The University of Chicago School Mathematics Project

UCSMP Newsletter

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Mathematics for High School Teachers – An Advanced Perspective

Mathematics for High School Teachers—An Advanced Perspective, to be published by Prentice Hall this December, was exhibited in preliminary form at the NCTM annual meeting in Las Vegas this April. Plans call for the published form to debut January 2003 at the joint AMS-MAA meetings. Early versions of this college course had the project title "High School Mathematics from an Advanced Standpoint." The course is designed for both prospective and experienced secondary school mathematics teachers as an upper-level undergraduate or beginning graduate mathematics course. For easier understanding, readers should have completed at least one year of calculus and a post-calculus mathematics course (such as real analysis, linear algebra, or abstract algebra) in which algebraic structures were discussed and proofs were required.

Many characteristics distinguish this course from others. It is rooted in the core mathematical content and problems of high school mathematics courses before calculus. Specifically, the course emanates from the following concepts: numbers and operations, algebra, functions, and geometry. The concepts are treated from an advanced perspective, differing considerably from materials designed for high school students.

The authors feel that the content developed for this course includes an area of mathematics that is of great benefit to all interested in mathematics at the secondary school level, but is rarely seen. Specifically included is the following:

- Analyses of alternate definitions and alternate language for mathematical ideas
- Why concepts arose and how they have changed over time
- A wide range of applications
- Alternate ways of approaching problems, including ways with and without calculator and computer technology
- Analyses of common problems of high school mathematics from a deeper mathematical level
- How problems and proofs can be extended and generalized

continued on page 2

What Is Meant by "An Advanced Perspective"?

An Excerpt from Chapter 1

"Our objective is to discuss the content of high school mathematics from an advanced perspective. This perspective takes into account not only the many interconnections among high school mathematics topics, but also their relationship to college-level mathematics. This perspective includes a deeper analysis of problems and concepts drawn from high school mathematics to help you gain important new mathematical insights and understandings. This advanced perspective is also mindful of the historical and conceptual evolution of mathematical theory and school mathematics. Finally, this advanced perspective is designed to encourage you to explore mathematical ideas in depth and to explain mathematical ideas with clarity and precision. In this way, we hope to help you to develop a deeper understanding of high school mathematics and a new appreciation of its beauty, its logical structure, and its applicability."

Inside this issue . . .

PROJECT UPDATES

- Connections between ideas that may have been studied in different courses
- How ideas studied in school relate to ideas students may encounter in later mathematics study

The chapter titles indicate the breadth of the materials.

Introduction
Chapter 1: What Is Meant by "An Advanced Perspective"?

Part I: Algebra and Analysis with Connections to Geometry
Chapter 2: Real Numbers and Complex Numbers
Chapter 3: Functions
Chapter 4: Equations
Chapter 5: Integers and Polynomials
Chapter 6: Number System Structures

Part II: Geometry with Connections to Algebra and Analysis
Chapter 7: Congruence
Chapter 8: Distance and Similarity
Chapter 9: Trigonometry
Chapter 10: Area and Volume
Chapter 11: Axiomatics and Euclidean Geometry

This three-year project has been based in the Department of Mathematics at the University of California at Berkeley with production of materials carried out by UCSMP. Funding for the project was provided by the Stuart Foundation of San Francisco.

The project was originally conceptualized by Dick Stanley from the University of California at Berkeley and UCSMP Director, Zalman Usiskin. Principal writers, in addition to Professors Stanley and Usiskin, are Anthony Peressini from the University of Illinois at Urbana-Champaign (also a co-author of UCSMP's *Precalculus and Discrete Mathematics*) and Elena Marchisotto from California State University-Northridge. An advisory board to the project includes college and high school faculty. Three trial versions of the text were piloted in colleges in Arizona, California, Colorado, Georgia, Illinois, Louisiana, Nebraska, New Jersey, New York, Texas, and Wyoming.

For further information about the new course, contact Joanne Wendelken of Prentice Hall's College division at Joanne_Wendelken@Prenhall.com. If you have questions for the authors, send them to UCSMP at ucsmp@uchicago.edu.

Prentice Hall Creates UCSMP Web Site

http://www.phschool.com/atschool/ucsmp

Teachers can now direct their students to Prentice Hall's newly created web site for four of the six textbooks in the UCSMP series: *Transition Mathematics, Algebra, Geometry,* and *Advanced Algebra.* In addition, teachers will find activities, materials, and reference links to supplement their texts with exciting student activities and links to data sources.

Last fall, Prentice Hall announced the creation of this new web site through a presentation at UCSMP's 2001 secondary conference. Angie Seltzer, Prentice Hall's Executive Editor, Technology, discussed key features of the recently launched site. Additional information has been added since the conference.

The home page offers links to a problem of the week (this week's problem questioned how many daffodil bulbs to plant in a garden when daffodils divide and multiply over the years), interesting facts about today's date, and biographies of mathematicians who were born or died on today's date. One of the special features on the home page is the Question and Answer section. There are questions about the background and goals of the curriculum as well as questions about teaching UCSMP. If a teacher has parents with questions about the program, this is the place to look for answers to many of their questions.

In addition to the special features, the home page allows the user to be directed to the student section or the teacher section of the web site. The student section provides links to additional information in particular chapters as well as additional examples for each lesson within the chapter, hot links to other web sites, and internet activities. For added interest, each lesson has a multiple-choice self-test that scores automatically. The teacher section provides an overview of the chapter, chapter objectives, and vocabulary. There are additional examples for each lesson, teaching links, and internet activities. Teaching links provide additional information in other texts or by individual teachers. Along the left side of the site is a section titled "Resource Center." Professional development, reference links, and technology support is offered.

These pages do not provide information for purchasing UCSMP textbooks. To order any of the six UCSMP secondary books, go to www.phschool.com, press "online catalog," and proceed from there.

