Speaker:

Richard Millman,
Georgia Institute of Technology and former Chair of the
Mathematics Colloquium Committee at SIUC

Title:

Mathematical Academic Outreach to K-12: ALGEBRA^3, SLIDER, and GIFT
Southern Illinois University, Carbondale

Date: April 1, 2010

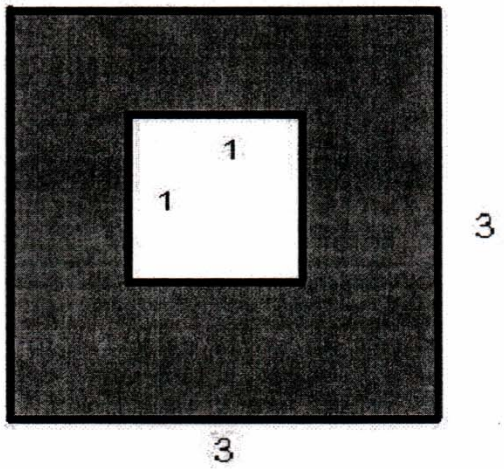
CEISMC

- Center for Education In Science, Math, Computing (and Engineering)
- KIDS Club, Student Summer Camp, GIFT, State MSPs, Large Projects, Calculus II and III in HS, Atlanta Public Schools
- Personnel: 26 people,
  - 5 Ph.D.s: Evaluation, P-chem, Math, Science Ed, and Biophysics

Topics of Today

- Content Issues in Math Education, Preservice Teachers (MA 308/309)
- Hyman Bass's approach to Math Ed
- Major Project 1: ALGEBRA CUBED
- Major Project 2: SLIDER
- GIFT Program: An content centered summer research project for HS teachers

What is the perimeter of the region between the two squares?

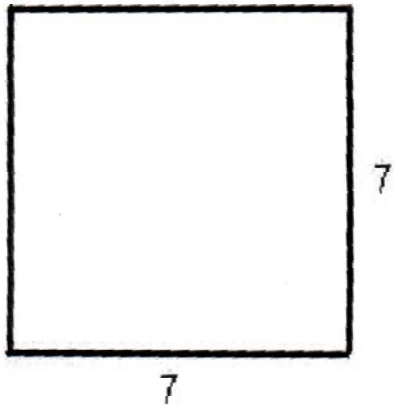


In the figure above:

A. What is the area of the shaded region?

B. What is the perimeter of the shaded region?

Teacher: "Frank, what figure is this?"

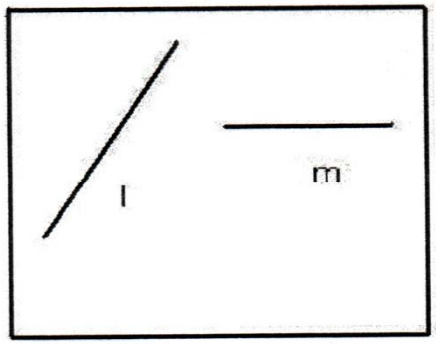


Frank (4th grader): "It's a rectangle Mr. Jones."

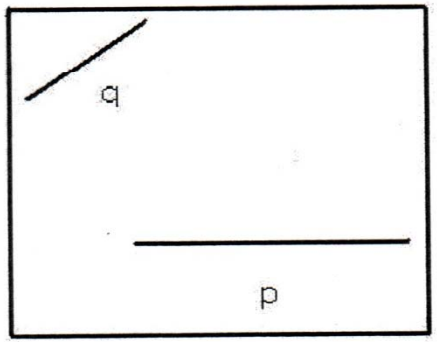
Conceptual knowledge as a necessity for responding to students.

Are these parallel?

C. Are lines l and m parallel?



D. Are lines p and q parallel?



Solid Shapes Museum *(Ongoing Activity)*

Focus Explore solid shapes.

