The Evaluation of State Mathematics Standards: New Jersey Perspectives

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I am very pleased to be here today to share with you some information about the development of the New Jersey Mathematics Standards, and my thoughts about the evaluation of state standards and other related matters.

Let me begin with a few words about myself. I am a professor of mathematics at Rutgers University. In the research phase of my career, I wrote a number of articles in mathematics and also a monograph entitled "Linear Orderings" which was published in the Academic Press Series on Pure and Applied Mathematics. About fifteen years ago I started to work on improving mathematics education, and for the last ten years, have devoted essentially all of my efforts on this area.

One of my focuses has been discrete mathematics -- I direct NSF-funded teacher enhancement projects that have involved over 1000 teachers from all K-12 grade levels in doing discrete mathematics. One outgrowth of these projects is that we are for the first time able to describe what topics in discrete mathematics are appropriate for children at all grade levels, based in part on the classroom experiences of teachers in the programs. This is described in a volume called "Discrete Mathematics in the Schools", which is likely the only volume ever co-published by AMS and NCTM. These activities have been under the co-sponsorship of two centers at Rutgers, the Center for Mathematics, Science, and Computer Education, and the Center for Discrete Mathematics and Theoretical Computer Science, known as "DIMACS", an NSF-sponsored Science and Technology Center.

Another important focus of my efforts has been the New Jersey Mathematics Coalition, of which I was a founder, and which I have served as director since its inception in 1991. The New Jersey Mathematics Coalition is an affiliate of NASSMC, the National Alliance of State Science and Mathematics Coalitions, which together with the MAA and the AMS Committee on Education, is co-sponsoring today's panel discussion. The New Jersey Mathematics Coalition is governed by a board which includes all sectors of the community -- teachers of mathematics from elementary grades through college, mathematicians, policy makers, school and district administrators, and members of the business community and the public.

One of the first accomplishments of the New Jersey Mathematics Coalition was obtaining a grant from the United States Department of Education in 1992 to develop mathematics standards and a mathematics curriculum framework for New Jersey. This grant was actually received through the New Jersey Department of Education, as required by the proposal guidelines. Two strengths of the proposal were, first, that the Department was in the process of developing and adopting standards in all content areas, so that the standards developed through the funded project would actually be adopted by the state, and, second, the Coalition Board involved representatives of all the stakeholders in mathematics education, so that broad involvement and support would be available in the process of developing the standards and framework.

Members of the Coalition Board participated actively in the panel that developed the initial version of the mathematics standards in 1993. After the completion of the draft standards document, it was circulated widely by the New Jersey Mathematics Coalition -- to all those involved in mathematics education in the state -- and comments were received from nearly 300 individuals.

With the completion of a draft of the standards, work began on developing a curriculum framework based on these standards. After much discussion, it was decided that the purpose of the mathematics curriculum framework would be to provide information and guidance to teachers and districts in implementing the standards. Although the terms "standards" and "frameworks" are apparently used in many different ways, in New Jersey we are very clear about the difference between the two. "Standards" describe the goals of education, and "frameworks" provide assistance in reaching those goals. "Standards" describe what we value, and "frameworks" help us achieve what we value. In many states, what is called "standards and frameworks" correspond to what we in New Jersey think of as standards alone.

New Jersey is a "home-rule" state -- each of its nearly 700 districts insists on making its own decisions about the curriculum in its schools. The framework is not intended to be a curriculum. It is intended to be a framework, like that of a house, which each district can use to build its own curriculum or curricula.

As with a road-map, there are many possible routes that will get you to your goal, but your best route obviously has to take into consideration your starting point. Thus, a framework should provide guidance in making good choices, and not simply prescriptions of what should be done. This is particularly true because high standards cannot be implemented overnight and therefore require prioritization of what is to be done first.

I don't believe that a document like the New Jersey Mathematics Curriculum Framework exists in many other states.