CONFERENCE UPDATE

Everyday Mathematics 2002 Conferences

SRA/McGraw-Hill provides professional development conferences for schools using *Everyday Mathematics.*

New User Conferences

Begin and Build Your Knowledge: Designed for teachers with no prior *Everyday Mathematics* experience, this course actively involves teachers in understanding the layout and management of the program. In these sessions, organized by grade level, teachers learn how to effectively implement *EM.*

Launch and Support Your Staff I: Designed for administrators with no prior training in *Everyday Mathematics*, the focus of these sessions is the crucial role that administrators play in the successful implementation of *EM.*

Experienced User Conferences

Level 1–Develop and Fine-Tune Your Teaching: In these sessions, organized K, 1-3, 4-6, teachers gain practical strategies and fine-tune their teaching. Discussed are managing *Everyday Mathematics* routines and procedures, adapting games and activities to meet individual student needs, and incorporating useful assessment tools into the *EM* classroom.

Level 2–Secure & Extend the Scope & Sequence: These sessions, organized K-3, 4-6, extend overall knowledge of the *EM* curriculum. They help teachers understand how concepts are revisited throughout the grade levels. Participants learn how to meet individual student needs and share open-ended assessment strategies.

Launch and Support Your Staff II: These administrator workshops discuss the administrator's role for success beyond the first year. They provide additional ideas to support staff, further develop mathematical content strand understanding, and they provide networking with other experienced *EM* educators.

***Everyday Mathematics* for Special Needs**

This new offering for experienced users builds teacher confidence in modifying *Everyday Mathematics* to accommodate the needs of inclusion and at-risk students.It focuses on creating and sustaining a successful *EM* learning community for all students. Sessions are organized K-6.

***Everyday Mathematics*/Exemplars Performance Based Assessment Workshops**

Exemplars is a company that publishes standards-based performance tasks with rubrics and annotated benchmark papers. These experienced user workshops are for understanding tasks and assessment rubrics as they apply to student work. Teachers investigate performance-based assessment and its effect on student mathematical problem-solving abilities and communications.

2002 Conference Dates

CITY	New User, Special Needs, Assessment	Experienced User
Charleston, SC	June 18-19	June 17
Seattle, WA	July 9-10	July 8
Denver, CO	July 10-11	July 9
Birmingham, MI	July 24-25	July 23
Chicago, IL	August 1-2	—
Rye Brook, NY	August 1-2	July 31
Wheeling, IL	August 8-9	August 7

Leadership Institutes

Level 1–Laying the Groundwork for Change: Level 1 is most beneficial for districts that have had initial training with *EM* materials. Attendees create a staff development plan and build teacher leadership skills to address common hurdles of *EM.*

Level 1 July 23-25 Lisle, IL

Level 2–Building a Culture of Reform: Level 2 is recommended for districts that have implemented *EM* for more than one full year and have received both initial and follow-up training. Participants strengthen leadership skills that focus on professional development models and mathematics reform.

Level 2 June 18-20 Lisle, IL

Contact 800-382-7670 or email allison_murdock@mcgraw-hill.com for more information.

2002 Secondary Conference

This year's Secondary Conference will be held at the University of Chicago campus on Friday and Saturday, November 9 and 10, 2002. Hilton Chicago & Towers will offer participants reduced rates. The Hilton can be reached at 312-922-4400 or 800-445-8667.

If you wish further information about the conference, contact Carol Siegel at 773-702-9770 or cssiegel@midway.uchicago.edu.

CONFERENCE REPORT

Great Teachers and New Ideas Featured at November 2001 Secondary Conference

Over 225 participants—from as far away as Salzburg, Germany—attended the Seventeenth Annual UCSMP Secondary Conference, held on Veterans' Day weekend, November 10-11, 2001, on the University of Chicago campus. The program included sessions for teachers of each UCSMP secondary textbook with information for teachers who were new users of the texts as well as for more experienced users. In addition, sessions on current issues in mathematics education were offered.

The conference opened with a talk by Zalman Usiskin on the shortage of qualified mathematics teachers, explaining how critical these individuals are to raising the bar in educating our nation's children. Dr. Usiskin stated, ". . .if we believe that it is important for all children to learn mathematics, then we must believe that it is important that they learn it well." The full text of his remarks begins on page 5.

New this year were four sessions from two "Great Teachers"—John Benson, Evanston Township High School, Evanston, Illinois; and Aminah Talib, Kind/Drew Magnet High School of Medicine and Science, Los Angeles, California. This new conference session recognized mathematics teachers who are considered to be great teachers by their peers. Each spoke about their experiences and classroom successes. See below for John Benson's wisdom about good and really good teachers.

Also new this year were sessions on Prentice Hall's UCSMP web site; External Test Preparation; and Using Technology: Fathom with *Functions, Statistics, and Trigonometry*. The Prentice Hall/UCSMP web site (http://www.phschool.com/atschool/ucsmp) features information and resources for both students and teachers of the 6-12 program. See the story on page 2 for further information.

Of the evaluations received after the conference, 84 percent of the respondents felt the conference was very worthwhile; 16 percent felt it was worthwhile. One teacher stated, "I learn so much each year I attend." Another told us, "It was greatly appreciated to have the opportunity to discuss practical ideas and problems with colleagues from around the U.S."

What Makes A Good Mathematics Teacher?

by John Benson, Teacher of Mathematics, Evanston Township High School

Good Teachers

- Have a clear idea of what their students know and can do.
- Know what is necessary for success on the night's task.
- Will use a variety of instructional methods to reach many learning styles.
- Are eager to spend extra time outside of class answering questions.
- Establish clear guidelines for student success and performance.
- Hold students to high standards.
- Account for individual differences.
- Provide clear explanations of the concepts students are expected to master.
- Continually preview and review.

Really Good Teachers

- Have a second set of objectives beyond mastery of today's lesson—a set of higher objectives that are ever present. They are consciously aware of these objectives and plan lessons with them in mind and are always on the lookout for opportunities to "seize the teachable moment" and move towards these higher objectives. DIAL 911.
- Believe that these meta-objectives are the really important part of teaching.
- Always are watching out for one of the items on this short list of important objectives and are constantly awaiting the opportunity to teach to one of them.

