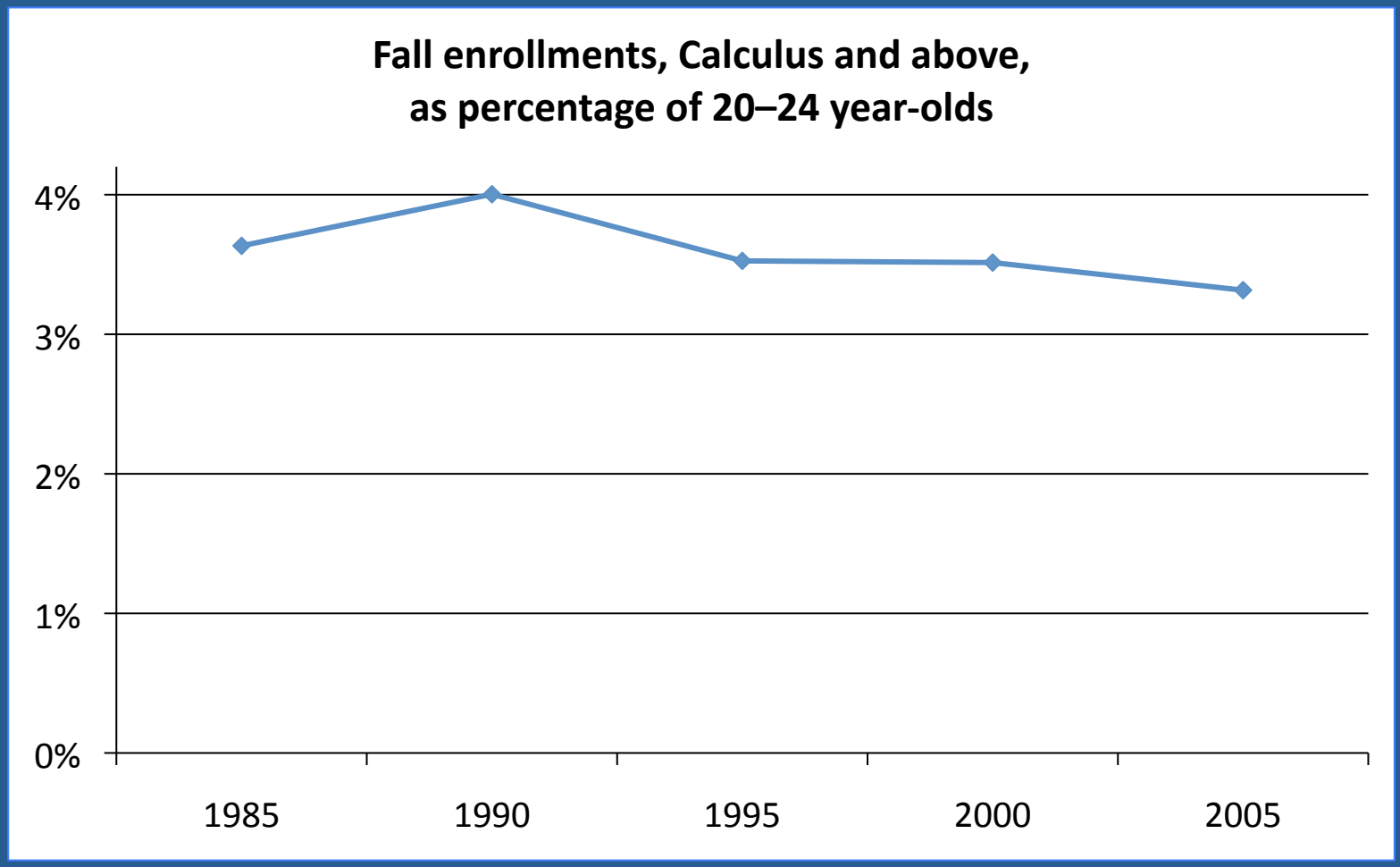
NCES data



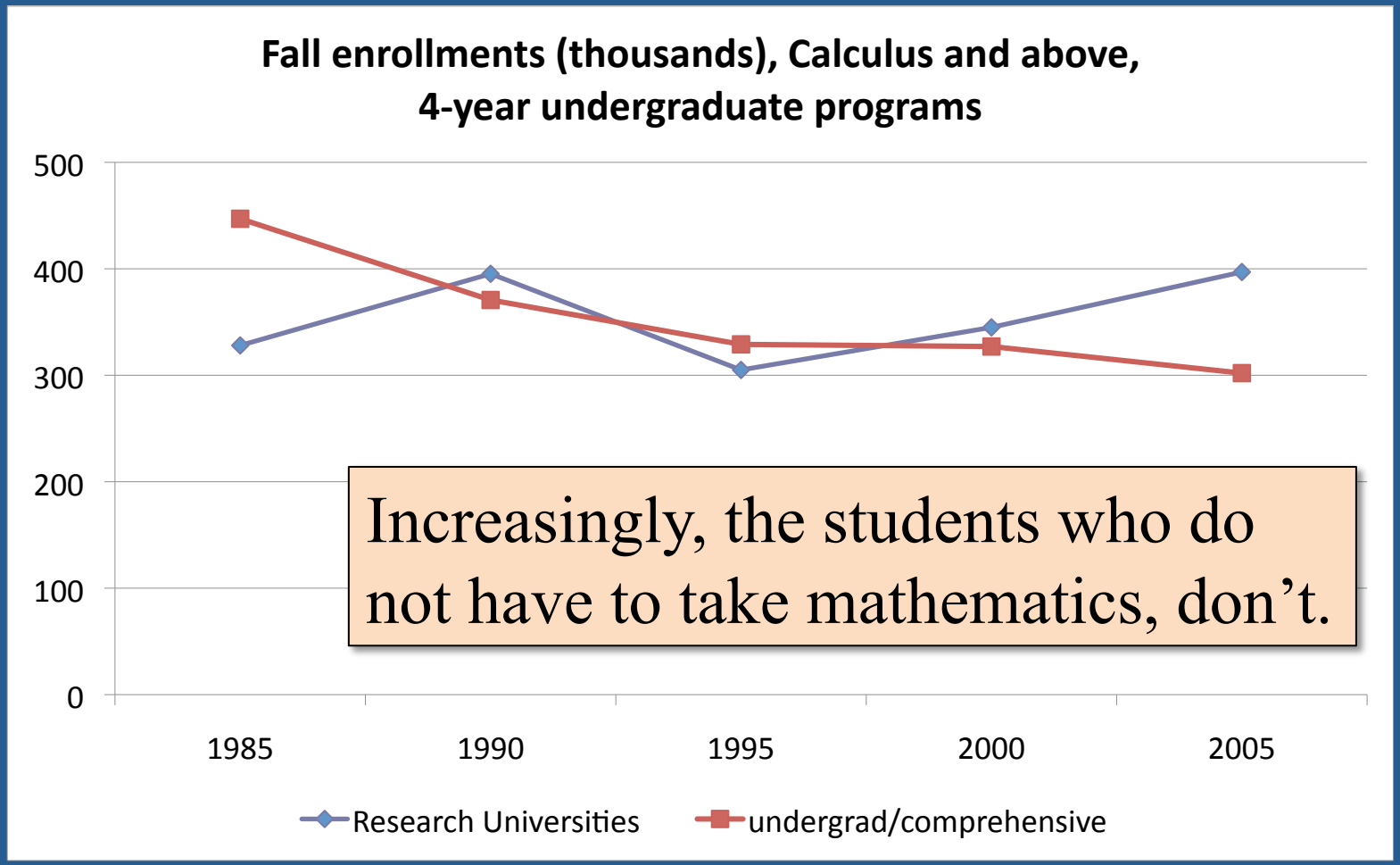
NCES & US Census data


Fall enrollments (thousands), Calculus and above,
4-year undergraduate programs
800
600
400
200
0
1985
1990
1995
2000
2005

