



ANNUAL REPORT, 2007–2008

**THE UNIVERSITY OF ARIZONA.**

*Arizona's First University.*



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# About the Institute

## What We Do

The Institute supports local, national, and international projects in mathematics education, from kindergarten to college, that pay attention to both the mathematics and the students, have practical application to current needs, build on existing knowledge, and are grounded in the work of teachers.

## The Need

Mathematics is crucial for innovation in science, technology and engineering; competitiveness in a global workforce, and informed participation in democratic government. Three decades of reports, from the Department of Education's *A Nation at Risk* (1983) to the National Academies' *Rising Above the Gathering Storm* (2006) offer ample evidence for the need to improve mathematics education in the United States.

## Our Approach: Collaboration

The problems of mathematics education cannot be solved by one group alone. Taking its cue from pioneering collaborations of recent years, the Institute includes participants from communities that are sometimes worlds apart: mathematics departments, colleges of education, school systems, government agencies, business, and commercial and non-profit education organizations. It engages mathematicians, statisticians, scientists, education faculty, teachers, parents, business people, and policy makers in collaborative work in which each group plays a key role and for which each group takes responsibility.

## Funding



Meeting Room



The Old Chemistry Lab



The New IME Conference Room

The Institute of Mathematics and Education is supported by funds from the University of Arizona Provost's Research Initiative Fund, the College of Science, and the College of Education; grants from the National Science Foundation, and collaborative arrangements with other institutions. If you are interested in supporting the work of the Institute, please contact William McCallum at 520-440-1729 or [ime@math.arizona.edu](mailto:ime@math.arizona.edu).

# Ongoing Programs

## Arizona Teacher Initiative

In September of 2006, the Institute was awarded a 5-year, \$4.8M National Science Foundation Math and Science Partnership grant (award 0634532) to start the Arizona Teacher Initiative. The Principal Investigator is Daniel Madden, the co-Principal Investigators are William McCallum and Rebecca McGraw of the Department of Mathematics in the College of Science, along with Erin Turner of the Department of Teaching & Teacher Education in the College of Education, and Roger Pfeiffer, superintendent of the Tucson Unified School District. The key activities are to develop a part-time 3 year Master's degree in Middle School Mathematics Leadership for current elementary-certified middle school math teachers, a full-time one-year Certificate in Mathematics Teacher Mentoring for high school teachers, and a Postdoctoral Fellowship in Teacher Preparation for recent Ph.D.s in mathematics.

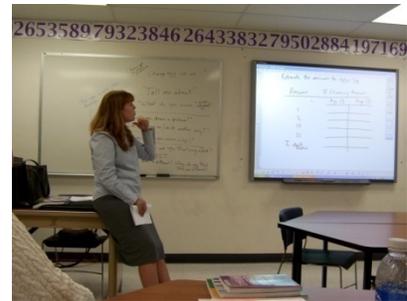
In 2007–08 the Institute initiated development and university approval of the degree programs, and recruited the second cohort of 15 middle school teachers who started their Master's degree with a course on Geometry taught by Daniel Madden in the summer of 2008. We recruited high school teachers Mike Schmidt and Alyssa Keri as adjunct instructors/certificate candidates, and Carolyn Wright from University of Georgia as our second post-doc.



Bill McCallum



The Master's Students



Rebecca McGraw

## Making Connections

The Making Connections project is funded by a 4-year, \$300K National Science Foundation Distinguished Teaching Scholar (award no. 0525009, PI William McCallum). It aims to establish a model for collaboration between mathematicians, educators, and teachers that is centered around analysis of student work on algebra problems. These three groups are brought together to participate in regional teams at a summer workshop where they undertake a joint analysis of school algebra problems and student work, which has been collected during the preceding semester by the teacher participants. The summer workshop is a laboratory for developing a model for collaboration between these three groups by focusing on concrete examples. Each team uses the workshop to develop instructional materials and collaborative activities in their own regions.