November 10, 2001

SECONDARY CONFERENCE TALK

The Shortage of Qualified Math Teachers: A Major Problem and Some Suggested Solutions

A Talk Presented by UCSMP Director Zalman Usiskin at the Seventeenth Annual UCSMP Secondary Conference, November 10-11, 2001

Each year since 1987, when I became overall director of UCSMP, I have been privileged to give a talk in which I examine an issue or question that I feel is important for us to think about as we go about our task of raising a generation of students able to use mathematics and mathematical thinking in their lives. This year my talk is about something that has been a subject of two conferences I've attended within the past 10 days, the shortage of qualified mathematics teachers.

The Extent of the Shortage

The extent of the shortage is difficult to document. Suppose a school needs n mathematics teachers. If it has n–1, then there is a shortage. If n = 10, then a district could report that 90% of its mathematics positions are filled but there would still be a shortage.

So we need to look at the problem in a different way. In a TIMSS report from 1999, 38% of U.S. school districts reported some sort of shortage of teachers at 8th grade. In some states, the shortage has been severe enough that bounties are paid for mathematics or science teachers. In Illinois, loans for tuition are given to prospective teachers in short-handed fields—mathematics being one of these fields—and the loans can be entirely forgiven if the student teaches the subject for five years.

Classrooms need teachers, and when schools are short of mathematics teachers, they find other teachers to teach mathematics. So another way to quantify the shortage is to ask what percent of teachers are qualified on paper to teach mathematics. Data from the 2000 National Assessment of Educational Progress (Braswell et al., 2001, p. 134) indicate that 43% of the nation's 8th graders had teachers with an undergraduate degree in mathematics. This agrees with TIMSS data from 1999 that reported 41% of U.S. 8th grade teachers had a mathematics degree. In the NAEP report 26% of 8th grade teachers had an undergraduate degree in mathematics *education*; in the TIMSS report 37% had such a degree. If we assume that these percents do not overlap (but there probably is some overlap), then between 22% and 31% of the nation's 8th grade students were taught mathematics by teachers without a degree in mathematics or mathematics education.

Whatever the situation, it is likely to get worse before it gets better. In 1999, according to TIMSS, 11% of 8th grade mathematics teachers were under age 30, and 36% were under age 40. If there were equal numbers of teachers at each age from 23 to 60, we would expect 18% and 45%. to be in these age groups.

Unlike the lower grade levels, NAEP does not collect specific data on teachers' backgrounds at 12th grade. Data from a Council of Chief State School Officers' 1998 survey indicates that approximately 88% of the secondary school mathematics teachers in the 32 states responding to the survey (Blank and Langesen, 1999) were certified in mathematics. However, this percent is suspect because a number of states reported that all or virtually all of their secondary school mathematics teachers were certified, something many people think is impossible.

Why the Shortage Is a Major Problem

Why not welcome a shortage? You can more easily switch to another district to teach, if you desire. Wherever you teach, you can more likely teach what you want to teach. You will more quickly gain seniority. You are likely to be more highly valued by the administration even if you do not receive a higher salary because you are a scarce commodity.

But if we believe that it is important for all children to learn mathematics, then we must believe that it is important that they learn it well. And it is more likely that a child will learn mathematics well if that child has a well-trained mathematics teacher.

The statement that I just made is one which we cannot afford to take for granted. In times of teacher shortages, and this is one of those times, states and school districts are forced to have mechanisms to ensure that every class has a teacher. Sometimes this is done by special, quickie certification programs, at other times by district waivers. Whatever mechanism is used tends to allow people who are not well trained to be mathematics teachers in the classroom. We must currently live with these mechanisms, but we must endeavor to

SECONDARY CONFERENCE TALK

rectify the current situation so that more people enter our profession, and so that alternative programs provide as much training as standard programs.

The TIMMS 1999 data (see Table 1) provide an interesting look at how shortages and achievement relate. They confirm what is generally well-known, that poorer-performing school districts have a harder time attracting teachers. So the shortage of mathematics teachers probably serves to increase inequities among schools.

Table 1: Percents of U.S. 8th-grade students in districts reporting various degrees of teacher shortage

Degree of Shortage	% of U.S. Students	Average Achievement
None	62	514
A little	23	497
Some	13	461
A lot	3	446

Source: Ina V.S. Mullis, Michael O. Martin, Eugenio Gonzalez, Kathleen M. O'Connor, Steven J. Chrostowski, Kelvin D. Gregory, Robert A. Garden, and Teresa A. Smith. *Mathematics Benchmarking Report: TIMSS 1999—Eighth Grade*. Boston, MA: International Study Center, Lynch School of Education, Boston College, 2001.

Do we have evidence that training improves quality? On National Assessment at the 8th grade level in both 1996 and 2000, students of teachers with mathematics majors or minors performed higher than students of teachers without a mathematics major or minor (Braswell et al. 2001).

These data support one of the beliefs of UCSMP since its inception in 1983, that students from grades 4 and higher should be taught mathematics by specialist teachers. That belief is also supported by the oft-cited study of Liping Ma. Ma's study, which compared the mathematical knowledge of elementary school teachers from the United States and China, is usually used by critics of U.S. education to disparage the mathematics training of U.S. elementary school teachers. But I do not interpret Ma's study in this way. The teachers from China in Ma's study were all from the Shanghai prefecture, and in that prefecture it is common practice for mathematics to be taught by specialist teachers from grade 1 up. I believe well over half of the teachers in Ma's study taught only mathematics. Because these teachers do not seem to have had any special training in their teacher preparation programs, I see Ma's study as providing evidence that being a specialist teacher of mathematics causes the teacher's knowledge of mathematics to improve.

Ma's result, together with the NAEP results, suggest very strongly that an elementary school student would be likely to learn more mathematics if taught by a specialist mathematics teacher. Thus, the more qualified the teaching force, the better prepared that students will be when they arrive at middle school and high school.

Why the Problem Is So Serious Now

The memory of society is very short. If times are bad, there is a tendency to think they are worse than ever before. I am only willing to say that the problem is the worst it has been at any time since before 1970.

At that time, non-college bound high school students usually took general mathematics as high school freshmen and consumer mathematics as sophomores. Many high school mathematics departments filled these teaching positions with teachers not well-trained in mathematics, for it was viewed that a person did not need to know much mathematics to teach those courses. So we were content with having only enough high school teachers well qualified to teach college-bound students.