CBMS data

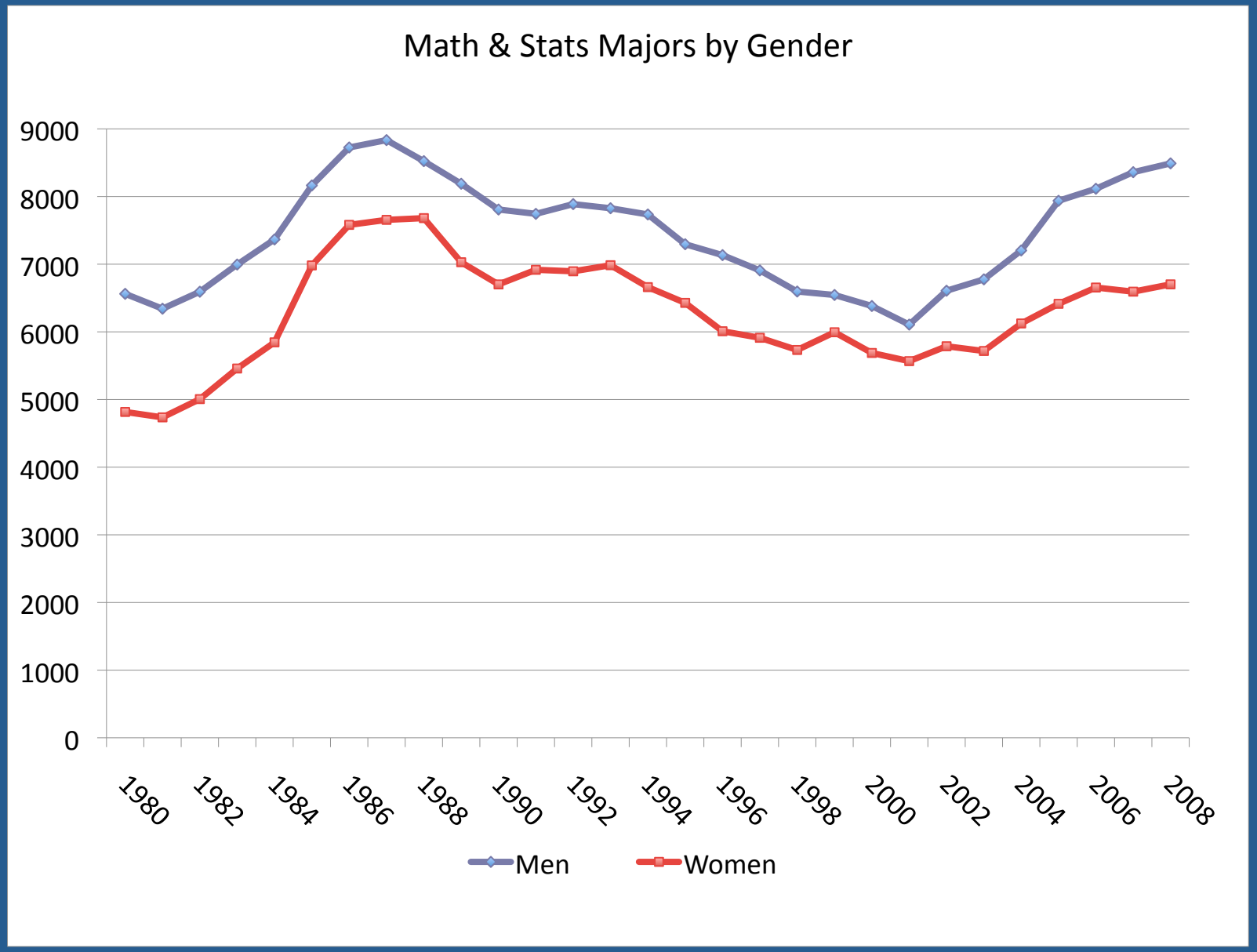


CBMS & US Census data

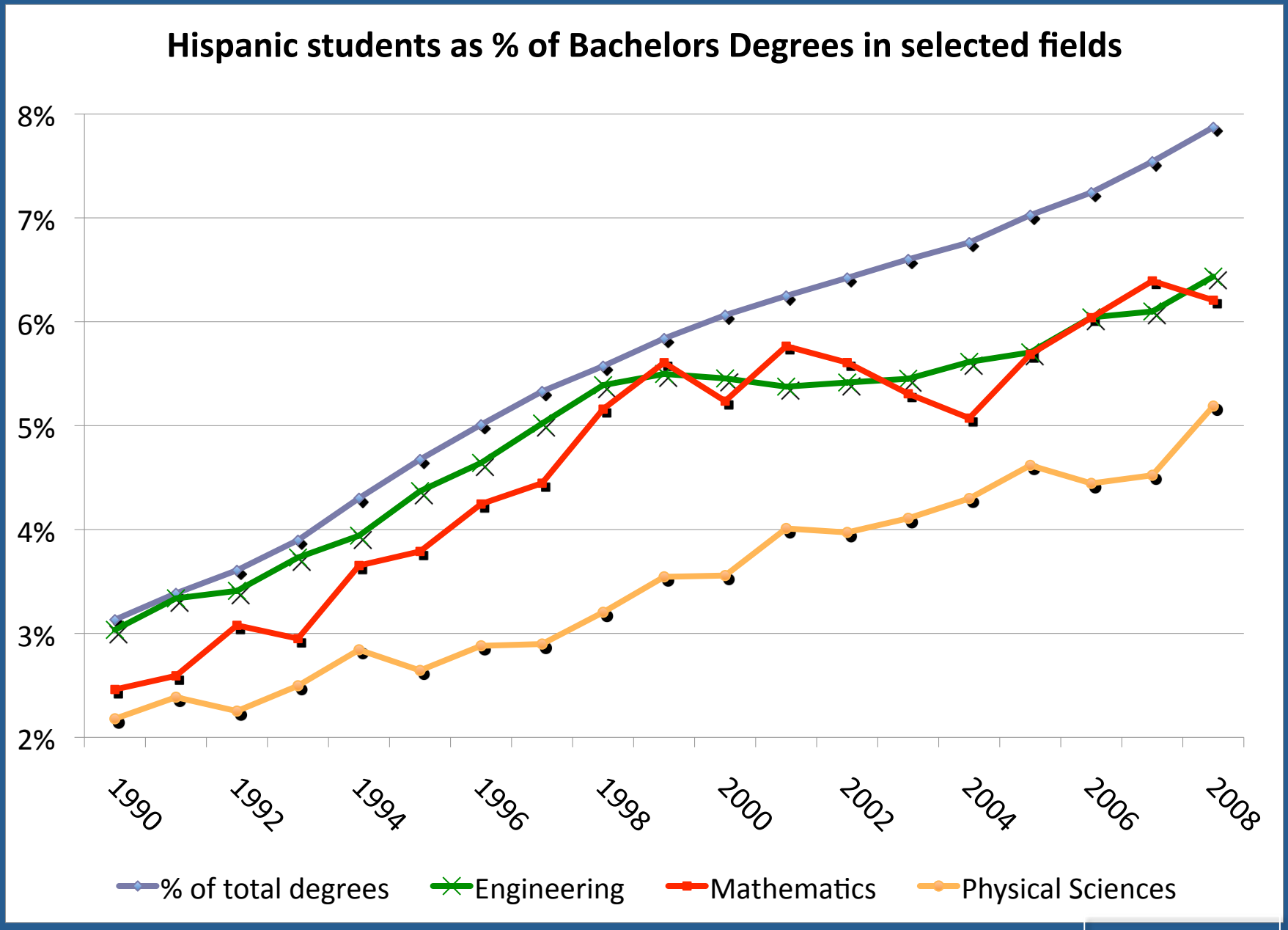