Between 1993 and 1995, the adoption of standards moved to the back-burner in the Department of Education, with the arrival of a new Commissioner of Education, then the election of a new Governor, and then, of course, the appointment of a new Commissioner of

Education. In the meantime, however, the New Jersey Mathematics Coalition involved over 100 people in different aspects of the development of a preliminary version of the curriculum framework, and, as called for in the project proposal, the Coalition established teams in thirty district clusters, which used the framework as a guide to implement the standards in their schools. All of these efforts led to many comments about the draft version of the standards and the preliminary version of the framework. The involvement of an extensive and diverse group of people in the development of the standards and framework turned out to be very significant, because when the Governor and the Department of Education returned to the development of standards in 1995, we had in place not only a set of standards and a preliminary framework, but also a community-based model for how both standards and frameworks can be developed, and widespread involvement in and approval for the recommendations of the standards.

New panels were set up by the New Jersey Department of Education in 1995 to review and modify the earlier drafts of the standards, and comments were solicited very widely from both educators and the public. Standards were adopted in all content areas in May 1996 by the New Jersey State Board of Education. Once it became clear that the mathematics standards that we had generated would likely be adopted by the Board without major changes, we proceeded to develop the revised version of the New Jersey Mathematics Curriculum Framework. This was completed in December 1996 and displayed to the legislature in the Governor's state of the state address the following month. Given the positive reception accorded the mathematics curriculum framework, the New Jersey Department of Education embarked on the development of frameworks in all other content areas; moreover, it adopted our development model by recruiting for each content area an appropriate agency outside of the state department of education to serve in a leadership role.

The New Jersey Department of Education has taken the standards-based approach beyond the development of standards and frameworks. Indeed, since the standards reflect what we value in mathematics education, our statewide tests should assess whether students are achieving the goals of the standards, and we should be encouraging teachers to become involved in standards-based professional development activities. The state assessment program includes the development of new standards-based assessments in all content areas at grades 4, 8, and 11, and a state Professional Teaching Standards Board has been appointed to ensure that districts implement standards-based professional development in response to newly adopted state regulations.

A few words about the structure of the New Jersey Mathematics Standards and the New Jersey Mathematics Curriculum Framework. There are altogether 16 standards, each consisting of a short declarative statement, a longer "descriptive statement", and three sets of "cumulative progress indicators" which describe what students should know and be able to do at the end of the 4^{th}, 8^{th}, and 12^{th} grades. Roughly speaking, the curriculum framework has a chapter devoted to each standard. The chapter begins with a K-12 overview of the standard, which provides district personnel with a perspective on how they might implement the standard across grade levels. After that, each chapter contains five sections, directed to teachers at the K-2, 3-4, 5-6,

7-8, and secondary grade levels; each section includes an overview of the standard at those grade-levels and activities which would help the teacher implement each individual cumulative progress indicator at those grade levels. The framework was distributed in loose-leaf format so that teachers could copy sections that were appropriate to their grade level; the framework is also available on the Web (http://dimacs.rutgers.edu/nj_math_coalition/framework.html) and on CD-Rom (with the science framework).

I should add that I played a leadership role in the development and adoption of the standards and the framework. To my knowledge, New Jersey was the only state where a mathematician was involved so intimately in the development of state standards.

People often ask how New Jersey has avoided the controversies that have arisen in California. Let me offer three reasons for this. First, as I have already emphasized, the process of developing the standards and framework was inclusive. All were invited to participate, all views were shared, all views were discussed. Second, common sense prevailed over ideology. On issues such as use of calculators, instructional methods, grouping of students, we tended to make recommendations which took into consideration the valid and sensible arguments of both sides. The preface of the framework states: "The recommendations provided here are very specific. Yet, it is not intended that they be implemented dogmatically; different situations call for different responses and different strategies. In education, as in other areas, there is a tendency to swing from one extreme to another. We hope that educators will utilize their common sense, judgment, and experience in finding appropriate ways of using the recommendations in this Framework to inform their decision-making." Finally, in California, education decisions are made in a way that invites confrontation and politicization. On one important spectrum, "state mandate" vs. "home rule", New Jersey is at the opposite end from California. In California, it is determined at the state level which textbooks may be used in the state; in New Jersey, each of our 700 districts decides for itself. Large-scale decisions like that invite protest and politicization. Ballot referendums have the same effect. In California, programs can be initiated or abolished by referendum, so California will now swing from an all-ESL state to a no-ESL state, instead of allowing local conditions to determine the kinds of programs are most suitable. To summarize, I believe that New Jersey has not experienced the "math wars" because we have involved all stakeholders in the process of developing the standards and framework, we have used common sense in drafting our documents, and, serendipitously, we have avoided the politicization of mathematics education.

