Some Challenges Facing Mathematics Education in the United States of America

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Epilogue

This paper is based on a talk made at the National Chiayi University in Taiwan in January 2006. After presenting my list of challenges, I asked the audience to make a list of challenges mathematics educators are currently facing in Taiwan. As these discussions evolved, it became clear that many of the challenges I identified are also being faced in Taiwan. While solutions to these challenges are formidable, we know that one of the first steps in solving any problem is understanding and recognizing that a problem exists. In that spirit, I am sharing these challenges in a written form. Perhaps identifying these challenges will accelerate efforts to solve them.

Opening

Much is happening in mathematics education in the United States. Challenges abound, and the list is long. Here are five challenges I think need to be addressed:

- Implementing Standards
- Resolving the shortage of mathematics teachers
- Adapting to changing technology
- Making the best of mandated assessments
- Advancing knowledge with research

This is a short list. It could be longer. If other mathematics educators in the United States were asked to compile a list of challenges, their list would likely be different. However, I think the intersection of their lists would include many if not all of the above issues. Now here is some elaboration on these challenges.

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Implementing Standards

The United States has no national curriculum. In fact, education in the United States is viewed as a local responsibility. Historically each state and community has made their own decisions about what, when and how learning in schools should take place. There are 50 states and more than 25,000 school districts in our country. This approach has resulted in much duplication of effort as individual schools, school districts, and states have developed their own curriculum frameworks. This piecemeal approach has resulted in much variability of what and when specific mathematical topics are taught. For example, some states expect mastery of multiplication facts in third grade, while other state frameworks expect mastery in second grade, and still others in fourth grade (Reys, et. al., under review). This lack of consensus of when certain topics are taught has created havoc for textbook publishers and has resulted in much duplication of the mathematics content in textbooks across the grades.

In 1989 the National Council of Teachers of Mathematics released a document entitled Curriculum and Evaluation Standards for School Mathematics. This was a landmark document for our country. It was the first time that any professional organization had offered national recommendations related to curriculum. It identified content and process strands along with a vision for mathematics teaching and learning. This document was followed by Professional Standards for Teaching Mathematics (1991). These Standards stated that mathematics is for everyone, not just a select few. They also asserted that mathematics learning should be characterized by sense making. These Standards have resulted in some significantly different mathematics curricula becoming available. They also advocated approaches to mathematics teaching that were unfamiliar to many teachers.

The 1989 Standards were followed in 2000 with an updated version entitled Principles and Standards for School Mathematics. This document provided updates regarding mathematics content and processes that need to be addressed. These standards were identified:

Problem Solving

Communication
Reasoning
Connections
Representation
Number and Operation
Algebra
Geometry
Measurement
Data Analysis and Probability

The content of these Standards documents provided an ambitious vision for mathematics curriculum and teaching that is far from being realized in the United States. For more than a decade, widespread implementation of these Standards in classrooms across the United States has been a challenge, and there is no end in sight.

Resolving the shortage of mathematics teachers

For more than 20 years there has been a shortage of mathematics teachers in the United States. There are multiple reasons for the teacher shortage, and here are some of them:

- An increasing number of students in schools in the United States.
- More students are taking more courses in mathematics in secondary school.
- Fewer people are preparing to be mathematics teachers.
- Many people who might have become mathematics teachers have jobs in business, computer science, statistics, related technologies and industry.
- More mathematics teachers are retiring than are entering the profession.

This shortage has resulted in many mathematics classes being taught by teachers with limited mathematics background. For example the National Center for Education Statistics reports that nearly 70% of middle/secondary mathematics teachers in the United States lack a major in or certification in mathematics, and 95% of large urban school districts have an immediate need for mathematics teachers. This challenge has resulted in many large school districts recruiting mathematics teachers from other

English speaking countries, such as India. Recruiting teachers from other countries is only a bandaid approach to a challenge that requires a long term fix.

Adapting to changing technology

There is general agreement that appropriate use of technology should be an integral part of school mathematics programs. This includes a wide spectrum of tools for classroom use, including graphing calculators, spreadsheets, Geometer's Sketchpad, and Mathematicia. While support for technological tools is strong their availability and actual use in mathematics classrooms varies greatly due to teacher competence in using these tools as well as their availability.