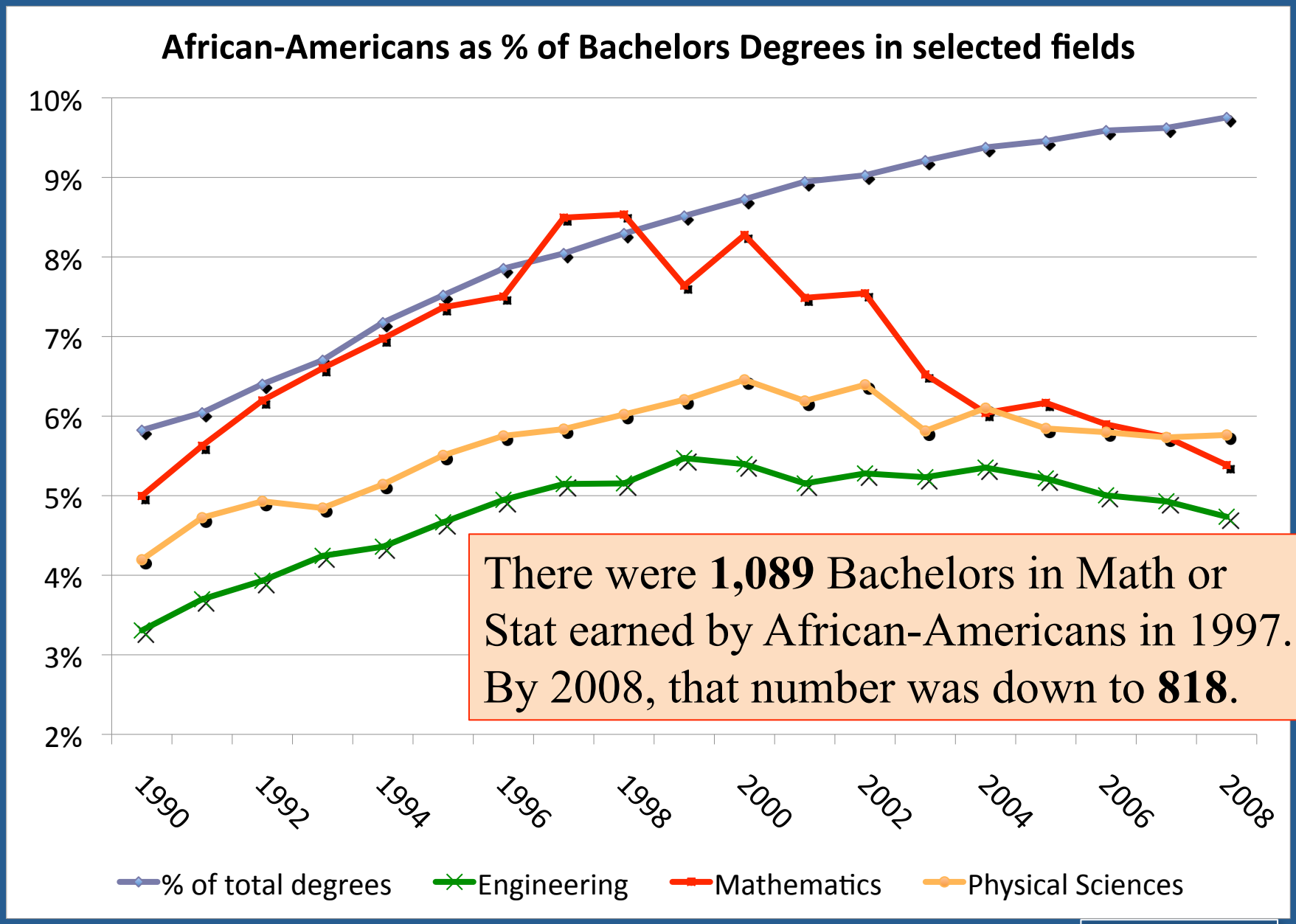
Increasingly, the students who do not have to take mathematics, don't.