At this point, it would be appropriate to review the ratings that the New Jersey Mathematics Standards received from each of the three groups that reviewed state standards. Interestingly, our scores were all different -- an "A", a "C", and a "D".

In the rankings of the Council for Basic Education, New Jersey was the only state to receive an "A" for the rigor of its mathematics standards. That means that our standards, when compared with each of the 81 benchmarks in the C.B.E. mathematics framework, received an average score of at least 3.7 out of 4. I don't have a copy of the item-by-item report; however, my calculations indicate that we must have received a score of 4 on at least 60 of the 81 items,

indicating that with respect to those 60 benchmarks, the New Jersey Standards "require every student to learn all of the essential concepts and skills as defined by the framework benchmark at or above the level of sophistication specified." It should be noted that two of the New Jersey Mathematics Standards were not referenced at all in the C.B.E. benchmarks -- the areas of discrete mathematics and underpinnings of calculus, in both of which the New Jersey standards go far beyond what is expected in other states. So I will continue to state my "unbiased" opinion that New Jersey's Mathematics Standards are the strongest in the nation.

Since my comments about the other two reports will take me in a different direction, I want to point out that the information provided by the C.B.E. report, unlike that of the other reports, will indeed be useful when it comes to the five-year revision of our mathematics standards that is due to begin this year. That is because the C.B.E. report provides concrete information about how our standards correspond to a set of independently generated and approved benchmarks; the other two reports only provide general information.

Can the C.B.E. benchmarks be improved? Certainly. And that would be a very worthwhile effort. A broadly approved set of benchmarks would be very valuable to every state that is reviewing its standards, and would undoubtedly influence most states to move in the direction of those benchmarks.

In the rankings of the 1997 report of the American Federation of Teachers, New Jersey's mathematics standards received a grade of "D". The only statement made in its report was that "the math standards overemphasize skills without adequate grounding in content knowledge". In a telephone discussion I learned that this comment was based on our placing at the beginning of our list of standards those which dealt with problem-solving, reasoning, communications, and connections. I examined the standards of states which received an "A" from the AFT, and found no evidence that our standards were in any way weaker than theirs. (The framework was apparently not taken into consideration since it had no official status.) In the 1998 AFT report, recently released, no ratings are given; however, this time the New Jersey Mathematics Standards receives a check mark because "the new Test Specifications strengthen the math standards significantly by clarifying the specific content and skills that are absent in the standards". For example, they note that, according to the test specifications, eighth graders should be able to "find equivalent forms of fractions, decimals, and percents", apparently preferring that formulation to the more general formulation in the standards, which say that all students should "investigate the relationships among fractions, decimals, and percents, and use all of them appropriately". Of course, the committee which developed the test specifications based them on the standards, so it appears that the AFT's previous ranking was based less on what the standards said, but on the format that was used.

Finally, in the rankings of the Fordham Foundation, New Jersey's mathematics standards received a ranking of "C". In this study, that was a good ranking -- indeed, only 12 states received "A" or "B", and New Jersey's score was clearly the highest of those getting a grade of "C", so we placed 13 out of the 46 states rated. Curiously, the New Jersey mathematics standards received high marks at the elementary and middle school levels, but a very low mark

at the secondary level, and a comment about the "falling off of Content in the high school years". This is particularly striking because New Jersey's mathematics standards includes benchmarks under probability and statistics, discrete mathematics, and underpinnings of calculus that likely go far beyond what is expected in every other state. That was apparently ignored, however, but the report did cite that "no proof of the Pythagorean theorem is demanded". (At the 8^{th} grade level, the standards say that "all students should understand and apply the Pythagorean theorem".)