In 2007 teams from Arizona, California, and Illinois studied work of elementary school students on algebraic thinking, and in 2008, teams from Arizona, California, and North Carolina studied work of high school students on algebra

## **Untangling KnotSS**

Modeled on the MSRI Elementary Mathematics Project, this NSF DR K-12 grant (#0821996, PI Rebecca McGraw) investigates the nature and processes of collaborative work between mathematicians and mathematics educators.

Teams of mathematicians and educators co-teach courses aimed at building an integrated knowledge of mathematics content and pedagogy. The project documents different approaches to collaboration, along with the methods and practices associated with those collaborations, and how student learning associated with them. Through analysis of the nature and processes of collaboration, and the interactions between content and pedagogy, the project generates critical knowledge about what teachers need to know for teaching secondary school mathematics and how that knowledge can be developed, and about methods and models of productive cross-disciplinary collaboration.

## **Tucson Teachers' Circle**

All middle school mathematics teachers who are interested in exploring engaging, accessible topics in mathematics and who strive to incorporate a problem solving approach in their classrooms are encouraged to participate in the Tucson Teachers' Circle. Participants gain a variety of resources, membership in a dynamic community of mathematics educators, and a renewed sense of appreciation for the fascinating world of mathematics. Participation is free of charge thanks to the support of the Institute for Mathematics and Education (IME) and the University of Arizona Foundation.

## **Tucson Math Circle**

At the Tucson Math Circle, run by mathematics professor Philip Foth, pre-college students sharpen their problem-solving skills in an informal setting. They work on interesting problems or topics in mathematics with professors and graduate students from the University of Arizona. The goal is to share the excitement about mathematics and learn through fun activities without formal tests and examinations. The circle meets weekly during the semester for 2 hours at the Institute for Mathematics and Education on the University of Arizona campus

## **Mathematical Modeling for Teachers**

Based on the Mathematics Department's Mathematical Modeling course and the 2007 Arizona Summer Program on Mathematical Modeling, this initiative of assistant director Joceline Lega aims to help teachers connect real-world problems to mathematics, illustrating the central role of mathematics in science and providing them with topics and teaching materials they can use in their own classes. We develop online modules to support activities for teacher professional development and for K-12 classrooms, drawing from issues of current interest described in newspapers and popular scientific journals. The goal of each activity is to understand a phenomenon by means of modeling, elementary mathematical analysis, and simulations.

## Events 2007–2008

### **Conference on Learning Technologies and Mathematics, March 31–April 1, 2007**

The Learning Technologies and Mathematics Middle East Conference was held at Sultan Qaboos University, Muscat, Oman, March 31–April 2, 2007. A joint effort by the University of Arizona's *Institute for Mathematics and Education* and the *Department of Mathematics and Statistics* at Sultan Qaboos University, the conference was designed to bring educators and learning technology experts together to share their views on the best ways to prepare university students for a world driven by technological innovations. This conference was among the first of its kind to be held in the Middle East. It covered subjects ranging from reforming the mathematics and statistics undergraduate curriculum to introducing *learning technologies* into the classroom and their effects on both undergraduate and graduate education. 144 participants were included in the conference.

### **MAA PREP workshop on Revitalizing College Algebra, June 18–21, 2007**

This workshop, co-sponsored by IM&E, considered different models for the college algebra curriculum, and developed in-class activities and out-of-class projects to supplement the college algebra course.

### **Making Connections workshop, June 28–30, 2007**

This year's workshop, the third in the series, focused on developing algebraic thinking in elementary grades. Teams from Arizona, California, and North Carolina produced plans for Making Connections workshops of their own. There was also a report presented by the Illinois team about student work on the problems.

### **Making Sense of Testing in Arizona, October 13, 2007**

Policy makers, K–12 professionals, and university faculty from Arizona, and around the country, met to consider the different tests students take from the end of high school to the beginning of college. As a result, the Institute for Mathematics and Education at the University of Arizona, in collaboration with the other two state universities, Cochise Community College, the Governor's office, the State Department of Education, and Achieve Inc., has initiated a correlation study of all the different mathematics tests that students take, with the goal of bringing coherence and clarity to the experience of students making the transition from high school or community college to a university. A report was also developed on options for fourth year high school courses.