Calculator use in elementary schools continues to be sporadic. The National Council of Teachers of Mathematics has a position statement on use of calculators and technology (available at www.nctm.org). A portion of the statement says:

> "when calculators are used effectively in the classroom, they can enhance students' understanding and use of numbers and operations. Teachers can capitalize on the appropriate use of this technology to expand students' mathematical understanding, not to replace it."

Striving for calculators to be "used effectively" remains a challenge. It should also be noted that while calculators are generally available, and are used in middle and secondary schools, calculator use in elementary school is much more varied. It is not unusual to find some elementary teachers using calculators in their classes, and other elementary teachers in the same school prohibiting the use of calculators. The same unpredictable use of calculator is seen in colleges and universities across the country. Some mathematics departments allow calculators to be used, others prohibit their use. Overall the investment in professional development of calculator use has been insufficient in the United States. Consequently, effective, consistent and widespread use of calculators in elementary school and colleges has not been achieved in the United States.

Making the best of mandated assessments

In 1995 the National Council of Teachers of Mathematics published Assessment Standards for School Mathematics. That document discussed different ways of using

assessments to promote and guide better learning of mathematics. While participation in international assessments and achievement tests have long been a part of the culture in the United States, during the last decade there has been an growing number of mandated assessments. These mandated tests have been developed at the state level and have typically focused on reading and mathematics. The results from these tests are widely published, and often cited when teachers and schools are evaluated.

In 2001, a new federal law entitled No Child Left Behind was passed. This law applied additional pressure on states and all schools within each state to have annual assessments that would be used to document annual growth of ALL students--including different sub-groups, such as gender and ethnic groups. Growth must be continuous over time (i.e., from one year to the next) otherwise schools are subject to potentially severe sanctions, including the loss of federal funds. The alignment of these state tests with individual school curriculum varies greatly. Consequently these mandated tests have placed great pressure on schools and classroom teachers for students to do well on tests over which the teachers have no control. Furthermore, the test scores do not generally impact individual student grades, so there is little motivation for students to do well on the tests. How to cope with this heavy emphasis on testing that is beyond teacher control is a major challenge.

Advancing knowledge with research

There has been a growing interest in research to guide educational decisions. Schools are looking for research evidence to guide practical decisions, such as

- What mathematics curriculum to use?
- Is the way mathematics is taught important?
- How should mathematics classes be organized to promote student learning?
- Do boys learn different than girls?
- How much homework is needed to anchor certain skills?

The list of practical questions for which mathematics teachers are seeking answers is virtually unlimited. And researchers in mathematics education are interesting in studying these issues in a systematic fashion. This would appear to be the ideal climate for initiating much research in mathematics education. So what is the problem?

First of all research in mathematics education is complex. There are many factors that influence outcomes, so even answers to what seem like simple and direct questions are difficult to produce (Berliner, 2002). Furthermore, there are very limited funds available to conduct research studies in education, and the United States Department of Education has set a "gold standard" for educational studies that are federally funded. Specifically the gold standard draws on the medical model and requires randomization to be an integral part of the research design. The randomization requirement makes it virtually impossible to get schools to cooperate in such research. In addition, research studies require additional time to collect data from students, via pre and post measures. This type of data collection imposes on actual instructional time. Teachers and principals are reluctant to sacrifice instructional time to research efforts. Thus designing and conducting school based research studies is a challenge, yet one that needs to be resolved if the frontier of knowledge in mathematics education is to be advanced.

Conclusion

During my talk, it became clear that at least one of the challenges in the United States are not a challenge in Taiwan. For example, while we have a shortage of certified mathematics teachers, Twaiwn has an abundance of teachers. For those of you that are excellent English speakers, there is a great opportunity for you to teach mathematics in the United States!

The challenges I highlighted here, related to Standards, Teacher shortages, Technology, Testing, and Research are not going to go away any time soon for us in the United States. They are complex. They involve many people. They require professional development. More money is needed to help address them. Having said that, the bright side is that these challenges are a reminder that our mathematics education community has much to do to resolve them. Our careers are built on the journey as we work toward solutions provided by the opportunities presented by these challenges.

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