A Conversation on the Issues in Teaching College Level Mathematics.

AMS Workshop for Department Chairs and Department Leaders
Tuesday, January 8, 2013

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Conversation Leader/Facilitator

The Problem (Part 1)

REPORT TO THE PRESIDENT
PREPARE AND INSPIRE:
K-12 EDUCATION IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) FOR AMERICA'S FUTURE

Executive Office of the President
President's Council of Advisors on Science and Technology
SEPTEMBER 2010

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf

“Despite our historical record of achievement, the United States now lags behind other nations in STEM education at the elementary and secondary levels. International comparisons of our students’ performance in science and mathematics consistently place the United States in the middle of the pack or lower. On the National Assessment of Educational Progress, less than one-third of U.S. eighth graders show proficiency in mathematics and science.”

“It is important to note that the problem is not just a lack of proficiency among American students; there is also a lack of interest in STEM fields among many students. Recent evidence suggests that many of the most proficient students, including minority students and women, have been gravitating away from science and engineering toward other professions.”

CONCLUSIONS (from the President's Council):

- **TO IMPROVE STEM EDUCATION, WE MUST FOCUS ON BOTH PREPARATION AND INSPIRATION**

- **THE FEDERAL GOVERNMENT HAS HISTORICALLY LACKED A COHERENT STRATEGY AND SUFFICIENT LEADERSHIP CAPACITY FOR K-12 STEM EDUCATION**

RECOMMENDATIONS (2010)

(1) STANDARDS: SUPPORT THE CURRENT STATE-LED MOVEMENT FOR SHARED STANDARDS IN MATH AND SCIENCE

(2) TEACHERS: RECRUIT AND TRAIN 100,000 GREAT STEM TEACHERS OVER THE NEXT DECADE WHO ARE ABLE TO PREPARE AND INSPIRE STUDENTS

(3) TEACHERS: RECOGNIZE AND REWARD THE TOP 5 PERCENT OF THE NATION'S STEM TEACHERS, BY CREATING A STEM MASTER TEACHERS CORPS

(4) EDUCATIONAL TECHNOLOGY: USE TECHNOLOGY TO DRIVE INNOVATION, BY CREATING AN ADVANCED RESEARCH PROJECTS AGENCY FOR EDUCATION

(5) STUDENTS: CREATE OPPORTUNITIES FOR INSPIRATION THROUGH INDIVIDUAL AND GROUP EXPERIENCES OUTSIDE THE CLASSROOM

(6) SCHOOLS: CREATE 1,000 NEW STEM-FOCUSED SCHOOLS OVER THE NEXT DECADE

(7) ENSURE STRONG AND STRATEGIC NATIONAL LEADERSHIP

The Problem
(part 2)

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

http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf

“Better teaching methods are needed by university faculty to make courses more inspiring, provide more help to students facing mathematical challenges, and to create an atmosphere of a community of STEM learners. Traditional teaching methods have trained many STEM professionals, including most of the current STEM workforce. But a large and growing body of research indicates that STEM education can be substantially improved through a diversification of teaching methods.”

"… data show that evidence-based teaching methods are more effective in reaching all students—especially the 'underrepresented majority'—the women and members of minority groups who now constitute approximately 70% of college students while being underrepresented among students who receive undergraduate STEM degrees (approximately 45%). This underrepresented majority is a large potential source of STEM professionals."

Recommendations from the President’s Council (2012)

The President’s Council of Advisors on Science and Technology (PCAST) proposes five overarching recommendations to transform undergraduate STEM education during the transition from high school to college and during the first two years of undergraduate STEM education:

1. Catalyze widespread adoption of empirically validated teaching practices.
2. Advocate and provide support for replacing standard laboratory courses with discovery-based research courses.
3. Launch a national experiment in postsecondary mathematics education to address the math preparation gap.
4. Encourage partnerships among stakeholders to diversify pathways to STEM careers.
5. Create a Presidential Council on STEM Education with leadership from the academic and business communities to provide strategic leadership for transformative and sustainable change in STEM undergraduate education.