### **Using Cases to Develop Knowledge for Teaching Mathematics, February 14–16, 2008**



Institute for Mathematics and Education



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The workshop focused on the use of instructional cases in mathematics teacher education. The cases consisted of video and/or written records of teaching, lesson plans, student work, and teacher reflections. They were constructed so as to highlight particular dilemmas or challenges related to teaching and learning mathematics. The workshop presenters engaged mathematicians, mathematics educators, and teachers in examining the case materials and considering their potential for helping teachers build and connect knowledge of mathematics with knowledge of teaching.

#### **Elementary Teacher Preparation in Mathematics, February 28–March 1, 2008**

This workshop brought together mathematicians, mathematics educators, and elementary teachers for discussions about teacher preparation in elementary mathematics, including mathematics content knowledge, teaching practices, and perspectives about learning and teaching mathematics critical for the beginning teacher, with particular emphasis on aspects of teaching elementary school mathematics that have been misunderstood, under-appreciated, or neglected. The workshop offered participants, with widely varying backgrounds, the opportunity to share their knowledge and experiences and gain new insights from those with different expertise.

#### **Secondary Teacher Preparation in Mathematics, March 7–8, 2008**

Attendees participated in sessions that gave a taste of the activities in different courses or programs and then discussed what's beneath the surface features – why these topics and the ways in which they are developed serve their underlying philosophies. The focus was on courses that are either co-designed or co-taught by mathematician-educator-teacher teams.

#### **Mathematicians in Mathematics Education, March 20–22, 2008**

This workshop, aimed the general audience of university mathematicians who wish to become involved in helping solve the problems in mathematics education, served to orient mathematicians on key issues in mathematics education: the core mathematics of K–12, the mathematical knowledge of teachers, the nature of the educational system, the profusion of standards documents, the variety of curricula, and mathematics education research. The purpose was to prepare mathematicians to contribute to work in mathematics education, such as standards development, validation of tests, curriculum design, textbook review, and the preparation and professional development of teachers.

#### **Southwestern Network Meeting and Proof Workshop, September 27, 2008**

Workshop participants sent, in advance, examples of areas of logic and proof where students have particular trouble. At the workshop they broke into four groups to produce tasks or ideas for how to help students grapple with these issues.

#### **Facing Choices about the Fourth Year in Arizona, October 18, 2008**

On December 10, 2007, the Arizona State Board of Education voted to increase the high school graduation requirement to include four years of mathematics. At last year's IM&E policy retreat, we anticipated this move by launching a project to develop a report on existing options for fourth year courses.

At this year's retreat, we brought together decision makers from the mathematics education system in Arizona, and the nation, to help focus our energies on developing fourth year mathematics courses that will meet the needs of all Arizona students

#### **Who Wants to Be a Mathematician, November 15, 2008**

The event was co-sponsored with the American Mathematical Society. Students from Tucson area schools proved that math is fun and rewarding when they competed in Who Wants to Be a Mathematician contest. The student con-

testants vied for the top prize of \$2000 in cash by answering multiple choice mathematics questions. Who Wants to be a Mathematician is a game of skill and excitement patterned after the TV show Who Wants To Be A Millionaire. The game rewards math performance in a fun and exciting way. The American Mathematical Society has been performing the game for over seven years at various locations.

## Upcoming Workshops

### **Mapping the High School Algebra Curriculum, February 19–21, 2009**

The workshop is based on a set of explanatory essays, written by mathematicians, which carefully examine core areas of school algebra. The essays were developed under a grant from the Noyce Foundation through the Charles A. Dana center.

At the workshop, teams of mathematicians, educators, and teachers produce surrounding support materials for the essays, such as problem sets, case studies, and curriculum guides, which can be used in teacher preparation, teacher professional development, standards development, and task design.