CBMS data


Math & Stats Majors by Gender
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Men
Women

NCES data

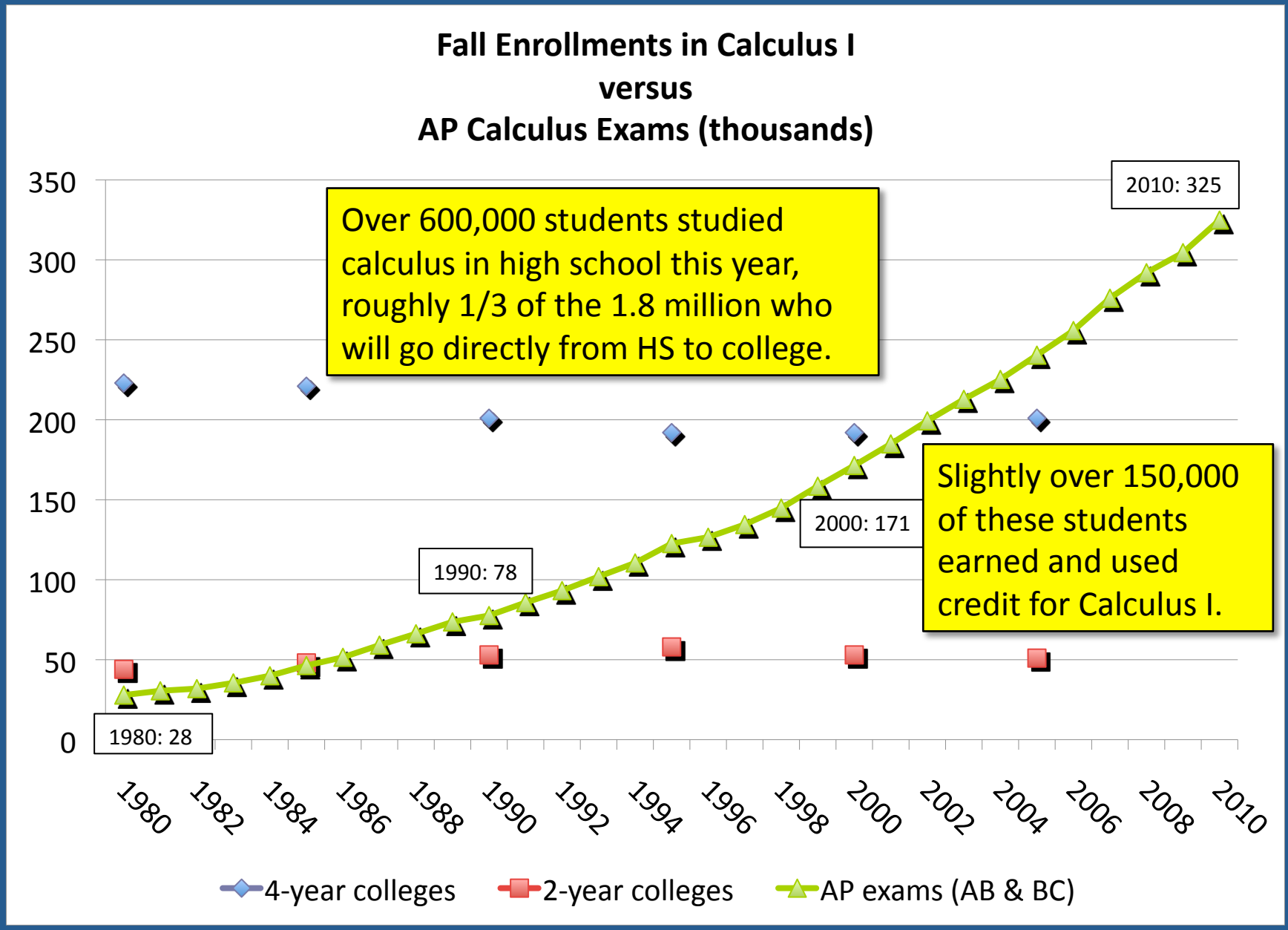

Hispanic students as % of Bachelors Degrees in selected fields
8%
7%
6%
5%
4%
3%
2%
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
% of total degrees
Engineering
Mathematics
Physical Sciences
NCES data


African-Americans as % of Bachelors Degrees in selected fields
10%
9%
8%
7%
6%
5%
4%
3%
2%
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
% of total degrees
Engineering
Mathematics
Physical Sciences
There were 1,089 Bachelors in Math or Stat earned by African-Americans in 1997. By 2008, that number was down to 818.
NCES data