“Peer Instruction”
An Endeavor from our Colleagues in Physics

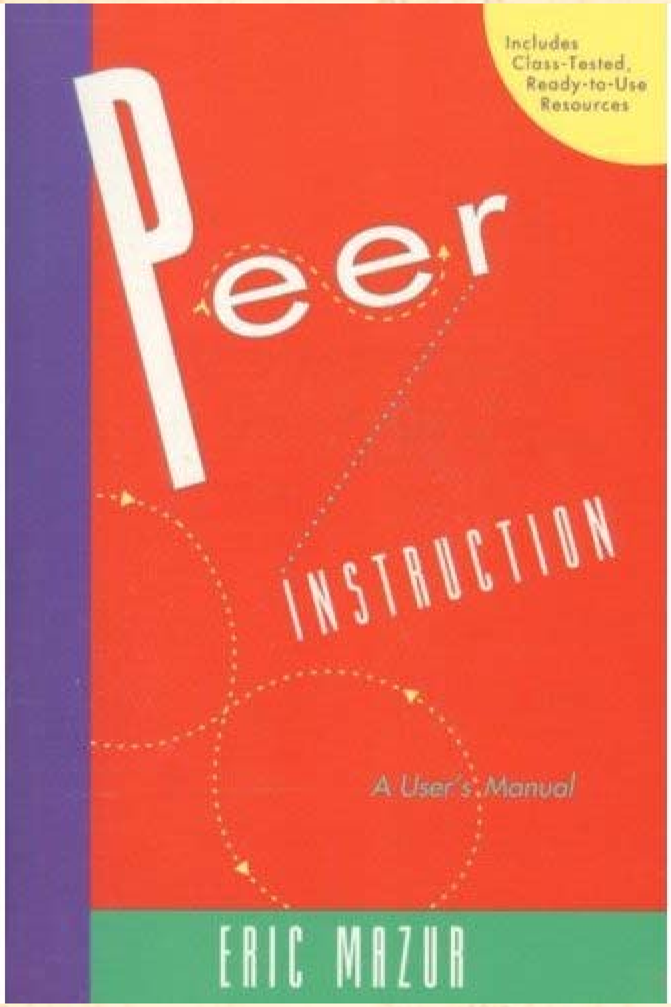
Created through the efforts of Eric Mazur at Harvard.

Peer Instruction

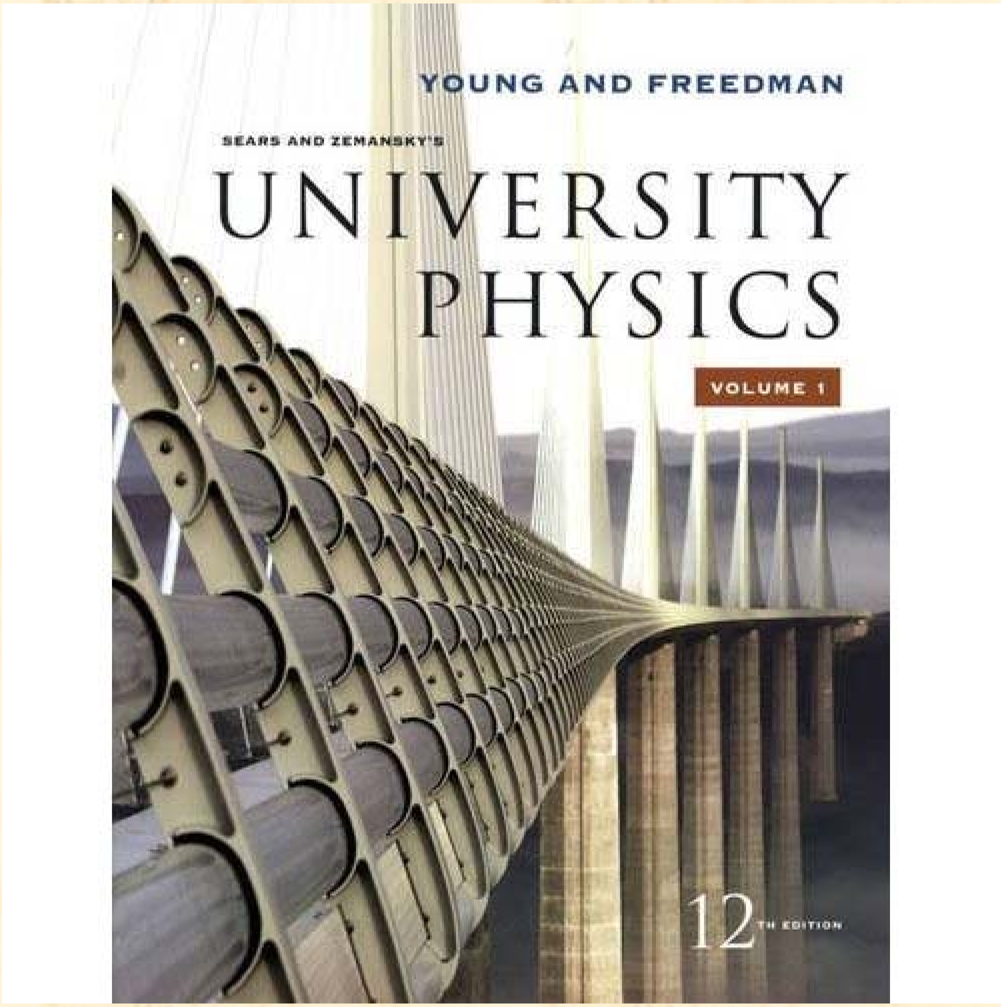
According to the Mazur Group (http://mazur.harvard.edu/): "Peer Instruction…involves students in their own learning during lecture and focuses their attention on underlying concepts. Lectures are interspersed with conceptual questions … designed to expose common difficulties in understanding the material."