### **Mapping the Geometry Curriculum, March 19–21, 2009**

Geometry is a curricular strand in many standards documents. Yet, when standards suggest that particular concepts are central to the domain, it is not clear that the authors and readers interpret them in the same ways. The purpose of this workshop is to identify core ideas in geometry, and to develop tools for examining mathematical competence related to these ideas. Participants will identify and describe some domains of competence that teachers, educational researchers and mathematicians agree are meaningful and worth examining. Then they will create written tasks that would be useful for assessing these areas of competence. Following the workshop, the organizers will work with participants to compile a collection of task responses that are representative populations.

### **Mathematicians in Mathematics Education, April 2–4, 2009**

The demand is increasing for mathematicians who can constructively contribute to work in mathematics education, such as standards development, validation of tests, curriculum design, textbook review, and the preparation and professional development of teachers.

This workshop will orient mathematicians on key issues: the core mathematics of K–12, the mathematical knowledge of teachers, the nature of the educational system, the profusion of standards documents, the variety of curricula, and mathematics education research.

It is aimed the general audience of university mathematicians who wish to become involved in helping solve the problems in mathematics education.

### **Mapping the Calculus Curriculum, April 18–20, 2009**

Participants produce guide pamphlets to specific high school calculus topics, starting from an analysis of selections from existing curriculum materials. Each pamphlet is produced at the workshop by a team of 3–5 people including at least one mathematician, a mathematics educator, and a teacher, and contains (a) a discussion of the mathematics (b) a discussion of the teaching of the topic, based on both research and practical classroom experience (c) a set of tasks that could form the basis of a small instructional unit on the topic (1/2–3 lessons long, usable by a wide range of mathematics teachers).

# Featured Programs

## Arizona Teacher Initiative

If today's parents are having difficulty helping their children with middle school math, they're not alone. Their children's teachers are having the same problem.

"A vast majority of middle school teachers are elementary school-certified. Many of them get coerced into teaching math," Sue Adams said. She's the Co-Director in the Center for the Recruitment and Retention of Math Teachers at The University of Arizona. "Here's the problem: Unless you are a recent grad you are ill-prepared for today's math."

According to Adams, even as recently as 1983, middle school students were taught primarily arithmetic, fractions, decimals, percents, and word problems. Today's students are seeing problems in probability, geometry, and data analysis. "For some teachers, that's brand new stuff," Adams said.

"There's also a vast difference in the way material is presented. It used to be the teacher would stand at the blackboard and work problems while explaining the theory. Today's classroom is student-centered," Adams said, "with more student interaction and exploring and less teacher explaining."

Enter Arizona Teacher Initiative, the inaugural program of the Institute for Mathematics and Education. Under the watchful eye of Professor Daniel J. Madden, the ATI offers a solution to this sticky math problem: a Master's degree in middle school mathematics. The three-year degree program, designed for the working middle school math teacher, focuses in-depth on mathematics and math pedagogy.

"The object is to have a solid Master's degree that covers the mathematics of middle school and educational leadership to really improve the quality of instruction in middle school," Madden said. "It is not a typical Master's degree."

To be accepted into the program, teachers had to undergo a rigorous interview process that included giving a math lesson. "The lessons were where they engaged us and then set us to work, so we knew that they were ready to know more and go further," Adams said. "That for us was a positive sign."

The first cohort of students, who began school in August of 2007, are now almost halfway to their degrees. The second cohort of teachers began work toward their Master's degrees in 2008. As an incentive to get teachers to enroll, ATI offered full scholarships to The University of Arizona along with a small stipend. At the end of three years, graduates will have a Master's Degree in Middle School Mathematics Leadership. Program funding comes from a \$4.8 million, five-year grant, awarded by the National Science Foundation Math and Science Partnership. After that, the program will have to find its own funding.

Because the participants already lead challenging lives—they work full time and often have families and other responsibilities—classes are designed to accommodate their schedules. Four-credit classes are divided into two nights a week and three-credit classes are offered one night a week, both for a two year period. The third year is dedicated to research. It is hoped that in the future, classes will be offered online. "We want to create a curriculum that anyone can take," Madden said.

