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The Teacher of Mathematics:
Issues for Today and Tomorrow

Proceedings of a Conference

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PREFACE

These proceedings contain papers and speeches presented at the third in a series of national conferences sponsored jointly by the Mathematical Sciences Education Board (MSEB) and the Center for Academic Interinstitutional Programs (CAIP) on critical issues in mathematics education. This meeting was held at the University of California in Los Angeles (UCLA) on October 16 and 17, 1987, and was attended by 150 participants from across the country. The first two conferences dealt with testing and curriculum in mathematics. The focus of the third conference was on teacher education. It was organized by MSEB's Committee on Teacher Education, chaired by John Dossey.

The Mathematical Sciences Education Board was established by the National Research Council in 1985 to provide national leadership, coordination, services, recommendations, and information for improving the quality of mathematical sciences education in the United States for all students at all levels. The Board has 34 members and constitutes a unique coalition of mathematics teachers and supervisors, college and university mathematicians, educational administrators, and representatives of business and industry.

The Center for Academic Interinstitutional Programs is located at the Graduate School of Education at the University of California at Los Angeles. The center is concerned with the continuity of curriculum and instruction between UCLA and its feeder institutions, schools, and community colleges. CAIP offers professional development institutes in the summer and throughout the academic year for teachers, instructors, and counselors, both onsite and at UCLA. The center also works with state and national bodies to establish and implement educational policies.

The Mathematical Sciences Education Board and the Center for Academic Interinstitutional Programs gratefully acknowledge support for this conference from the:

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OVERVIEW OF THE CONFERENCE

John Dossey
Illinois State University

This conference on the education of teachers of mathematics was designed to provide a forum for four aspects of change now being advocated in mathematics instruction. These aspects are: the general reform movement in mathematics education and the emergence of a national standards board for subject matter areas; the appearance of draft copies of the Mathematical Sciences Education Board's (MSEB's) curriculum framework and philosophy document and the National Council of Teachers of Mathematics' (NCTM's) standards for school mathematics; the support bases for changes in teaching at the school, local, and state levels; and the formulation of guidelines for teacher education programs by the Mathematical Association of America (MAA) and NCTM. All of these issues resulted in a packed agenda and excellent attendance. The consensus of the participants was that the meeting represented an important step in providing facts and opinions required for the early stages of each of the four major issues under discussion.

Shirley Hill's opening talk set the stage for consideration of the issues of change that already are affecting teacher education programs and the performance of teachers in the classroom. Her remarks about the national reports on education, the goals envisioned for teaching as a profession, and the movement to establish national professional standards for teaching sounded the keynotes of the conference. These topics were underscored and expanded by Rick Marks in his comments on the formative work taking place at Stanford University under the leadership of Lee Shulman. This group is attempting to identify important concepts, procedures, and knowledge that effective teachers must employ in imparting mathematical skills and ideas to their students. Initial efforts have focused on the development of prototype exercises that might be used in the assessment of teachers' strengths in various areas of mathematics teaching. Mr. Marks outlined many of the probable contributions to be made by the center at Stanford, including detailed descriptions of the prototype assessment activities for mathematics. The model shown in the video tapes and discussed in his remarks indicated that emphasis is being placed on "what teachers need to know and what teachers must be able to do" in the teaching of mathematics.

This presentation was followed by Albert Shanker's luncheon address on his vision of changes in the teaching and learning of mathematics. This vision, which is consistent with those of the MSEB curriculum framework and the NCTM standards, predicts future progress in teaching being made in an environment that promotes increased knowledge and higher goals for students. The changes envisioned may involve school entrance ages, the packaging of curriculum, and the delivery of instruction.

The afternoon session dealt with specific recommendations for change in the mathematics curriculum and was highlighted by the remarks of Thomas Cooney. He provided a challenging, in-depth analysis of the prospects for change outlined in the conceptual models developed by Fred Goffree and William Perry. He pointed out some of the hurdles that must be cleared if we are to achieve the basic instructional and philosophical goals of the new curricula. His remarks were pointed, well-founded, and cited the major tasks that must be undertaken if "mathematical power" is to become a reality in our classrooms.