Mazur's original program sought to improve learning in the introductory undergraduate physics classes at Harvard. It is now used worldwide in other disciplines in addition to physics.

The basic idea is the following questioning procedure: The instructors ask students questions in class based on assigned readings and reviews the various students' responses; students then discuss their answers and the thought process leading to their answers with their peers. Based on these peer discussions, the students respond again, potentially modifying their answers; based on the evaluation of the new responses the instructor determines whether further lecturing is needed on the given topic or whether to move on to the next topic/question and repeat the question-answer-peer evaluation process.



Includes Class-Tested, Ready-to-Use Resources
Peer
INSTRUCTION
A User's Manual
ERIC MAZUR


YOUNG AND FREEDMAN
SEARS AND ZEMANSKY'S
UNIVERSITY PHYSICS
VOLUME 1
12TH EDITION

Peer Instruction Links

There is a network: https://www.peerinstruction.net/

The Harvard site has links to a body of research that supports this type of pedagogy: http://mazur.harvard.edu/education/educationmenu.php

Supporting the Assessment of Undergraduate Mathematics

MAA website: http://www.maa.org/saum/

MAA NSF Grant to Support Assessment

The grant was a three-year project beginning 2002 titled "Supporting Assessment in Undergraduate Mathematics". The project's products included a workshop series, a volume of case studies and syntheses of case studies on assessment, and a website for information about assessment.

MAA: Supporting Assessment in Undergraduate Mathematics

Website:

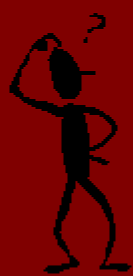
http://www.maa.org/saum/cases/welcome.html

Bernard L. Madison (University of Arkansas), Project Director; Senior personnel are Bonnie Gold (Monmouth College), William E. Haver (Virginia Commonwealth University), Sandra Z. Keith (St. Cloud State University), William A. Marion, Jr. (Valparaiso University), and Lynn A. Steen (St. Olaf College); Thomas W. Rishel (MAA Associate Executive Director) will manage the project at the MAA offices.

From SAUM website.

Why is assessment done?

- The University administration mandated it.
- The governing board mandated it.
- The legislature mandated it.
- The accrediting agency mandated it.
- To evaluate academic programs.
- To evaluate students.
- To evaluate faculty performance.



Interactive Session I.

Discuss the questions on Assessment.

10 minutes.

Have someone from your table be prepared to report to the group.

Report from the tables:

10 minutes.