The existence of algebra as an 8th grade course began in most areas of the country in the 1960s or early 1970s and typically involved one 8th grade class in a school. The teacher of this class might have needed some retraining, but other teachers could be content with knowledge of little more than arithmetic. Now we have a different situation at all three levels—elementary, middle, and high school.

We are asking elementary school teachers to teach not only arithmetic, but geometry and measurement, and even a little algebra, and probability and statistics, and to do it emphasizing not rote skills, but problem-solving and reasoning and communication and representation and connections with other subjects. At the same time, science educators are asking these same elementary teachers to teach the basics of biological and physical sciences through inquiry and experiments. Likewise the teaching of social studies has become more complex. And society is expecting greater competence in reading and language arts as evidenced by programs trying to ensure that all students read by the end of grade 3. They are also expected to provide drug education and sex education. It is unrealistic to expect our elementary school teachers to be so widely versed. Even if we were able to convince enough extraordinarily well-educated people to teach in our elementary schools, few people have the time to create rich lessons in all these areas and still have a life.

MATH TEACHER SHORTAGE

A century ago when teacher certification took its current shape, the teacher of 6th, 7th, or 8th grade needed only to know arithmetic well. Furthermore, the lessons consisted mainly of practicing algorithms and solving routine problems. A generalist K-8 teacher often possessed that knowledge. The entry of algebra into one class by 1980 only perturbed the situation slightly.

Table 2 shows the dramatic change in the two decades since 1981. In the Second International Mathematics Study, 76% of 8th grade classes were classified either as typical, meaning that arithmetic dominated their curriculum, or as remedial, meaning that K-6 arithmetic dominated. Only about half as many students in the year 2000 were in such classes.

Table 2: Percents of 8th-Grade students in various types of classes

SIMS-1981 (% of classes)				
	Algebra	**Enriched**	**Typical**	**Remedial**
	13	11	66	10
NAEP-1986 (% of students)				
	Algebra	**Prealg.**	**Reg.Math**	**Other**
	16	19	61	5
NAEP-1996 (% of students)				
	Algebra	**Prealg.**	**Reg.Math**	**Other**
	20	36	39	5
NAEP-2000 (% of students)				
G or AA	**Algebra**	**Prealg.**	**Reg.Math**	**Other**
3	25	31	37	3

The column with algebra is also revealing. On the 2000 NAEP, 25% of 8th grade students reported taking Algebra, 3% reported taking either Geometry or Advanced Algebra, and 2% (not shown on the table) reported taking an integrated mathematics program (which might be a high school integrated program started at 8th grade). We at UCSMP take some pleasure in this change; we were the first curriculum and remain the only curriculum with an algebra course designed as much for 8th grade as for 9th grade.

Algebra is a key topic for all of high school mathematics. To teach first-year algebra well, a teacher needs to know how the simpler skills and problems in that course are used in more complex skills and problems to be studied in later years, how algebra is used in geometry, and how the study of functions fits in. Thus middle school teachers now not only need to have a broad knowledge of mathematics and how to teach it, but 8th grade teachers need to have a broad knowledge of the teaching of high school mathematics.

It is quite difficult to determine what mathematics U.S. students are taking in high school. NAEP data has historically asked students to indicate the highest mathematics course taken. From this we can roughly determine the percents of students who have enrolled in each high school mathematics course. These percents have been rising steadily for 30 years, as seen in Table 3.

Table 3: Percents of 17-year-olds reporting highest level of math course taken

Course	1978	1990	1994	1996
Pre-Algebra or General Math	20	15	9	8*
Algebra I	17	15	15	12*
Geometry	16	15	15	16
Algebra II	37	44	47	50*
Precalculus or Calculus	6	8	13	13*

*Indicates the % in 1996 is sigificantly different than that in 1978. Source: *NAEP Trends in Academic Progress* (Campbell, Voelkl, and Donahue, 1997; Campbell, et.al., 1996; Mullis, et. al., 1991)

The taking of algebra at 8th grade has had the expected effect on course-taking at the high school level, and more. From the reports of the 12th graders in 1996, 92% had taken or were enrolled in first-year algebra, 79% geometry, 63% a second year of algebra, and 13% precalculus or calculus. The datum on precalculus or calculus enrollments disagrees with TIMSS data for enrollments collected a year earlier in which 22% of 12th-grade students were classified as taking or having taken precalculus or calculus (Mullis et al., 1998, p. 19).

On the 2000 NAEP, the course-taking question was changed from prior years. Students were asked to identify the course they had taken in each of grades 8 through 12. From their responses, 94% report taking a year of algebra, 88% report taking a year of geometry, and 80% report taking a second year of algebra. That last statistic seems quite high to me, and I wonder if some students are not reporting a second year of first-year algebra as if it were what we might call "advanced algebra." Responding to the same question, 37% reported taking precalculus, 18% reported taking calculus, and 18% reported taking a course in statistics (Braswell et al., 2001, p. 169). Examining individual student responses, NAEP evaluators found that 50% of students reported taking either trigonometry, precalculus, statistics, discrete mathematics, or calculus before or during 12th grade.

The NAEP percentages all seem high, but they are not as high as those found from reports of students taking the SAT.

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SAT-takers are not a random sample of college-intending students since weaker students often do not take them, and in non-SAT states only the best students take the SAT. But SAT data can indicate whether the NAEP data are on track. Last year, 24% of seniors taking the SAT reported taking calculus before graduation, and 45% reported taking precalculus. These numbers are up from 19% for calculus and 32% for precalculus ten years ago.

The most reliable data come from various studies of transcripts done by the U.S. Department of Education. These data tend to support these high percents. Table 4 shows that 26.2% of students in 1978 took mathematics beyond a second year of algebra, while 41.4% took such mathematics in 1998. In this transcript report, 14.4% of graduating seniors in 1998 took calculus.

