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Making Points For MATHEMATICS EDUCATION REFORM

A Presenter's Guide

THE MATH CONNECTION
American Association of Colleges of Teacher Education
American Association of School Administrators
Mathematical Association of America
National Association of Elementary School Principals
National Association of Secondary School Principals
National Association of State Boards of Education
National Council of Teachers of Mathematics
National School Boards Association

Coordinated by the
Mathematical Sciences Education Board

TO THE USER:

The document you have in hand is a Work In Progress. Our intention is to keep it that way. Like the new developments and changes in mathematics education, this *Presenter's Guide* is not etched in stone.

One of the purposes of this booklet is to provide a helping hand to those of you on the front lines of these changes. Another purpose is to give those of us at greater distance from your communities and schools the opportunity to share in all the feedback we can get from you, so that we can more closely attune our efforts to yours. We need your help at least as much as you will need ours.We would appreciate your completing the enclosed evaluation form after you have reviewed this booklet and have used it at least once for a presentation.

Unlike the vision of mathematics that most of us were reared on – a rigid, time-locked set of rules, relationships, and abstractions – mathematics today is a dynamic, and ever-changing subject, much more anchored in the work-a-day problems of the present world than in those of our ancient past.

All of this seems strangely at odds with traditional wisdom about school mathematics curricula and their value in teaching "rigorous and logical thinking." And, because it seems strange it is not surprising to find a good deal of opposition among parents, teachers, and even some school administrators to some of the ideas being proposed—especially as these changes follow on the heels of the ill-conceived and well-remembered New Math of a couple of decades ago.

What is new about **Math Power** is that it solidly incorporates the best of the "old mathematics" and builds upon it. The curricular changes are a mixture of pedagogy and content, whose primary purpose is to dramatically increase the mathematical literacy of all students.

We know **all children can learn mathematics.** They don't know this yet, neither do many of their teachers and very few of their parents. We also know that learning mathematics can and should be an enjoyable experience for **all** children.

FACTS & FIGURES

- By the year 2000, the U.S. economy is expected to create more than 21 million new jobs, most of which will require both postsecondary education and the use of mathematics. *A Challenge of Numbers*; 1990, National Academy Press.

- The numbers of U.S. students receiving bachelor's, master's, and doctoral degrees in the mathematical sciences were lower in 1986 than they were in 1966. *A Challenge of Numbers*; 1990, National Academy Press.

- An enrollment of about 3.6 million ninth graders 14 years later results in only about 400 U.S. doctorates in mathematics awarded. *A Challenge of Numbers*; 1990, National Academy Press.

- A comparison of math and science skills among students around the world shows American 13-year-olds scoring at the bottom of a group of five countries and four Canadian provinces. *A World of Differences*; 1989.

- Only 16 percent of American 13-year-olds can compute with decimals, fractions and percentages; recognize geometric figures; and solve simple equations. *National Assessment of Educational Progress*; 1989.

- Mothers in Minnesota, China, and Japan were asked to rank the importance of effort, natural ability, luck, and difficulty of school work in determining a child's performance. Japanese mothers ranked effort the highest, while American mothers put natural ability first. *Chronicle of Higher Education*; January 11, 1989.

- The average Japanese high school student (50th percentile) knows more mathematics than the average American gifted and talented high school student. *The Underachieving Curriculum*; 1987

- Of the nation's 200,000 secondary school teachers of mathematics, over half do not meet current professional standards for teaching mathematics. Probably no more than 10 percent of the nation's elementary school teachers meet contemporary standards for their mathematics teaching requirements. *Everybody Counts*; 1989, National Academy Press.

- By the year 2000, over 40 percent of new workforce entrants will be minorities and immigrants. *America's Choice: High Skills or Low Wages*; 1990, National Center on Education and the Economy.

- One in five American children – one third of our future front-line workforce – is born in poverty. *America's Choice: High Skills or Low Wages*; 1990, National Center on Education and the Economy.