MAA Calculus Study
Characteristics of Successful Programs in College Calculus

Five-year NSF supported study; announced July 2009:
http://www.maa.org/columns/launchings/launchings_07_09.html

"[To] investigate the instruction of mainstream Calculus I courses …"

PI : David Bressoud, (MacAlester); Co-PI's: Marilyn Carlson (ASU), Vilma Mesa (U. Mich), Michael Pearson (MAA), Chris Rasmussen (SDSU).

Calculus Study Goals

1. To improve our understanding of the demographics of students who enroll in calculus,
2. To measure the impact of the various characteristics of calculus classes that are believed to influence student success,
3. To conduct explanatory case studies of exemplary programs in order to identify why and how these programs succeed,
4. To develop a theoretical framework that articulates the factors under which students are likely to succeed in calculus, and
5. To use the results of these studies and the influence of the MAA to leverage improvements in calculus instruction across the United States.

Some results from the MAA Calculus Study

http://www.maa.org/cspcc/CSPCC4IJMEST-12-09-18.pdf

Following are some highlights from the presentation by David Bressaud given at the 2012 AMS Committee on Education meeting, Washington DC, Oct.

"Good Teaching"

My Calculus Instructor:

- listened carefully to my questions and comments
- allowed time for me to understand difficult ideas
- presented more than one method for solving problems
- asked questions to determine if I understood what was being discussed
- discussed applications of calculus
- encouraged students to seek help during office hours
- frequently prepared extra material

Assignments were challenging but doable

My exams were graded fairly

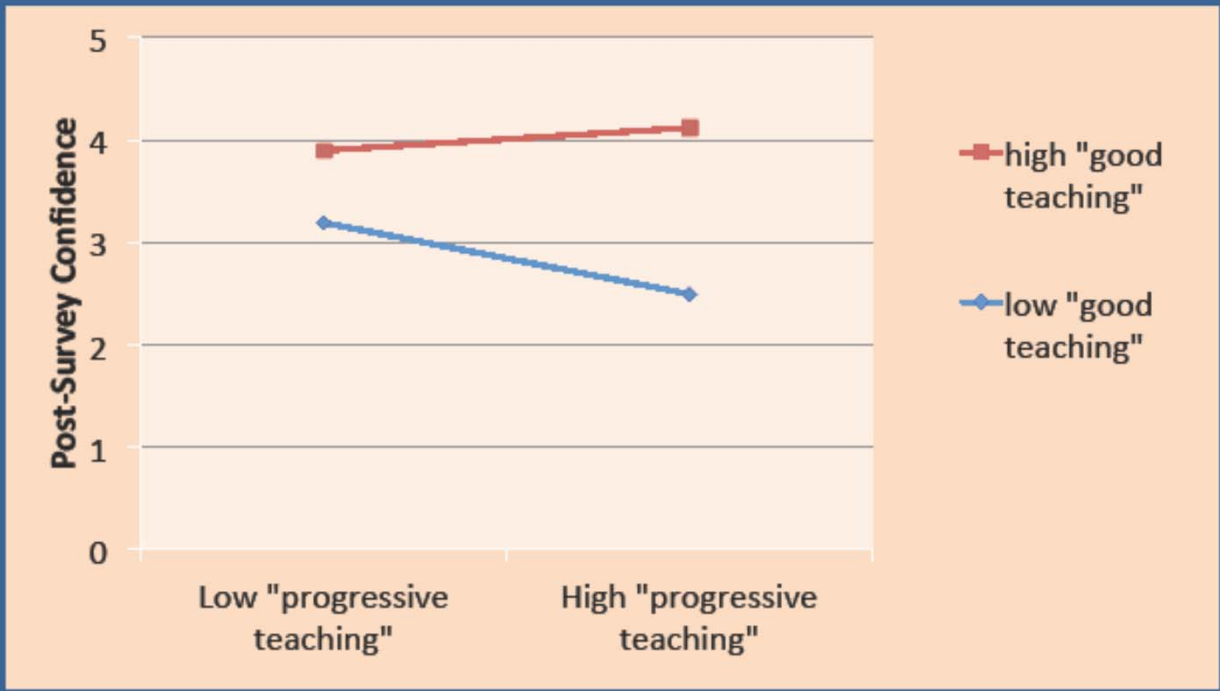
My calculus exams were a good assessment of what I learned