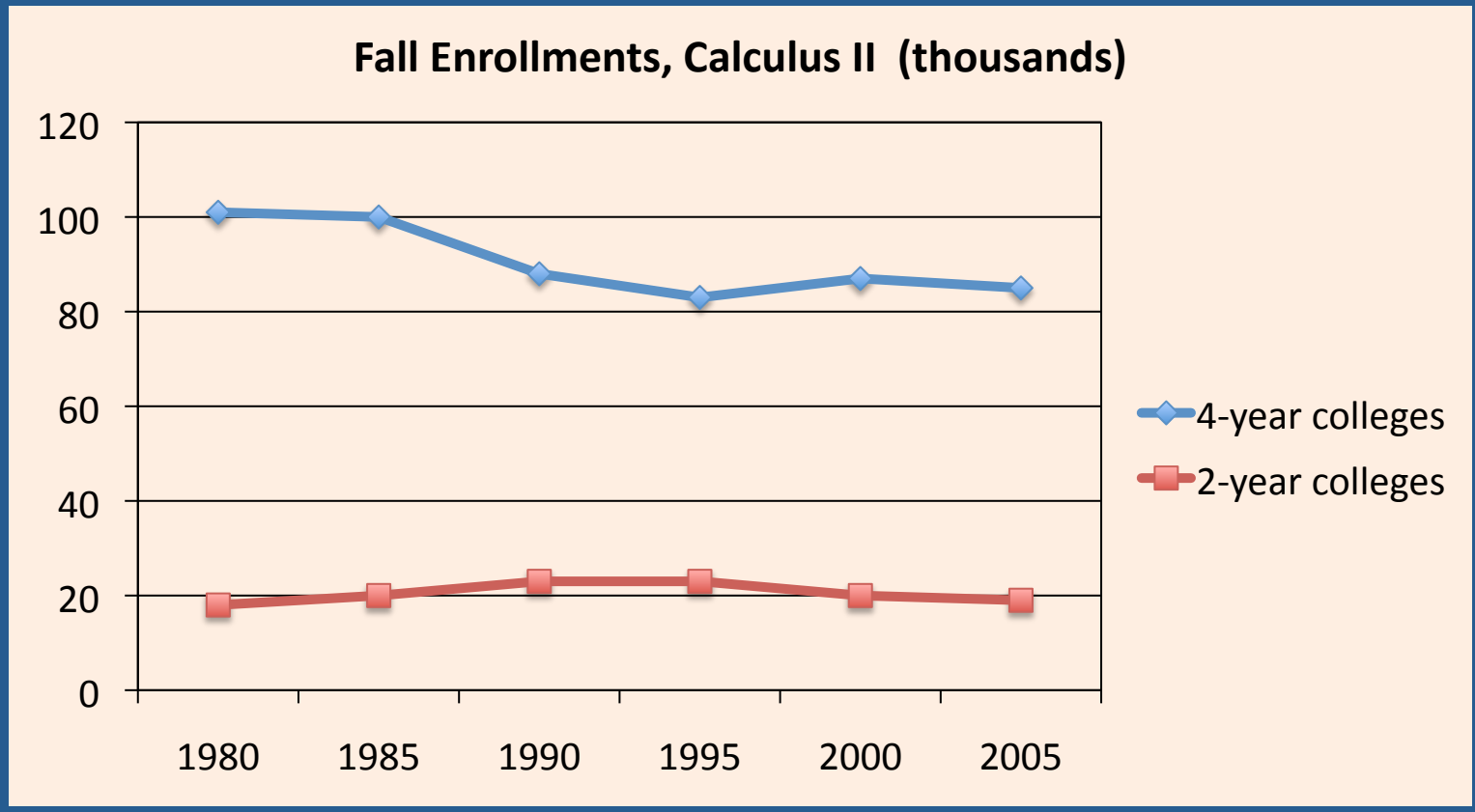
In the Fall of 2009:

186,000 students entered four-year undergraduate programs with the intention of majoring in engineering, a physical science, mathematics, or statistics.

Approximately 600,000 of the entering students passed a class in calculus while in high school.

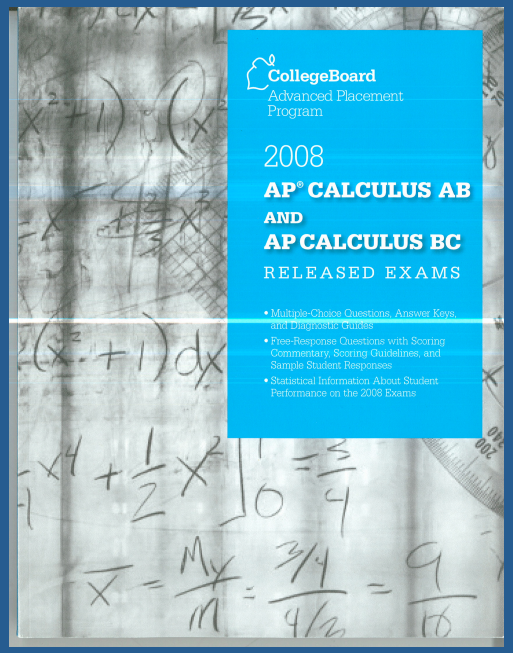


CBMS and College Board data


Fall Enrollments, Calculus II (thousands)
120
100
80
60
40
20
0
1980
1985
1990
1995
2000
2005
4-year colleges
2-year colleges

CBMS data

Those who do not have access to calculus in high school are at a serious disadvantage.



All evidence suggests that calculus in high school works well for most of the roughly 25% who earn and use their college credit.

What about the other 75%?

ies NATIONAL CENTER FOR EDUCATION STATISTICS | U.S. Department of Education Institute of Education Sciences

Of the high school students who graduated in 1992 and studied "calculus" while in high school, 31% took *precalculus* in college, and a further 32% took *no calculus* in college.

Of the high school students who graduated in 2004 and studied "calculus" while in high school, 17% took *remedial mathematics* in college.