NOTES

five minutes

EVERYONE CAN LEARN MATH. VERY FEW DO. WHY?

Everyone can learn math...but few people do because:

- Hardly anyone believes they can – not parents, teachers, or children.
- We currently teach an antiquated curriculum using medieval methods.
- Mathematics is more than arithmetic and learning is more than memorization.
- Excessive drill can kill the mathematical – and economic – futures of all children.

There are a handful of classrooms in this country in which **all** children not only learn mathematics, but enjoy the experience. These classrooms can be found in both urban and rural, in poor and majority minority districts. In these schools, all the children have mastered the whole number arithmetic curriculum by the end of the second or third grade. This feat is "normally" not accomplished until fourth grade and then only by about half of American students, with many still at it in grades seven, eight, and nine. On the other hand, visitors to these schools see very young children happily learning elements of algebra, geometry, and statistics as well as their "sums and products."

The teachers are not miracle workers nor magicians. They are simply engaged in applying what we now know about good teaching and learning in mathematics, as described in the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics*. They are demonstrating with all students that everyone **can** learn math.

NOTES

more than thirty minutes

Do the thirty minute version and sit down.

Bridging the Arithmetic-Algebra Gap

A California-based program for middle school teachers and students was designed to help bridge the arithmetic-algebra gap between elementary and secondary schools. It involves teachers in the reconstruction of the pre-algebra/ algebra curriculum in an institute that is run in conjunction with a school's regular summer program. Morning sessions are devoted to working with students in workshops organized around a problem-solving format. Afternoons are hands-on seminars in which teachers become familiar with the broader mathematical implications of the new curricular material and pedagogy.

Both teacher and student sessions place a high priority on collaborative learning. They operate under the philosophy that the application of mathematics to real, data-based problems is a more intuitive and natural way of learning, rather than the traditional reverse, where abstractions are first memorized and then applications sought. Plotting the recorded data from in and out of class experiments, students see the real-world significance of the intersection of curves, develop a sense of the connections among data, graphs, and events; and integrate algebraic, geometric, and physical concepts with an intuitive introduction to the ideas of calculus.

A visitor to one of these classrooms would have difficulty in knowing whether it was science or mathematics that was being taught, and would be even more surprised by the enthusiasm of both students and teachers. The program has been funded by the National Science Foundation.

ten minutes

- **EVERYONE CAN LEARN MATH** (see *five minutes*)

- **ECONOMICS AND DEMOGRAPHICS**
- **MATH POWER**

Economics and Demographics

The U.S. economy ranks first in today's world because we are the richest nation in the world. In the next twenty years the information technologies will become world commodities. When that happens, the U.S. must either have become the smartest nation in the world or accept a serious decline in living standards. Economic survival in the 21st century will require us to maintain a leading position in the development of cutting-edge technologies and their applications. This can only be done with a mathematically powerful citizenry.

American schools have done well at producing an educated elite. While that was sufficient to supply the command, control, research and development needs of an economy based in the industrial-mechanical technologies of the late 19th century, it isn't good enough anymore. To be competitive in today's global information economy, every student needs an elite education. A characteristic of information technologies is that users must be able to problem solve, communicate, reason, and make connections. No one should leave school without these skills. This means that everyone must become more proficient in the use of mathematics and better versed in mathematical concepts.

Our nation's "math gap" cannot be bridged by fixing only some schools. Jobs requiring mathematical skills, such as data analysis, problem-solving, pattern recognition, statistics, and probability, are growing at nearly double the rate of overall employment. In the past, white males have usually filled such jobs. But by the year 2000, over 40 percent of new workforce entrants will be minorities and immigrants. The American "jobs problem" is no longer one of too few jobs, but of too few skilled workers for existing jobs.