“Progressive Teaching”

My Calculus Instructor:

- Required me to explain my thinking on homework and exams
- Required students to work together
- Had students give presentations
- Held class discussions
- Put word problems in the homework and on the exams
- Put questions on the exams unlike those done in class
- Returned assignments with helpful feedback and comments

Interaction



Lessons:

1. Know your local data. What are your success rates? Persistence rates? Are there significant subpopulations that are not being served?
2. Know the effectiveness of your placement procedures and change them if they are not working.
3. Get your best teachers into the calculus classroom.
4. Get the students actively involved during class.

A pdf file of this PowerPoint is available at www.macalester.edu/~bressoud/talks

Calculus Study Phase II

Phase II begins Fall 2012 with in-depth case studies of eight institutions that have been identified as having successful programs in Calculus. “During fall term 2012, four teams, each consisting of a researcher in undergraduate mathematics education, a mathematician, and a graduate student will each visit two institutions identified as having particularly effective programs in Calculus I.”*

* Quote from: http://www.maa.org/cspcc/

Calculus Study Phase II
Institution Types

Following are the “team leaders” and the institution types to be studied:

1. Vilma Mesa (University of Michigan), two-year colleges
2. Sean Larsen (Portland State University), four-year colleges
3. Eric Hsu (San Francisco State University), master’s degree granting institutions
4. Chris Rasmussen, PhD granting institutions

Interactive Session II.
10 minutes discussions at tables,
10 minutes responses.

Discuss the questions on Calculus instruction; generalize to service courses (e.g. DE, stats.)

Inquiry Based Learning (IBL)

Inquiry-based learning, also called discovery learning, the Socratic method, problem based learning. Is an instructional approach that presents the student with questions or problems and asks the student to arrive at their own answers to questions and their own solutions to problems.

The implementation of IBL in Mathematics

The Educational Advancement Foundation
http://eduadvance.org/

"The Educational Advancement Foundation is a … philanthropic organization that supports … the development and implementation of inquiry-based learning at all educational levels in the United States, particularly in the fields of mathematics and science …"*

*from the website.

Models of Types of IBL

1. Straight Socratic Method as explicated in Plato's Meno – teacher one on one question and answer session with a student.

2. Mazur's Peer Instruction – teacher questioning and soliciting a group answer.

3. Teacher asking question at one class meeting and asking for student responses at the next meeting (similar to one on one but with a day between question and answer.) E.g. homework assignment day 1, presentation of homework day 2.

Models of IBL continued

4. Teacher presenting students with a list of axioms and the statement of theorems. Students are expected to use the axioms to prove the theorems and present them in class. More often used in upper level classes (Abstract Algebra, Analysis, …)

5. Teacher presenting the student with axioms and some background theorem and asking the student to come up with their own questions and conjectures and then present their answers to their questions and proofs or counter examples to their conjectures.

Some programs implementing various types of IBL

Harvard Mathematics IBL project:
http://www.math.harvard.edu/ibl/

University of Texas:
http://www.ma.utexas.edu/ibl/

University of California, Santa Barbara:
http://math.ucsb.edu/department/cmi/

Michigan
http://www.math.lsa.umich.edu/ibl/index.html

Interactive Session III.
10 minutes discussions at tables,
10 minutes responses.

Discuss the questions on IBL and pedagogical programs.

Recommendations

Talk to

- -Mathematics Education Faculty at your institution,
- -Colleagues who have demonstrated successful teaching,
- -Your professional network,
- -Consider NSF grant opportunities in Mathematics Education.

Provide me with relevant links on the subject and I will add it to my power point which I will make available online.
My email: smith01@auburn.edu.

Thank you for participating with me in this conversation.

Link to Careers in Mathematics.

At the following link follow the MAA Link and it will take you to information about the "101 Careers in Mathematics" as I promised at the workshop:

http://www.auburn.edu/~smith01/careers.htm