NCES, NELS:88 and ELS:2002/06 data.

ies NATIONAL CENTER FOR EDUCATION STATISTICS | U.S. Department of Education Institute of Education Sciences

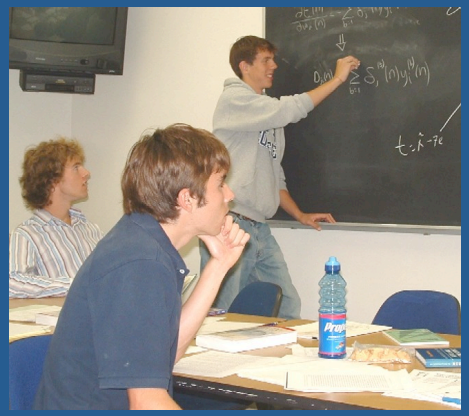
Of the high school students who graduated in 1992 and studied "calculus" while in high s a f

We must have clear, enforced guidelines for what it means to be ready for calculus in high school.

Of the high school students who graduated in 2004 and studied "calculus" while in high school, 17% took *remedial mathematics* in college.

NCES, NELS:88 and ELS:2002/06 data.

SOLUTIONS: Gather better information



What happens to those who take calculus in High School?

What are the strengths and weaknesses of incoming students?

How well are existing placement programs and courses serving our students?

ASU School of Mathematical & Statistical Sciences

Arizona State University study of student data, 2001–06

Pat Thompson, lead author

Of students who took pre-calculus and

- Their declared major required at least one semester of calculus, and
- They earned an A in pre-calculus,

43% chose *not* to enroll in calculus.

ASU School of Mathematical & Statistical Sciences

Arizona State University study of student data, 2001–06

Pat Thompson, lead author

During the period fall 2001 through fall 2006,

- 43% of engineering majors,
- 54% of mathematics majors,
- 51% of physical science majors, and
- 50% of technology majors

who enrolled in Calculus I at ASU and whose intended majors required Calculus II never earned credit for Calculus II.

ASU School of Mathematical & Statistical Sciences

Arizona State University study of student data, 2001–06

Pat Thompson, lead author

During the period fall 2001 through fall 2006,

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The point is that ASU gathered this information, and they are now doing something about it.

Harvard University Department of Astronomy

Phil Sadler

National Science Foundation
WHERE DISCOVERIES BEGIN

Factors Influencing College Success in Mathematics

Controlling for socio-economic factors, what aspects of high school mathematics prepare students for success in Calculus I?

MAA

Bressoud, Carlson, Pearson, Rasmussen:

Characteristics of Successful Programs in College Calculus

College factors that influence success in Calculus I and case study analysis of successful programs.

National Science Foundation
WHERE DISCOVERIES BEGIN

SOLUTIONS: Improve PreK-12 Math

COMMON CORE
STATE STANDARDS INITIATIVE
PREPARING AMERICA'S STUDENTS FOR COLLEGE & CAREER

Bill McCallum

Dr. Kenneth L. Gross

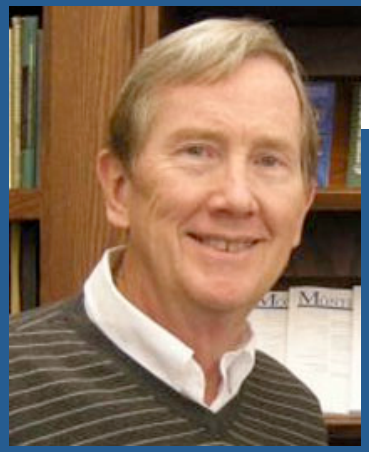
Vermont Mathematics Initiative
Building Capacity across Vermont for High-Quality Mathematics Instruction

PREP
PRofessional Enhancement Programs of the MAA

Intel Math: Mathematics Professional Development for K-8 Teachers

intel

SOLUTIONS: Improve PreK-12 Math

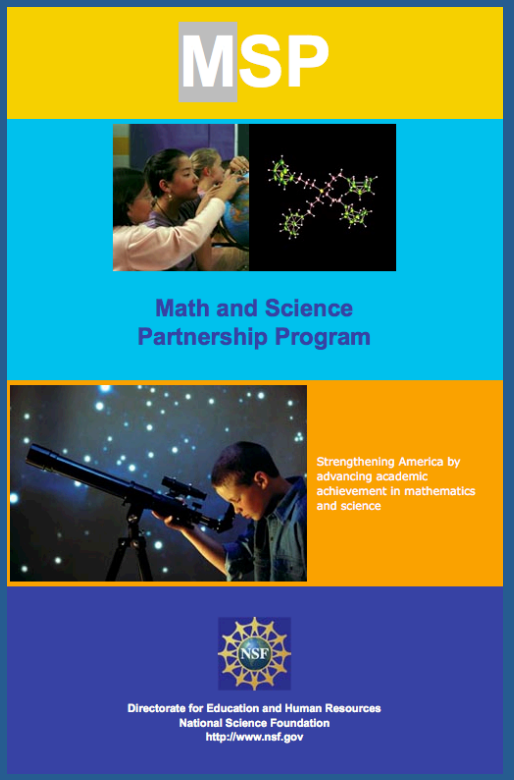


Jim Lewis

NebraskaMATH
A Partnership to Improve Mathematics Achievement

NJ Partnership for Excellence in Middle School Mathematics

Amy Cohen



SOLUTIONS: Improve PreK-12 Math

SIGMAA on Circles

The participants of the first Math Teachers' Circle at AIM, Summer 2006.

SOLUTIONS: Improve first-year college mathematics

Place students in appropriate courses.