Math Power

There is a re-defining of mathematics education which holds that:

- Mathematics is much more than an abstraction of rules and calculations.
- Mathematics arises naturally out of real-life problems and should be studied that way.
- Some mathematics is learned more efficiently in groups.
- Hands-on is better than hands tied behind your back.
- Counting on fingers is no longer a punishable offense.
- Manipulatives of all types are a proven means by which every child learns mathematical concepts.
- Calculators and computers are as essential to learning mathematics as tape measures and carpenter squares are to building houses.
- To know mathematics is to have the ability to use mathematics.

The content, pedagogy, and spirit of this re-definition of mathematics are perhaps best captured by the images of the computer and the balance beam. No child who has puzzled through the concepts of arithmetic by manipulating weighted and numbered blocks on a balance beam is ever intimidated by the algebraic concepts of equality, unknown, or equation. Similarly, the ubiquitous computer and calculator give students the mathematical power to tackle real-life problems so complex as to be inaccessible without them. Moreover, computers and calculators have an unprecedented capacity to cast light upon many mathematical concepts.

Math Power upgrades our classical notions of what it means to **know** mathematics. For example, it is manifestly more valuable to **know** that seven times six is forty-two because seven groups of six things and six groups of seven things contain forty-two things, than because it is a number at the row/column intersection on a multiplication table. Finally, **Math Power** asserts that reading and writing are as essential to learning mathematics as these skills are to the study of history, geography, or any other subject matter.

Little Kids, Big Mathematics

There are schools in South Texas in which all second and many first graders can (among many other mathematical feats) add 10, 10-digit numbers. The kids call it Monster Math, and they're nuts about it. So are school officials, parents, and their teachers. On average, these first and second graders perform at grade levels well above grades two and three in both mathematics and reading on the California Achievement Test.

These results are obtained through elementary school curricular revision which is fully compatible with the NCTM *Standards*. An emphasis is placed on the development of strong counting skills which are then combined with the concepts of "trading up" and "trading down" or of making "fair exchanges" to drive whole number addition, subtraction, multiplication, and division.

The psychological benefits accrued to students, teachers, and parents upon witnessing first and second graders add any 10, 10-digit numbers and subtract any two 10-digit numbers would be difficult to overstate. Mom says, "Wow! You did that? I never could do that hard a problem." The kid comes back to school the next day with a grin on his face and says to the teacher, "Give me a harder problem!"

thirty minutes

- **EVERYONE CAN LEARN MATH** (see *five minutes*)
- **ECONOMICS AND DEMOGRAPHICS** (see *ten minutes*)
- **MATH POWER** (see *ten minutes*)
- **STANDARDS IN CURRICULUM, TEACHING, AND ASSESSMENT** (see *twenty minutes*)
- **CALCULATORS, COMPUTERS, FINGER COUNTING** (see *twenty minutes*)

- **SPECIFIC LOCAL PROGRAMS**

Specific Local Programs

It is difficult to imagine a school district today that does not have some pieces of an NCTM *Standards*-compatible curriculum in place in some school. If possible, these should be publicized. There isn't any experience quite as valuable as visiting a classroom in which all children are being successful at mathematics to resolve doubts in the hearts and minds of parents, teachers, and community leaders about the validity of the changes taking place in mathematics education.

The two programs below, while dealing with quite different student populations, share some important characteristics in their staff development format and structure. Both train teachers in the new curriculum in a summer-school setting which involves students, and feature year-long follow-up and further development.

- **NOTES**

twenty minutes

- **EVERYONE CAN LEARN MATH** (see *five minutes*)
- **ECONOMICS AND DEMOGRAPHICS** (see *ten minutes*)
- **MATH POWER** (see *ten minutes*)

- **STANDARDS IN CURRICULUM, TEACHING, AND ASSESSMENT**
- **CALCULATORS, COMPUTERS, MANIPULATIVES**

Standards for Curriculum, Teaching, and Assessment

Standards for Curriculum, Teaching, and Assessment are the three legs of the school mathematics reform triad. New standards in curriculum and teaching have been developed and promulgated by the National Council of Teachers of Mathematics. Through the efforts of the Mathematical Sciences Education Board, consensus has been reached on new standards for assessment in mathematics. The development of tests which will reflect these standards is well underway. In and of themselves standards for curriculum, teaching, and assessment, cannot change school outcomes in mathematics. But when applied to the classroom these standards change what mathematics is taught, how it is taught, and how the results are measured. This is the task which now confronts us.