Madden feels program participants are actually smart, inquisitive teachers.

"In Arizona, people teaching middle school math are trained to teach kindergarten through the eighth grade. They are good teachers. They weren't afraid of a challenge and they weren't afraid of math," Madden said. "Therefore," he

said, "It was a very short jump to teaching middle school math full time. A lot of people looked at that and said these people are the problem. We think they're the solution".

### **Tucson Teachers' Circle**

Who would think that learning math could be rejuvenating?

For 15 to 22 middle school math teachers, however, that's just what happened as they passed the school year in The Tucson Teachers' Circle, a new program sponsored by the Institute for Mathematics and Education at The University of Arizona. For two and a half hours one night a month in the IME classroom, the teachers of the Tucson Unified School District sloughed through lessons like *Geometry Models*, *Chinese New Year and Other Number Problems*, and *Issues of Our Time: the Quadratic Formula*.

Circle classes, which were taught mostly by UA Department of Mathematics professors, began promptly at 5:30 in the evening when teachers were presented with a math problem. Modeling student-centered classrooms, teachers set to work solving it. An hour later everyone ate supper, then finished the night with discussion and more problem solving. Rather than wearing the teachers out, Bohme said the opposite happened. They were rejuvenated.

"They'd come in dragging; you could just see the shoulders dragging," Virginia Bohme said. She's a School Specialist on loan to the Teachers' Circle from the IME. "Every single time they left with more energy than when they came in."

The program provides middle school math teachers, who are often not specially trained in mathematics, an opportunity to delve further into the subject they teach. "Teachers gain a deeper understanding of math," Bohme said. This is where teaching postdoc Dr. Nate Carlson came in. "One of the tenets should be that there's a connection between the students (in this case the teachers) and a mathematician. That's basically my role," he said.

What Carlson discovered about the participants, he said, is that these teachers look at math differently. They sought to find ways to "rope their students in with activities and interesting problems." It is remarkable considering that teachers "are tied to a very strict curriculum."

Speakers and topics included Fred Stevenson on *Exploratory Problems*; David Gay on *Geometry Models*; Rebecca McGraw on *Geometry Investigations: Using Geometer's Sketchpad*; Nate Carlson and Virginia Bohme on *Chinese New Year and Other Number Problems*; Sybilla Beckman on *Singapore Math – Using Simple Diagrams to Solve Word Problems*; Willia McCallum on *Great Issues of Our Time: The Quadratic Formula*; and Paul Zeitz on *Seven Mathematical Games*.

A second benefit of the program, both Carlson and Bohme said, is to provide a place for teachers to find support and to some degree, friendship.

"There teachers feel very alone so they're finding a support group in this," Carlson said. "They talk about their jobs; they talk about their days. Sometimes with no holds barred. It's good."

"They don't have time to share with colleagues," Bohme said. With the Teachers' Circle, "(they) are forming a community of educators." Besides, "They love math and this reconnects them with why."

# People

## Staff

William McCallum, Director

Rebecca McGraw, Assistant Director

David Savitt, Assistant Director (2006-07)

Joceline Lega, Assistant Director (2007-08)

Teresa Stovall, Program Coordinator

## Planning Group

Deborah Hughes Hallett (chair), Professor of Mathematics, University of Arizona and Adjunct Professor of Public Policy, Kennedy School of Government, Harvard University

Deborah Loewenberg Ball, Dean of the School of Education and William H. Payne Collegiate Professor, University of Michigan

Hyman Bass, Roger Lyndon Collegiate Professor of Mathematics and Professor of Mathematics Education, University of Michigan

Al Cuoco, Senior Scientist and Director of the Center for Mathematics Education, EDC

Roger Howe, Professor of Mathematics, Yale University

## Visiting Scholars

David G. Haase, NC State Univ., October, 2008

Al Cuoco, EDC, February-March, 2008

Guershon Harel, UC San Diego, August, 2007

Roger Howe, Yale University, March, 2007

## Advisory Board

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Mark Saul, Templeton Foundation

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