Table 4: Coursetaking in advanced mathematics

Year	Level I (Adv Alg, Trig)	Level II (Precalculus)	Level III (Calculus)
1982	15.5	4.8	5.9
1987	12.9	9.0	7.6
1990	12.9	10.4	7.2
1992	16.4	10.9	10.7
1994	16.3	11.6	10.2
1998	14.4	15.2	11.8

Source: National Center for Education Statistics, *The Condition of Education 2000*, pp. 66, 157, 216.

The cluster of statistics on enrollments yields a robust conclusion: students are taking more mathematics now than they did ten years ago. The result is that high school mathematics course offerings look quite different now than they did 20 years ago. Geometry is now the most offered mathematics course at the high school level. Second-year algebra rivals algebra for second place. Significant numbers of students are taking courses beyond second-year algebra. We at UCSMP take pride in these numbers, too, because we think we had something to do with the trend. We just wish that more people would recognize that we support 8th grade algebra for large numbers of students, not because we think all of them should take calculus in high school, but because we think most students should study mathematics beginning with algebra for five years before calculus. This is the only way for many students to obtain the broad kind of mathematics education needed today.

The pressure on high schools for well-trained mathematics teachers thus comes from a number of major changes in the curriculum. Relatively few high school students now take courses below algebra. Students are taking more college-preparatory mathematics than ever before. And because more students are taking algebra in 8th grade, the mathematics they take in high school is more advanced. On top of this there has been a major change in the kind of instruction that is considered best for students—from instruction that is mostly lecture and explanation, to instruction that engages the students in discovery, problem-solving, and discussion. And on top of that, the standards have been raised from facility with skills to facility with problems. A teacher who might have been reasonably qualified to teach in 1980 can easily lack the qualifications needed by a teacher today.

Reducing the Shortage

Let me begin with the obvious. To reduce the shortage of qualified mathematics teachers, we need to train more mathematics teachers and we need to keep good teachers in the classroom longer.

Tout the Profession

To train more mathematics teachers, we need to attract more people to our profession. Teachers play an important role. I for one decided to teach when I was an 8th grader because I had a teacher, Mrs. Wright ("My name is Wright and I'm always right" was her motto), whom I adored and who seemed to love her job. And then in 9th grade I decided to teach mathematics because I liked math, but I had a teacher who destroyed the subject for so many students. My decision to go into teaching was reinforced every time I encountered a poor teacher; I felt so strongly I could do a better job. I couldn't wait to student teach to see if this was true.

If you enjoy your job, and then you have students who show a desire to teach others, talk to them about teaching. Play up our field. Mathematics is one of the noblest enterprises of humankind. It is interesting, useful, and beautiful. Mathematics is a part of literacy and knowing a good amount of it is part of being a literate citizen. It is too important for people to be content with mathematical ignorance.

Mathematics has special aspects that differentiate teaching it from the teaching of other subjects. Point out the enormous influence a mathematics teacher can have because, unlike reading and writing and social studies that are often learned as much out of school as in it, almost all the mathematics a person knows is learned in school. And mathematics is particularly interesting to teach. Some students have attitudes

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towards mathematics quite unlike their attitudes towards any other subject: they may have math anxiety, or dyscalcula, or disdain that they would never have towards reading, writing, or science. They may have been told by a parent to expect not to be able to succeed in mathematics because the parent didn't. At the other end of the spectrum, many students enjoy doing mathematics and force a teacher to look for interesting or challenging problems. And in the middle are the vast majority of students who need to know mathematics and can be swayed either to like the subject or dislike it depending on the quality of instruction.

Find a reason to bring students to your local meetings of mathematics teachers, so that they can see that teachers do things other than teach, and that there is a community of nice people who teach.

Even one teacher can have enormous influence. We have had a quite small MAT teacher-training program here at the university. Over the years, I have had at least four students in the MAT program who attribute their decision to go into the teaching of mathematics at least in part because of John Benson, one of the Great Teachers we have with us today. I am sure other students of his went into teaching but studied elsewhere.

Reduce the Barriers to Entry

We also need to reduce the barriers that keep good and interested students from entering teaching. Many students who might make great teachers and who are very bright, are turned off either by the content of mathematics beyond calculus or by the way that content is taught. They came to college having enjoyed mathematics, and possibly thinking of majoring in mathematics, but they find themselves in courses that seem to have nothing to do with the mathematics they enjoyed. They may follow a curriculum designed for those going on to do research in mathematics even though they have no interest in research. At last year's conference, I spoke of the special mathematics needed by teachers. Since then, the Conference Board of Mathematical Sciences has recommended special mathematics courses for all teachers (CBMS 2000). If advertised widely, these courses might be attractive enough for students interested in teaching to keep them in mathematics.

Requirements for certification present a problem in many states. Virtually every state has requirements for three types of courses: subject matter (in our case, mathematics), professional education (methods, educational psychology, etc.), and general education (a couple of courses here, some there, etc.) The subject matter and professional education requirements connect to the job. But the general education requirements seldom do. Why should every teacher in Texas have to take a course in the history of Texas? Why should every teacher in Illinois have to take a course in political science? Every college that I know with a mathematics department has distribution requirements for its bachelor's degrees. The existence of the undergraduate degree should be taken as evidence that a prospective teacher has had a broad education. This would make it much easier for many people with college degrees interested in teaching to try to enter the profession. In mathematics and science, this would enable engineering graduates to more quickly obtain certification.

Examinations that prospective teachers must pass pose a different problem. Of course, all teachers should be competent in reading and writing. A mathematics teacher ought to be competent in the mathematics the teacher is certified to teach. But it makes little sense for a teacher to be certified K-8 if the teacher only wishes to teach kindergarten or first grade. When there is an exam, one way to increase the number of those who pass is to tailor the exam more specifically to what the teacher will teach. Some people may want the flexibility of being able to teach at all grades K-8. Some districts may want their teachers to have that flexibility. Then it makes sense for a teacher to have to take more tests to show competence at all those grades. But it seems quite reasonable to have broad teacher-training programs in colleges and then have exams that are more specific.

The mathematics needed to teach the grade intervals K-2, 3-5, and 6-8 varies so much that the NCTM Principles and Standards split their descriptions for these grades. So perhaps there should be three different tests for teaching mathematics in grades K-8. Certainly there should be a closer match between what we put on those tests and what the teacher needs to know in order to teach what he or she plans to teach.