Maple T.A.™ MAA®
Placement Test Suite 6
Partnering with the MAA to revolutionize placement testing

Bernie Madison

College Placement Testing in Mathematics

Educational accomplishments in mathematics often exert a strong influence on career accomplishments. College-level mathematics study must build on and extend prior experiences. Students entering higher education have diverse preparations for college mathematics due to many factors including academic background, time since high school graduation, age, and work experience. As a result, mathematics departments in colleges and universities have difficulty in placing students in their first college mathematics courses by using only data such as high school rank-in-class, grade point average, or record of high school mathematics courses.

Placement tests can be an effective component of a comprehensive placement process. However, it is important to recognize that the development of testing instruments is a nontrivial process. The Mathematical Association of America recommends that college placement tests in mathematics should:

MEASURE DEVELOPED MATHEMATICAL REASONING SKILLS. College admission tests such as the SAT or ACT measure students' general readiness for college, whereas placement tests seek to measure students' knowledge and skills that are prerequisite for specific entry-level college mathematics courses. Nationally administered tests such as SAT and ACT measure a broad range of quantitative skills, and this measure is often too general to distinguish between readiness for entry-level mathematics courses such as college algebra, trigonometry, pre-calculus and calculus. Therefore, very often, high school record and admission test scores need to be supplemented to make decisions about placing entering students into their initial mathematics courses.

EMPHASIZE REALISTIC AND CURRENT EXPECTATIONS. Placement tests should not reflect obsolescent expectations in mathematics preparation in the secondary schools. Placement tests must be carefully reviewed as more is learned about what contributes to success in post secondary education and in light of changes in content and effectiveness of pre-collegiate mathematics programs.

AVOID SINGULAR FOCUS ON COMPUTATIONAL SKILLS. Good placement tests assess computational skills in unexpected contexts and a balance of procedural fluency, conceptual understanding, and strategic reasoning.

INCORPORATE APPROPRIATE TECHNOLOGY. Calculators and computers are an integral part of most pre-collegiate mathematics instruction. Even though prerequisite skills for a college mathematics course can be assessed without computers or calculators, students may be more comfortable working on a placement test in the familiar environment that includes use of technology. Therefore, calculators and computers should be considered for use in placement testing programs.

USE APPROPRIATE TESTING METHODS. Great care should be used in the design and administration of placement test programs. Informed consultants and helpful literature should be utilized in the design of placement test programs.

Further information on design of effective college placement programs for mathematics can be obtained from the Mathematical Association of America, 1529 Eighteenth Street, NW, Washington, DC 20036.

— MAA Board of Governors
August 2010

SOLUTIONS: Improve first-year college mathematics

Alison Ahlgren

ALEKS®

Use online resources to address individual student weaknesses.

SOLUTIONS: Improve first-year college mathematics

UNITED STATES MILITARY ACADEMY
WEST POINT
DUTY • HONOR • COUNTRY

MA 103: Mathematical Modeling and Introduction to Calculus.

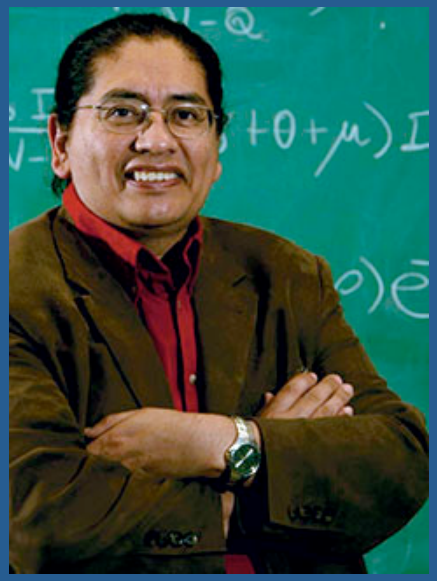
The course lays the foundation for calculus and differential equations through difference equations

This course has now been in place for twenty years.
A similar course at Macalester is over 5 years old.

SOLUTIONS: Improve first-year college mathematics

ASU School of Mathematical & Statistical Sciences

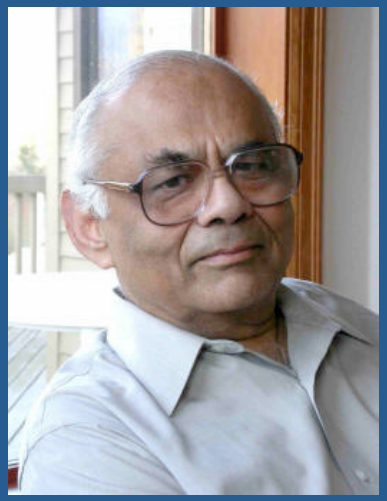
mathematical and theoretical biology institute



Carlos Castillo-Chavez

MTBI supports the development of students through educational, research and mentorship activities from the undergraduate to the postdoctoral level.

"The mathematics profession as a whole has seriously underestimated the difficulty of teaching mathematics."



Ramesh Gangolli
MER Workshop
May 31, 1991

With thanks to Susanna Epp
for preserving this quote.

PowerPoint available at
www.macalester.edu/~bressoud/talks