This difficult and complex job of changing what goes on in classrooms between teachers and students is a fragile, bottom-up, developmental process of fermentation, experimentation, and percolation. Prototypes are introduced which must then be allowed to adapt, develop, and grow – subject always to the external parameters of standards in curriculum, teaching, and assessment. Meaningful change in education also requires a similar overhaul of the entire delivery system of pre-service teacher education and on-going staff development.

Calculators, Computers, Manipulatives

Calculators are smart chalk and computers intelligent blackboards. But as long as computers and calculators are mis-used and abused in our schools they will be a source of controversy.

The calculator is not second cousin to the "cheat sheet," although many still think of it that way: Teachers say, "Yes, we let them use calculators. But only to check their answers, and, never on tests." Computers enjoy somewhat the same shady reputation. "Computers are wonderful, in their place. We use them for drill and practice of the students who aren't getting it."

Used in these ways, the calculator and computer reinforce some of the worst aspects of the old mathematics: that mathematics is only about rapid pencil and paper computation in arithmetic, and that this is best learned by drill and rote. The NCTM believes that because "technology is changing mathematics and its uses," calculators and computers should be available to all students in every classroom at all times – both for the performance of calculations and to investigate and solve problems. There are more than 100 classroom-based studies that confirm that children who have access to calculators while learning arithmetic perform at higher levels on standardized, paper and pencil calculations than those who have been denied their use.

Manipulatives have been around schools a long time. Once thought of as useful only for those students "having trouble," they are now widely recognized as powerful tools for teaching mathematical concepts to all students. Some manipulatives, such as fingers and toes, are unavoidably available to all students at all times. All the others should be. Blocks, games, puzzles, balance beams, fraction cakes, and a whole assortment of other "manipulatives" used in the new elementary school mathematics have rendered obsolete the flash cards and drill and rote methods of the old curriculum. They have made the study of mathematics the most enjoyable part of the school day for children fortunate enough to be in schools engaged in learning mathematics in new ways based on the *Standards*.

■ **How would you rate the *Presenter's Guide* as an aid for making the presentation?**

❑ **Excellent** ❑ **Good** ❑ **Fair** ❑ **Poor**

*Comments:*_____

■ **What did you find to be the most useful parts of the *Presenter's Guide?***

■ **In your opinion, what were the least useful parts of the *Presenter's Guide?***

■ **Would you suggest any additions?**

■ **Would you suggest any deletions?**

Thank You Very Much. Your comments will be very useful in future revisions of this document. We appreciate your interest in mathematics education and your willingness to participate in the reform of mathematics by using and reviewing this booklet.

PLEASE RETURN THIS FORM TO:

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Making Points For MATHEMATICS EDUCATION REFORM

Evaluation Form

Name: _____

Address: _____

_____

Phone: (_____)_____

Title: *(Please indicate)*

- ❑ Elementary Mathematics Teacher
- ❑ Secondary Mathematics Teacher
- ❑ Mathematics Educator/Collegiate Level
- ❑ Elementary School Principal
- ❑ Secondary School Principal
- ❑ Local School Board Member
- ❑ State School Board Member
- ❑ Mathematics Supervisor
- ❑ Business/Industry Representative
- ❑ Other _____

Please describe the audience and/or setting for which you based a presentation on these talking points. For example: "My audience was a group of 45 parents of elementary school children in a PTA meeting," or "My audience was a group of 58 businessmen and women at a Rotary Club luncheon.")

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