The following morning, participants heard presentations on ways in which teachers can change and the support required for such changes to occur. June Yamashita reviewed her study of winners of the Presidential Award for Excellence in the Teaching of Mathematics. Her findings showed that professional activity played a major role in the continued learning and development of these individuals. Further, they seemed to build their own networks to support their professional growth. These observations were echoed by Magdalene Lampert in her remarks about the distance between the ideal and the realities of the mathematics classroom. She described clearly the distance between what is possible and what is happening now. She also listed the challenges that must be addressed to narrow this discontinuity in mathematics education. These challenges may hold the key to moving teachers from the mechanistic, textbook-bound setting to the reflective, problem-solving mode envisioned by many reformers.

Jack Price and Ted Sanders provided outlines of what local districts and states can do to support teachers in building networks and in gaining access to continuing education for the teaching of mathematics. Both stressed the importance of allowing teachers to have a voice in setting the agendas for change. They also discussed the need to support teachers during their early professional years through induction programs designed to foster increased competence in dealing with the day-to-day problems of the classroom.

The program closed with a useful and lively discussion of the guidelines for the continuing education of mathematics teachers proposed by NCTM and MAA.

The Challenge

The challenge that remains for those in attendance, as well as for those who read these proceedings, is to continue the discussion, to analyze the issues, and to become active in the reform of teaching philosophy and methods. This transitional process will require

attention to the implications of change, the development of curricula--both for students and for teachers, the creation of supporting networks for teachers involved in change, and the establishment of criteria that define the bounds for professional mathematics educators working in the schools of our nation.

As mathematics educators, we must move to a consensus of what we need to do to make these changes, to define the appropriate interactions between such changes, and to implement new visions of curricular assessment and programmatic changes in school mathematics. The situation of the individual teacher in the classroom will not alter until more basic reforms are made in administration, scheduling, and expectation. The pronouncements of teacher education specialists and teacher organizations alone will not alter conditions. Change in one part of the educational system will not be enough. All aspects of the nation's educational infrastructure must be altered to meet the new educational needs of our country. We can delay no longer in starting to overhaul the engine that fuels our children's minds and drives our nation's competitive edge forward in the world's economy.

NEW PERSPECTIVES ON THE EDUCATION OF TEACHERS

Shirley A. Hill
Chairman, Mathematical Sciences Education Board
and
Professor of Mathematics and Education
University of Missouri-Kansas City

The focus of this conference is on teaching mathematics in the general sense. My remarks are more specific, in particular, about perspectives on the education and preparation of teachers. However, we cannot talk about teacher education and teacher preparation except in the contexts of teaching and of the profession in general. I shall attempt to set the stage for the proceedings in order to try to bring out some of the issues that are crucial in teacher education today.

These are interesting times in teacher education. Many things are happening and there are a number of initiatives that hold great promise for the future. But none of them is without the attendant risks that profound changes entail. The implications of today's proposals and movements and their goals and objectives are profound. In fact, they are often revolutionary in their goals--revolutionary because they ask for and, indeed, demand deep structural changes in schooling, in institutions, in the governance of schools, in attitudes about schooling, learning, and teaching, and in deeply entrenched traditions.

They are also revolutionary in terms of a concept that is new to education and that may be the most important premise underlying the very serious movement today in education generally and in teacher education specifically. It is the premise that we cannot achieve change by any one or two of the means proposed--not by them alone. We cannot achieve change by intervening at only one or two or several points in the system, not by just changing textbooks, tests, even school law and governance, not by changing the practice of legislative mandates or the teaching profession itself--not alone. Alterations in all of these are probably necessary for the overall changes needed, but no one is sufficient by itself. In part, our failures in the past to make sustained changes were failures to understand this point and this concept. Our professional organization reports, pronouncements, recommendations, and guidelines have not had the deeper effects we had hoped they would have. They have been responsible, but often naive. They have been intellectually sound, but in some ways simplistic. Our task today is to change a very complex system by moving at once on all points, in an interrelated, interactive, coordinated, and planned way.

Can this be done? Will it be done? We cannot afford not to try. What are the risks? There are always negative aspects to any revolution. In other words, if we have to bring down traditional structures to make room for new and untested ideas, if we strike down what has been built up over long periods of time, what will be left if we fail and if the new ideas do not keep their shining promises?

To undertake what is being proposed, and what many of you are doing already, requires either extraordinary hubris or else one must be convinced of its dire need. We are at that point--dire need. Others would say this is arguable, and there is evidence on both sides of that issue. After all, we are not without operational standards today. There are the standards of professional groups, whether called standards or guidelines. There are the standards of accreditation agencies which have been in place a long time and are revised frequently. There are the standards represented by state requirements and state testing. Certainly, the present system has its defenders. Each component of the system will find proponents--defenders who will not welcome change. When we talk about change, we must consider those serious vested interests. But, at some point, we have to assume the good faith of all of the players in the game.