An eternal problem is that the cut-offs on these teacher-induction tests are arbitrarily set. In Illinois, there is now a debate whether a prospective teacher needs to obtain above a particular percent correct on each subject part, or whether the parts can be combined and the prospective teacher needs only to obtain a global score higher than some percent. Just two days ago the Superintendent of Public Instruction noted that if the global cut score is placed at 50%, then only 70% of people overall who take the test will pass, and only 30% of the minority candidates.

There is no credibility to such results. On any test, a test-maker can write simple questions that will yield high percents of correct responses and subtly complex questions on the same topic that will yield lower percents of correct responses. By

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these means, a test-maker can manipulate any test with sufficiently many questions to raise or lower the percent of students who will pass. A more objective criterion is needed. But even without an objective criterion, the more information given about the test to those who take the test, the greater number that will pass. In Illinois, this was the first year the so-called "harder test" was given, so there was little guidance regarding what it would cover or how prospective teachers would fare.

Reward Rather Than Punish

Another problem is that the mere fact of having such a certification test, particularly a "basic skills" test, demeans the profession. Why should a smart individual enter a profession that requires a basic skills test for certification? One possibility is to sweeten the pot by providing cash rewards for individuals who take the test and score the highest.

In the same vein of favoring positive reinforcement over negative reinforcement, once a teacher is on the job, states should not have penalties for not meeting some requirement for teacher renewal. As strongly as I believe there is a need for teachers to engage in professional growth, to give a penalty for non-engagement is to demean the profession. Even though the law changes constantly, we do not require lawyers to engage in professional growth to keep their license. Similarly, once a CPA, always a CPA unless there is malpractice. Only if we were in a time of surplus, might we be able to afford the luxury of culling the profession for reasons other than incompetence. If we must have teacher recertification, then give a bonus for engaging in professional activities rather than a punishment for not engaging in them.

Improve the Conditions of Teaching

Obviously one can help to reduce the shortage of teachers by improving the conditions of teaching itself.

The variance in working conditions among teachers is quite large. In many schools, teachers are treated as the professionals they are. They do not make the salaries of doctors, but they can live comfortably on their salaries. They have a nice computer and a phone on their desk. They can attend professional meetings and take additional courses either partially or wholly at school expense. Benefits are competitive. There are two or three free periods a day in which to help students and prepare lessons. In other places the job is carried out under far-less-than-optimal conditions. We must be honest in describing job conditions to prospective teachers, but we do not have to say to them what we would say at a bargaining session with the administration. The more awareness that can be raised about treating teachers as professionals, the more likely we are to reduce the shortage.

Why Is It So Difficult to Prepare Good Mathematics Teachers?

This question was posed at a meeting in Washington last week billed as an education summit on the mathematics education of teachers. None of three panelists asked to answer it tackled the question. Perhaps they did not want to give the answer, which is actually quite easy. *It is difficult to be a good mathematics teacher.* It takes education, experience, lots of planning, and great skill to carry out the plan.

In fact, it may be that the lower the grade level the more difficult it is to be good, because students at lower grades know less and can do less, and because teachers at lower grades tend to be given less time to prepare lessons.

Good teaching requires not only knowing content and pedagogy but being able to match those to the students one is teaching. Compared to teaching in a middle school or high school, teaching at the college level is a snap. A professor can succeed knowing only the content. Pedagogy is ignored by resorting to lectures. Students are viewed as having to show their stuff regardless of the quality of teaching. There is no open house for parents, no accountability.

My son is a senior at one of the top universities in the country. It hurts me to hear how often he complains about the quality of teaching there, about the poor quality of the lectures from people who know their subject well. More professors than we college faculty would like to admit think that all they have to do is exposit their subject without error, and that this constitutes adequate teaching.

Mathematics seems particularly sensitive to poor teaching. Some years ago I was asked by our Graduate School of Business to speak to incoming faculty about the teaching of mathematics. Why did they invite me to come in? The business school considered the quality of teaching to be important for its competitive success. Reports from students indicated that students felt that in courses that utilized a good deal of mathematics, the professors did not explain the mathematics well. Let us emphasize the point: knowing mathematics well does not at all guarantee that you can teach it well. In mathematical terms, knowing mathematics may be necessary but is not sufficient for teaching it well.

Summary

Perhaps what is needed most is for us to remind the public of how great a job we perform. Not only can we *do* mathematics, we can *teach* it. Ask someone in business if they would like to direct five meetings a day, each 40-55 minutes in length, and then be held accountable for what the people who attended

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each meeting got out of it. Ask a college professor if he or she would be willing to have someone from the outside come in and give his students a test they have never seen, with the results published in a newspaper. Teaching mathematics used to require mainly the ability to explain algorithms and grade students on their ability to carry them out. Now it requires a breadth of knowledge including statistics as well as mathematics, applied mathematics as well as pure, in all areas of elementary mathematics.

Mathematics is essential in today's world. Good mathematics teachers not only *count*, but they *measure* up well to any other professionals. Good mathematics teachers are important *figures* in the community; they help to solve *problems* of society; they help society to *function*; they are not just another *statistic*.

A job that seems difficult to those who do not do it is not necessarily a difficult job to those who do it. I point out the many aspects of teaching to indicate how hard good teachers work and how well they perform, not to brand teachers as martyrs. I will repeat: it takes great knowledge and skill to be a good teacher. To reduce the teacher shortage we need to get that message across to all of society and reward teachers commensurately.

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Results from the Evaluation of the Second Edition of UCSMP's *Advanced Algebra*

What impact have the changes to the second edition of *Advanced Algebra* made on students' attitudes and achievement? How does UCSMP *Advanced Algebra* compare with more traditional second-year algebra texts? These were the primary questions that motivated "An Evaluation of the Second Edition of UCSMP *Advanced Algebra*," by Denisse R. Thompson, Sharon L. Senk, Zalman Usiskin, Gurcharn Kaeley, and David Witonsky, the final report analyzing the 1995-1996 *Advanced Algebra* second edition field study.