Materials table or shelf to serve as a shapes museum; solid shapes from home and from around the classroom

Children add to a collection of common geometric solid shapes (cans, balls, ice cream cones, party hats, and so on) in order to make and display a Shapes Museum. As children add new entries to the museum, begin to talk about the properties of the various shapes, such as the shapes of the faces and bases and the number of corners (vertices).

pyramids | triangular prism | hexagonal prism | rectangular prism

☑ **Whole Group**

Note

Any standard packing box is a rectangular prism. Some chocolate candy packages are hexagonal prisms. Express mail companies supply triangular prisms as mailing tubes. Pyramids come to a point from any polygon base. The faces are all triangles. Pyramids are difficult to find in the common world except as pictures. For further definition and explanation of solid shapes, see the Solid Figures section of the Geometry essay in the *K-3 Teacher's Reference Manual*, pages 135–137.

From Publisher and Commercially Produced Posters in Middle School Classrooms:

1. What do you call the place on a line that is a certain distance from a start point?

2. What do you call the place on a plane that is a certain distance from a start point?

3. Hanging among terms to be understood:

Irrational Numbers (square roots and pi)

From Publisher and Commercially Produced Posters in Middle School Classrooms:

1. What do you call the place on a line that is a certain distance from a start point?

2. What do you call the place on a plane that is a certain distance from a start point?

3. Hanging among terms to be understood:

Irrational Numbers (square roots and pi)

Answers:

1. A point

2. Circumference of a circle

3/8/06

Preservice Teachers

- Traffic Jam Problem:
- There is a 3 km traffic jam on Interstate 75 near Georgia Tech. How many vehicles are caught in the traffic jam?
- Talk at your table: How would you do this problem?
- How do you think your fourth grade students would respond to this problem?

Bibliography for PST

- Peter-Koop, Andera “Fermi Problems in Primary Mathematics Classrooms”, *Australian Primary Mathematics Journal 10 (2005), p. 4 - 8*

BULLETIN (New Series) OF THE
AMERICAN MATHEMATICAL SOCIETY
Volume 42, Number 4, Pages 417–430
S 0273-0979(05)01072-4
Article electronically published on June 23, 2005

MATHEMATICS, MATHEMATICIANS, AND MATHEMATICS EDUCATION

HYMAN BASS

I am one of a growing number of research mathematicians who are substantially engaged with school mathematics education. Such outreach has a long and honorable tradition. In this lecture, I illustrate some of the ways that I think this can be helpful, and even essential.

Upon his retirement in 1990 as president of the ICMI,[1] Jean Pierre Kahane spoke perceptively of the intimate connection between mathematics and mathematics education in the following terms:

- In no other living science is the part of presentation, of the transformation of disciplinary knowledge to knowledge as it is to be taught (*transformation didactique*) so important at a research level.
- In no other discipline, however, is the distance between the taught and the new so large.
- In no other science has teaching and learning such social importance.
- In no other science is there such an old tradition of scientists' commitment to educational questions.

Conclusion

Let me conclude here by summing up my argument about productive interaction among mathematics, mathematicians, and mathematics education.

- The mathematics profession has a long and honorable tradition of involvement in mathematics education.
- Eminent mathematicians from around the world, and throughout history have exemplified this tradition.
- Important contemporary mathematicians are continuing, and expanding this tradition.
- This work can be productively pursued in the spirit of "applied mathematics" by first deeply understanding the domain of application.
- As practitioners of the discipline, research mathematicians can bring valuable mathematical knowledge, perspectives, and resources to the work o mathematics education.
- This is a tradition worthy of continued development and support.

ALGEBRA CUBED

A GK-12 project funded by the National Science Foundation

Executive Summary

Funding: $1,829,662
Project Dates: March, 2006- March 2009

Number of Graduate Fellows: 10 per year
Number of Teacher Mentors: 10 per year

Principal Investigator: Richard Millman (Math)
coPIs: G.T. Lineberry (Mining Engr), Xin Ma (Curriculum & Instruction), Jeff Osborn (Bio), Paul Prater (Principal, Bath CountyHigh School)

Purpose:

- Focusing on algebra, increase the mathematical conceptual understanding and procedural fluency of Middle and High school students in Bath and Powell counties.
- Establish professional learning communities across levels of teachers, middle and high school students, faculty, Fellows (graduate students at UK) and other stake holders to enrich all participants.
- Increase the algebraic content knowledge and enrich the view of applications among all participants.
- Develop and utilize lessons for algebra that stress the use and applications of algebra in the context of the Kentucky Core Content.
- Establish a lifelong interest in the math and science of middle and high school in the Fellows.
- Increase the communication and teaching skills of the Fellows through interactions with the teachers in the schools and add to professional development opportunities for the math teachers resulting in content gain.
- Increase the performance of the students on the algebra portion (especially) of the Kentucky Core Content Test (KCCT).

Finance:

- All Fellows are supported by NSF through University of Kentucky.
- Teacher Mentors receive stipends from UK for work with the graduate students.
- Travel money is available for participants for trips between the counties and UK and for other ALGEBRA^3 purposes.
- The stipend for Fellows is $30,000 (plus academic year tuition) for twelve months. The stipend for the Teacher Mentor is $4500 per year to mentor a Fellow (as of 2008).

Practical Issues:

- Fellows will have duties of about 15 hours per week as math specialists and will be in the schools for ten hours per week (on a two days a week schedule) during the academic year. The stipend includes obligations during the summer.
- Mentor teachers are in charge of the classroom and the graduate students need to follow their instructions.
- Fellow selections will be made in an open application process, subject to NSF guidelines, with significant input from the teachers, principals, and superintendents.
- The matching of Fellows with Mentor teachers will be made with substantial input from both.
- Mentor teacher selection will be made based on recommendations from the principals and superintendents.
- There will be clear, written expectations of Fellows and Mentor Teachers.
- The doctoral advisor of a graduate student will need to give approval for that person to be considered for a GK-12 fellowship. Fellows will be in their second year or beyond at the time of their fellowship.
- Only graduate students from the Sciences, Engineering, Statistics, and Mathematics (STEM) are eligible to be a Fellow.
- All Fellows must be U.S. citizens, nationals, or permanent residents (an NSF rule).

Practical Issues:

- The KCCT exam results will be an important part of the evaluation of the project.
- All involved are expected to cooperate with the evaluators of the project.
- All Fellows are required to participate in a two week orientation in mid August.
- All Mentor teachers are expected to be available for some group meetings and individual conversations.
- Classes which include algebra (not just those labeled algebra) can be involved.
- The first Fellows join the K-12 schools in Fall, 2006. The grant is for three years of Fellows in the classroom.

Cube Fellow Expectations ALGEBRA CUBED An NSF Graduate K-12 Project

The graduate students who are Cube Fellows are expected to:

- Attend a mandatory two week summer orientation (August 16-30) which includes an introduction to mathematics classrooms in the middle and high schools, your role in the school and the classroom, the Kentucky mathematics curriculum, and the culture of the students in those schools. The emphasis will be on a conceptual, NCTM standards based teaching approach. The orientation is given by project PIs and others from the schools.

- Spend a minimum of 15 hours per week during the academic year on the project as follows: 10 hours per week in the classroom(s) assisting teachers and students as a content expert and 5 hours in preparation, conferences with mentor teacher(s) and attending faculty meetings.
- Attend biweekly seminars during the UK academic year
- Discuss classroom issues with the classroom teachers on a continuous basis.

The graduate students who are Cube Fellows are expected to: (cont)

- Keep an updated and detailed journal of all activities for the project. This activity should especially emphasize interactions with teachers and students in the assigned school classroom(s). Although journals will only be read by the PIs and you, when aggregated, this database will be used for seminar discussions, for reflective papers to be submitted, and for project reporting. Your journals are to be submitted electronically to the Project Director (Richard Millman) every other Friday.

- Submit a progress report monthly to the Project Director. This report should summarize significant accomplishments, reflect on difficulties, and include recommendations for the future.

- Plan conceptually based activities jointly with the Mentors, class test the activity, and present it at one of the Fellow seminars.