My own positions on teacher preparation rest on these assumptions:

- First, the system of education of teachers, both initial and continuous, needs a drastic overhaul now.

- Second, the forces in motion at this time will result in substantial change, but the choice of whether this change is structural and sustained is still ours to make.

- Third, old distinctions--for example, between pre-service and in-service, between undergraduate and graduate, between teacher and supervisor, between coursework and apprenticeship, between theory and practice--should be discarded and abandoned. They no longer serve a purpose.

- Fourth, we must accept what I call the "discrepancy" model of teacher education: this is that an individual completing the formal teacher education program, whether undergraduate or graduate, is not a complete teacher yet. Teacher education should be a continuum, a seamless whole, a continuing process; as in life itself, we continue to learn and to change.

We have all read a great deal about the recommendations made in the report entitled *A Nation Prepared: Teachers for the 21st Century,* issued by the Task Force on Teaching as a Profession of

the Carnegie Forum on Education and the Economy. When teacher assessment for purposes of certification is discussed, two questions are often asked. They are questions that we need to consider at length. First, "What should a teacher know?" (in our case, "What should a teacher of mathematics know?") and, second, "What should a teacher (of mathematics) be able to do?" I accept these questions as starting points, but I submit that they are too limited. They are intended to encompass more. First, "What should a teacher know, understand, and believe?" And, second, "What should a teacher be able to do, and what criteria should this teacher have in making judgments about what to do and when to do it?" These questions have to be applied in both licensing and certifying teachers. It is important to make a clear distinction between those two words. When I say "licensing," I mean the state's legal responsibility to provide teachers with licenses to teach. When I use the words "certificate" and "certifying," I mean a professional standard.

To what and when, in the continuum of teacher education, do we apply these particular questions in their specific detail? To start our discussion, let me suggest that we begin completely at the beginning by asking ourselves the question, "What is a teacher?" And, for our opening discussion, I propose three parts for the answer:

- First, a teacher is an educated person, in the current jargon, perhaps, a culturally literate person, but I would go well beyond that; a teacher is a liberally educated person whose education is a foundation for thought, choice, and the application of values in all realms of life, including the teaching profession.

- Second, a teacher is a specialist; a teacher is an authority, an expert in teaching, in subject matter, and in content. This includes the understanding of content-specific pedagogy and all that this entails. It also means an understanding of the context of application of the content in which the teacher is an authority.

- Third, the teacher is a skilled craftsman and artist. This is the vocational education part of preparing to be a teacher--the teacher's ability to deal with all aspects of the job, the teacher as a manager.

Now, what is a professional? Traditionally, the term "professional" has included at least the last two components of my three-part answer--a specialist and a skilled craftsman. In fact, professions other than teaching typically have included an emphasis on these two. A colleague of mine, a philosopher, has been critical for many years of the training in a number of the professions because he says that it produces "skilled barbarians." Perhaps that is an apt term. In teaching, especially when we finally have the kind of

profession that everyone respects as a profession in every sense, it will not be enough to be only a specialist and a skilled craftsman. Teachers should be known by all of society as educated people of that society. Professionalism also demands demonstrated standards determined by the profession itself. It demands self-governance, ethics, commitment, and a positive self-image--a good and positive self-image of the profession.

I would like to turn now to the salient points of two reports that recommend changes in teaching and teacher education--movements that have a good deal of momentum today and which may have considerable influence. One of these reports is by the Holmes Group and is called *Tomorrow's Teachers*. The second is the Carnegie report I mentioned earlier, entitled *A Nation Prepared*.

Tomorrow's Teachers states:

> We have become convinced that university officials and professors must join with schools, and with the teacher organizations and state and local school governments that shape the schools, to change the teaching profession. Schools, no less than universities, are places in which teachers learn.

Here is the idea of teacher education occurring in schools as well as in colleges and universities. Teacher education is a continuum. Teachers are not completed professionals upon graduation.