Advanced Algebra is the fourth of six courses in the UCSMP secondary curriculum. Like other UCSMP courses, it integrates reading so that students develop the ability to learn on their own as well as from teachers and classmates, and it covers UCSMP's four dimensions of mathematical understanding—skills, properties, uses, and representations (SPUR). This text addresses the important questions students have about why they need algebra by using real-life applications to motivate concepts and skills. The course incorporates a modified mastery-learning strategy with continual review, an end-of-chapter review, and a self-test tied to objectives. In an earlier 1987-1988 formative study of *Advanced Algebra's* first edition, teachers felt its strengths were its clarity and organization, the examples of applications of mathematics, and its suggestions for teaching, particularly in the use of technology.

With input from Zalman Usiskin and Sharon Senk, Co-Directors of the Secondary Component of UCSMP, Gurcharn Kaeley designed, monitored, and oversaw the second edition evaluation study, combining both formative and summative analyses. The study was composed of two parts. In the first part, evaluators took the unprecedented step of comparing first and second editions of a high school mathematics textbook.

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UCSMP Programs Increase Test Scores

In the context of accountability, mathematics instruction across the nation is under scrutiny. President Bush's education initiative, No Child Left Behind, has pushed the issue even further by incorporating additional accountability measures, stressing mathematics and science excellence as an outcome.

UCSMP, with over 3 million students using its materials, has had numerous evaluations by researchers. A number of districts using UCSMP have recorded student achievement data over time that indicate positive results. Their data provide us with compelling stories.

Illinois Districts Make Gains

Kildeer Countryside District 96, located about 30 miles northwest of Chicago, serves several middle- to upper-class suburban communities. A total of 3,600 students in kindergarten through eighth grade attend district schools.

According to officials from District 96, the ability to understand and apply math concepts—not rote memorization—is the key to understanding mathematics and better test scores. That means students learn how to solve problems in a variety of ways, understanding how they got their answers. The proof for District 96 is in their scores on the 2001 Illinois Standards Achievement Tests (ISAT), a new statewide test initiated in 1999.

In 2000, 80 percent of the district's fifth graders met or exceeded state math standards; in 2001, the percentage jumped to 91 percent. According to district officials, the cause of the rise in math performance is attributed to *Everyday Mathematics*, which Kildeer Countryside began implementing one year at a time in 1996, when the 2001 fifth graders were in kindergarten. Therefore, the 2001 fifth grade class had used *Everyday Mathematics* throughout the elementary grades, while the 2000 fifth grade class had followed another curriculum. The rise in test scores can be seen as the effect of the *Everyday Mathematics* curriculum among two sets of very similar students.

"It's having children understand the reasoning behind the computations," says Arlene Steinberg, a District 96 math specialist. "They develop meaning as opposed to rote drill and practice. When it comes to problem-solving, students are required to give explanations about how they arrived at an answer."

According to Superintendent Thomas Many, "The trend line is moving up, and that's very rewarding for all of us."

For McClure Junior High School in the Chicago suburb of Western Springs, Illinois, the proof is in the test scores.

Teachers require students to try new concepts on their own at home beginning in sixth grade. They discuss the concepts in class the next day. This approach is part of the UCSMP curriculum, which McClure uses K-8. Also part of this program is the introduction of algebraic concepts as early as 4th grade, and McClure has taught some form of algebra to all 8th graders for at least 15 years. At McClure, which includes 6th through 8th grades, an accelerated 8th-grade group takes a full algebra course; 65 percent take about half that course. Experts say this early introduction of algebra, traditionally taught in 9th grade, helps improve test scores. In 2000, 81 percent of McClure's 8th graders met or exceeded state standards on the ISAT. In 2001, the number was 94 percent. The statewide average was 50 percent in 2001. According to math teacher Barb Simak, "They can't just sit back and be observers. They need to think and not just recite." McClure educators say that is the key to good teaching and learning in math.

South Carolina Suburban and Rural Schools Show Improvements

Lexington-Richland School District 5, serving several rapidly-growing suburban communities located near Columbia, South Carolina, has long been recognized for academic excellence. Shortly after the last state math adoption, several Lexington-Richland Schools adopted *Everyday Mathematics* for all grade levels simultaneously. The first year was difficult, says the district's math curriculum coordinator, but they addressed the issues with staff development and support. "We had to let our teachers know that we realized they were encountering a lot of math that had not been taught at the elementary level before, including geometry, algebra, and probability," says Fanni Simmons, the math curriculum coordinator. Our staff worked together to produce grade-specific parents' handbooks that provided information and support about

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the new content, procedures, and components of *Everyday Mathematics*.

Ms. Simmons states, "Students are learning more mathematics than they were ever expected to in the past." The 5th grade scores show the trend: 28 percent of the students at Lexington-Richland scored at the advanced level of the Palmetto Achievement Challenge Test (PACT) Scores in 2001, compared to 11 percent in 1999.

Fennell Elementary, located in Yemassee, South Carolina, serves a very rural, very poor area in Hampton County. Of the 275 students who attend Fennell, 91 percent are eligible for free or reduced price lunches. First grade teacher Peggy Bing O'Banner started using *Everyday Mathematics* materials in her classroom in 1996 to supplement the adopted text. Her class's scores were going up at such a rate that the principal implemented *Everyday Mathematics* in grades K through 3. Buoyed by the success of these students, the school received a grant to implement *Everyday Mathematics* throughout Fennell. "My students love math," says Ms. O'Banner. More importantly, they are speaking and thinking mathematically." The 5th grade test scores show the progress the school has made, thanks to Ms. O'Banner's initial success: 77 percent of the students scored at the basic level or above of the PACT Scores, compared to 43 percent of the students in 1999.

Washington State's Northshore District Makes 29 Point Gain on the WASL

Northshore School District is located in the Seattle-Everett metropolitan area, serving 20,000 students in the three suburban communities of Bothell, Woodinville, and Kenmore, Washington. *Everyday Mathematics* was fully implemented at Northshore K through 6 in 1997. The implementation was supported by a full complement of professional development activities, starting with the philosophy and design of *Everyday Mathematics*. After one year of *Everyday Mathematics* under their belts, the Northshore School District moved to a new professional development model, seeking to refine use of the program in the classroom. Nancy Young, Assistant Director of Elementary Education, says, "The challenge of any professional development is to support teachers so that they feel competent and confident teaching mathematics."