The graduate students who are Cube Fellows are expected to: (cont)

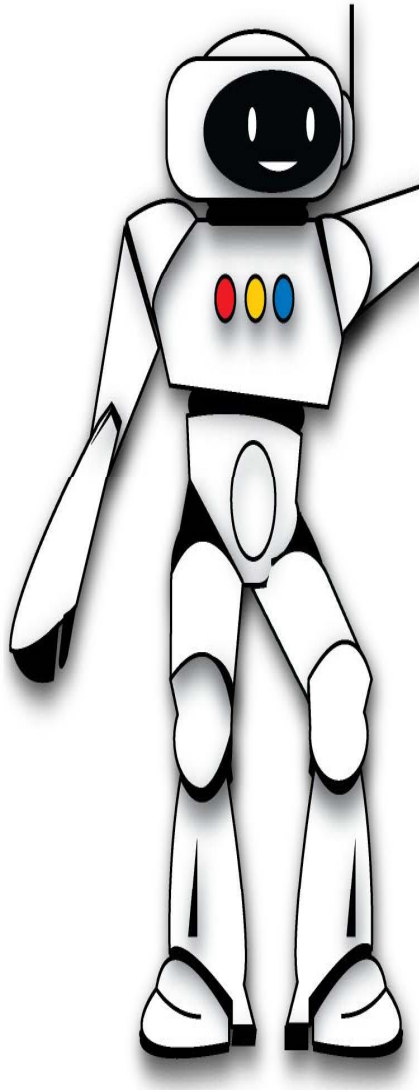
- Write up at least one lesson each semester that you have successfully developed and in a form that is suitable for publication on the ALGEBRA CUBED website (at least).
- Keep a log of your hours working with teachers. This log is to be submitted monthly to the Project Manager.

- Conduct yourself professionally, treat the teachers as colleagues and everyone with respect, and dress professionally when in the public schools. Do not engage socially with students at the schools.
- Recognize that the teacher is the individual in charge of the class and follow the teacher's explicit directions.
- Abide by any school rules for guests and/or faculty at the school site assigned. This also applies to any specific protocol(s) for entering and leaving the school.

The graduate students who are Cube Fellows are expected to: (con't)

- Be willing to attend professional conferences (e.g. KYMAA, KCTM, NCTM, AMS, MAA, NSTA, etc.) and participate in other scholarly activities concerning ALGEBRA CUBED, as time permits, the expenses for such activities will be reimbursed according to UK policy by the ALGEBRA CUBED grant. (DISSEMINATION)
- Provide assistance and expertise in math content to other educators or classes at the middle or high school as requested by mentor teachers or project PIs, subject to workload considerations.
- Cooperate with those who are doing evaluation of the project and, should there be a visit by NSF officials, with them also.
- ALGEBRA CUBED activities follow the UK calendar, not those of the schools.

The NSF award number is 05-38465. The opinions expressed are those of the PI and co-PIs and not the National Science Foundation



SLIDER®

Science Learning Integrating

Design, Engineering, & Robotics

What is SLIDER?

- Science Learning: Integrating Design, Engineering and Robotics
- NSF DR-K12 Program
- $3.5 M over 5 years, began 10/1/09

SLIDER

- Georgia Tech in collaboration with 3 middle schools: urban, suburban, rural; and the Georgia Department of Education

- Curriculum design, development, implementation, research

Who is on the team?

- PI: Richard Millman

- Co-PIs:
  - Donna Llewellyn (CETL), Research
  - Marion Usselman, (CEISMC) Project Director
  - Juan Aguilar, GA DOE

The Team

- Curriculum Development:
  - Mike Ryan and Jeff Rosen
- Researchers:
  - Barbara Fasse and Richard Catrambone
- Implementation:
  - Teacher coaches: Doug Edwards, Fred Stillwell, Jess Bush
  - 6 Graduate Student “SLIDER Fellows”

Why do we need a new curriculum?

- Current curriculum not doing the job!

- For example:
  - New Georgia standards promote process skills and deeper learning
  - In 2007, 40% students failed the 8th grade CRCT in Physical Science

Why Engineering Design Scenarios?