What disturbed me about the Fordham report was the bias of the authors. One bias was their focus on the words "proof" and "prove". In their brief discussion of the New Jersey standards, the authors note that "the classical content of mathematics, and its backbone of deductive reasoning ... , are often slighted in these standards", and later they note disparagingly that in our discussion of the evaluation of the sums of finite and infinite series, we omitted the word "prove". The rare use of the words "prove" and "proof" was a conscious decision on our part. Outside of our own circles, those words evoke the almost universal response "two-column proofs in geometry, the kind I had to memorize in high school, ugh!" Our goal was not to rehabilitate those words, but, rather, to get students to reason. We insisted throughout the standards that all students at all grade levels be able to understand, to explain, to demonstrate, and to justify all of the steps that they carried out. That was not good enough for the authors of the Fordham Report; we didn't "demand" proofs.

A second bias is their aversion to "real world" terminology. We challenged teachers to motivate their students through the many connections between mathematics and the real world, between mathematics and their world. That is one reason we gave greater focus, at the secondary level and earlier, to the areas of probability and statistics, discrete mathematics, and the concepts of calculus. Here is what the authors say about this: "There is visible in these documents a currently fashionable ideology concerning the nature of mathematics that is destructive of its proper teaching. That is, mathematics is today widely regarded (in the schools) as something that must be presented as usable, "practical", and applicable to "real-world" problems at every stage of schooling, rather than as an intellectual adventure." They go on to note that despite its successes in modeling reality, mathematics is to be seen as a "deductive system".

Let me ask you how many of your first-year liberal arts students would respond positively to the idea of mathematics as an intellectual adventure, or to the idea of mathematics as a deductive system. Then imagine how many students in an ordinary high school would respond positively to mathematics were it presented in that way. Then imagine how students in an urban high school would respond. Now all of us here became mathematicians because we loved the intellectual adventure, because we loved playing with equations. But that's not how the rest of the population appreciates mathematics. Students in the United States want to know "what it's good for", and the only way we will get them to appreciate mathematics is through its applications.

In a way the biases of the Fordham Report crystallize what "the math wars" are all about. It should be understood that there are two major problems for mathematics education in this country. One problem is to provide a good background in mathematics to all students, so that they will be able to find jobs in our increasingly global, technological, and information-based economy, and so that our nation will have enough skilled human resources to meet employment needs. Let's refer to this as the 80% problem. The second problem is to train the highly qualified personnel that will replace us -- the mathematicians, computer scientists, scientists, engineers. Let's refer to this as the 15% problem. Both problems are very important. Let me repeat that -- both problems are very important.

The standards movement primarily addresses the 80% problem. It seeks to improve the mathematical knowledge and competency of the student population as a whole. Its focus is not on dealing with the 15% problem. Many of those opposed to the standards movement are primarily concerned with the 15% problem -- in part because of their concerns about future scientists and mathematicians, in part because of concerns about their own children's future, in part because of excesses of the standards movement (where, as always, dogma tries to drive out common sense), and in part because some of those who support the standards movement do not recognize that there is a 15% problem at all.

Unfortunately, the solutions offered by those opposed to the standards movement may be solutions to the 15% problem but do not address the 80% problem. For example, an "intellectual adventure" or "deductive reasoning" approach to mathematics may help solve the 15% problem; but it will be entirely useless in dealing with the 80% problem.

We must reject the two radical perspectives that fuel the "math wars" -- the one which says, in effect, that we should forget about the 15% problem and focus entirely on the 80% problem, and the one which says, in effect, that we should forget about the 80% problem and focus entirely on the 15% problem. Each problem needs its own set of solutions, and trying to impose a 15% solution on the 80% problem is counter-productive.

The common sense perspective is to combine a "standards" approach to dealing with the 80% problem with a "beyond the standards" approach to dealing with the 15% problem. That's what our focus should be. Both problems can be addressed, and must be addressed, by our society. And the mathematical community should be supporting efforts which work toward addressing both problems.