Ms. Young says *Everyday Mathematics* makes a difference in how students perceive math: "Students are challenged in a positive way and are more actively involved in math. Kids are more willing to dive in and persevere with math. With *Everyday Mathematics* it's great to see small children think deductively, intuitively, and to be successful with mathematics."

Washington State uses a standards-referenced test that tests mathematics in 4th grade. The Washington Assessment of Student Learning (WASL) requires the application of basic skills to problem-solving tasks and real world situations. Since adopting *Everyday Mathematics*, the percentage of students meeting or exceeding the mathematics standards at grade 4 has climbed 29 points, from 35 percent in 1996-1997 to 62 percent in 2000-2001.

Kentucky School Believes Professional Development Is the Key

East View Elementary School in rural Owensboro, Kentucky, is located about 20 miles southeast of Evansville, Indiana. Fifty-five percent of East View's students qualify for a free or reduced price lunch.

"We were looking for a challenging new mathematics curriculum, which emphasized problem solving. That's what we found with *Everyday Mathematics*," states Principal Julie Hawkins of the math adoption in fall 1998.

The principal believes a key factor in East View's success is in the professional development: "The quality of professional development training from *Everyday Mathematics* is now the benchmark against which I measure all other professional development programs." The teachers in East View use all the materials available. Ms. Hawkins states, "I think that is one of the reasons for our success with the program. The games and other hands-on activities are essential."

Finally, *Everyday Mathematics* seems to engage East View students. Ms. Hawkins says, "When I have lunch with students, I always ask, 'What is your favorite class?' Now, I frequently hear students tell me that their favorite class is math! I think our students opened up to math because they were interacting with it, playing games, working on projects together."

These districts represent only a few of the schools using UCSMP materials, but each shows measurable results for the progress their students are making in mathematics. Most attribute that progress to the UCSMP materials their school uses. In times when accountability is such a pressing issue for schools, test score gains and increases in student interest in math are goals all schools wish to embrace.

NEW EVALUATION REPORT

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Student achievement was measured in order to compare the implemented curricula of UCSMP's two editions. The second part of the evaluation compared the implemented curricula UCSMP's second edition to three other widely-used, second-year algebra texts.

Design of the Study

Initially, classes for the study were selected in ten states in different parts of the country. To participate in the study, a school needed at least four sections of second-year algebra students. Participating schools were located in Oregon, Montana, Colorado, Kansas, Texas, Mississippi, Georgia, Pennsylvania, Massachusetts, and Illinois. The study tried to achieve a demographically mixed sample of students. However, because classes could not be selected randomly, a matched pair design was used. To control for factors such as socioeconomic status, size of the community, and location, each school had to supply both a class using the UCSMP second edition text and a comparison class (either a class using the UCSMP first edition text or a non-UCSMP text). To control for differences in mathematical abilities between the UCSMP second edition and comparison classes, students in both classes were given a UCSMP-developed, multiple-choice pre-test. As a result of this pre-test, the final sample included 13 pairs of classes (383 students) for the UCSMP second edition versus UCSMP first edition component, and eight pairs of classes (306 students) were in the UCSMP second edition versus non-UCSMP component.

At the beginning of the year, students completed a questionnaire that addressed attitudes and technology use. During the second semester, each field-trial school was observed for one to two days. Toward the end of the school year, students were given a multiple choice post-test, a problem solving and understanding test, and a questionnaire similar to the one at the beginning of the year. All UCSMP second-edition teachers were asked to complete a chapter evaluation form after teaching each chapter. They met in Chicago twice during the year to give feedback to the developers. Extensive individual interviews were conducted and recorded. Then, at the end of the year, teachers were asked to complete a questionnaire.

Conclusions

Although the first and second editions of *Advanced Algebra* are quite similar in content, there are two major differences. First, the second edition begins the study of functions in Chapter 1, allowing functions to play a central role as a thread running throughout the course. Second, Chapter 14, Dimensions and Space, was removed from the second edition. Other changes to the second edition focus on instructional features: the second edition encourages more active learning by students, including group explorations, small-group activity, and writing in mathematics. Teachers who use the second edition are encouraged to use broader assessment practices by including extended projects at the end of each chapter. Graphing calculators became more available when the second edition was planned; *Advanced Algebra* requires students to have continual access to these calculators during the course.

The non-UCSMP texts used to compare with *Advanced Algebra* were *Algebra and Trigonometry: Structure and Method, Book Two* (Dolciani, Sorgenfrey, Brown, and Kane 1986); *Merrill Algebra Two with Trigonometry* (Foster, Rath, and Winters, 1983); and *Addison-Wesley Algebra and Trigonometry* (Smith, Charles, Keedy, Bittinger, and Olfan, 1988). Although there were considerable similarities in the mathematical topics covered by the UCSMP and non-UCSMP texts, the study found that there were significant differences in the emphases placed on the four dimension of understanding. The three other texts tended to have problems that emphasized the skills dimension more, while the UCSMP text had problems that were more evenly distributed among the four dimensions. In addition, a greater number of problems and examples in the UCSMP text tended to apply real-world contexts.

There were similarities and differences in instructional features (no in-class activities in non-UCSMP texts), but there were substantial differences in the way UCSMP *Advanced Algebra* (second edition) and non-UCSMP texts treated technology. In the non-UCSMP classes, calculator use was a part of instructional practice, although the texts did not support their use.

The UCSMP second edition versus non-UCSMP component of the study confirms the conclusions from the first edition studies: *Advanced Algebra* students maintain their hold on traditional advanced algebra skills while enriching their advanced algebra background in the application of algebra and in problem-solving and understanding of mathematics. For the UCSMP second edition versus UCSMP first edition component, the report concludes that student performance was as strong for students using the second edition as the first.

The full report of this study is available from UCSMP. Call 773-702-1130 for information.

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