- Proven way to engage learners
- Provides context for learning
- Embodies content and skill knowledge
- Provides opportunities to
  - Innovate
  - Create original solutions
  - Experience what real engineers do

Why Robotic-based Activities?

- Can be correlated with
  - Over 75% of math content standards
  - Over 60% of physical science content standards

Why Legos?

- Affordable
- Accessible
- Adaptive
- Reliable
- Reusable
- Long-lasting
- Non-intimidating
- Associated with fun

What are our research questions?

1. Can research-based physical science instructional materials that use problem-based, inquiry learning in the context of engineering design scenarios empower a broad range of middle school learners to learn physical science content and reasoning skills?

Research Questions, cont'd

2. Can these educational materials lead to increased engagement, motivation, aptitude, creativity and interest in STEM fields, and if so, does this effect persist as students move into high school?

Research Questions, cont'd

3. Do students engage with the materials differently depending upon their gender, race, socioeconomic status, prior academic achievement level, or location (urban, suburban, rural)?

Secondary Research Questions, cont'd

5. What type of support, both in instructional materials and professional development, is necessary to adequately prepare teachers to deliver this type of curriculum?

What will we do – Curriculum Development?

Based on paper by D. H. Clement:

"Curriculum Research: Toward a Framework for 'Research-based Curricula," *Journal for Research in Mathematics Education*, 38 (1), pp. 35-70, 2007.

Basic Steps continued

4. Market Research
   - Robotics
   - Theme: "How Can We Design Solutions to Problems Facing People, Communities, and our World?"

How do these two relate?

- Where does curriculum development stop and science learning research begin?
- And, where does program evaluation fit in with each of these?

What are some of our challenges?

- IRB
- Teacher turn over
- Being all over the state
- Observing without influencing
- Controls
- Comparisons
- Many, many small pieces of legos

Challenges

- Staffing limitations
- Geography
- No do-overs: Witnessing and Capturing the right data and the “aha” moments
- Operationalizing nebulous qualities
- Participant fatigue
- Goldilocks Theory (how much data is just right?)
- Guest appearances by GaTech altering the environment

"Georgia Intern-Fellowships for Teachers" (GIFT)

What:

- Seven week collaboration between research lab (industry) and high school teacher to contribute to solving problems of business and to provide classroom teachers 'real life' experiences in the applications of science and mathematics.
- There have been 1540 GIFT teachers since 1991. GIFT now places 75-80 teachers per summer.
- GIFT provides teachers the answers to "Why do I have to study this?" and "What will I ever do with it?"

GIFT Program Benefits:

For Sponsors (university or industry)

- Get enthusiastic summer employees capable of contributing to meaningful projects.
- Have opportunity to help teachers understand the use of technology.

For Teachers (mostly high school)

- Gain hands on experience in the use and application of science, math and technology in the workplace.
- Translate work experiences into inquiry-based learning lessons at HS.

For Students

- Gain increased exposure to real life STEM examples in the workplace.
- Become more aware of career opportunities in the STEM fields and the skills required.

GIFT Program Services:

- Provide industry efficient method of identifying and selecting teacher(s).
- Orient teacher to research work environment and the mentor to K-12 workplace culture.
- Provide ongoing support to mentor and teacher during internship.
- Assist teachers in creation of an Action Plan (i.e. lesson plan) for transferring experience to the classroom.
- Provide support for implementing Action Plan into the classroom.
- Cost per GIFT sponsorship is $7100 per teacher, including teacher stipend.

Resulting Presentation and Article

- *"A Meta-analysis of Mathematics Teachers of the GIFT Program Using Success Case Methodology"* by Richard Millman, Meltem Alemdar, and Bonnie Harris, ICMI-ICIAM Study Conference, “Educational Interfaces between Mathematics and Industry", April, 2010 , Lisbon, Portugal, to be published by COMAP, accepted.

Contact Information

- Dr. Richard Millman
- Professor of Mathematics, Director of CEISMC
- Georgia Institute of Technology
- Richard.millman@ceismc.gatech.edu
- (404) 894-6179
- GO BUZZ!