There are two major points in the Holmes Group report that are radical. One is the proposal of a differentiated teaching profession. Let me quote further:

> It seems indisputable that teachers' assignments must be changed. The best education will be no antidote to demeaning jobs that make little room for what has been learned, that offer few incentives for learning more, and that are swamped with clerical and other responsibilities....Above all else, teaching must make room for top practitioners who can lead their field to improvement. This means jobs in which fine teachers can use their pedagogical expertise to improve other teachers' work, as well as to help children. It means jobs in which teachers can become experts in a specialized area.

And here is what they propose:

> [J]obs in which real leaders can exercise the responsibilities and reap the rewards of serious professionalism.

They call these leaders "career professionals" and they would play a role in teacher education not unlike that of a clinical professor of medicine. However, the majority of the teaching force would be "professional teachers," people who have proved their competence at

work through rigorous qualification examinations. These jobs would differ from those of today's teachers in their more serious educational requirements. They would be jobs in which teachers would continue to learn and improve, among other ways, through their work with one another and with the career professionals. Finally, many teachers would be novices. They are called "instructors." They would be beginning teachers. Work as instructors would offer many talented people an opportunity for service and learning and give them a chance to explore a job about which they might be uncertain. Instructors would be qualified to teach, but their work would be supported and supervised by career professionals. This array of teaching assignments would make room only for well-educated teachers.

The second of the radical changes is the one we have been hearing a great deal about. It proposes an extended initial preparation for teachers and includes a degree in a discipline:

> [T]he undergraduate education major must be abolished in our universities. For elementary teachers, this degree has too often become a substitute for learning any academic subject deeply enough to teach it well. These teachers are certified to teach all things to all children. But few of them know much about anything because they are required to know a little of everything....Professionally certified teachers should teach only subjects they both know well and can teach well.

The report continues by stating that these changes should not stop with abolishing the undergraduate education major. It says:

> We argue...that eliminating those majors without dramatically improving the academic subjects that undergraduates learn would be a sad error. To cut down on courses in pedagogy for intending schoolteachers without improving pedagogy in the universities would make a horrible joke of educational reform.

This item draws attention to the responsibilities of the universities. Much needs to be done at the university and college levels to improve pedagogy and to "revise the undergraduate curriculum so that future teachers can study the subjects they will teach with instructors who model fine teaching and who understand the pedagogy of their material."

Another part of the Holmes report that is central to the present topic states:

> Finally, along with all of these changes, our schools and universities must open up new connections with schools. One connection would be to bring expert teachers into universities as more important and more responsible participants in professional education....Bringing expert teachers into universities will require forging new arrangements with schools to redefine those teachers' jobs.

This suggests joint appointments and the clinical medical faculty analogy holds again.

The Holmes Group recommendations certainly could not take place without some basic structural changes in the schools. I believe that those changes will have to go hand-in-hand and be made interactively, not just in parallel, with changes in teacher education. If we try to alter the preparation and education of teachers without those structural changes in the schools, the changes we make will be irrelevant at best, and counterproductive at worst, with the loss of some small gains that we have made already. I agree with the call for stronger subject matter preparation for teachers and with the need for teachers to be liberally educated people. I also agree that pedagogy should be primarily content-specific. There is a point which is often missed in the political and public discussions about the criticism of teachers as "education majors." Often, the education major is simplistically characterized in the media as someone who is prepared to be a teacher and has taken a lot of education courses, but does not know specific subject matter. Obviously, that is a misunderstanding of teacher preparation. Our secondary preparation programs and licensing requirements already demand a strong major in the subject matter field. That major often requires for high school teachers of mathematics a stronger mathematics program than for many other degrees associated with applications of mathematics. The subject matter preparation for secondary mathematics teachers may include more mathematics than is required for engineering, for example. And, yet, the public appears to be quite content with the idea that engineers, retired engineers, retired military personnel, and retired whatever else can step in as fully prepared mathematics teachers.

The Holmes Group report is somewhat facile, often silent, in its delineation of what the subject matter major for an elementary teacher should be. It does acknowledge that the elementary teacher cannot be educated in depth in all subject areas, but, having diagnosed that problem, it has not come to grips with the solution. I, too, want a liberally educated person who knows the subject matter he or she teaches, instructing at every level of the elementary schools. There is far too little mathematics in the preparation of elementary teachers. For a literature major or a history major teaching mathematics at those levels, there may be less. And I would assume that teachers in the fields of literature and history would have the same concerns about mathematics majors teaching elementary school children. The concept of the self-contained classroom, with a teacher who teaches many subjects, cannot assume that he or she is a specialist in all of them. This dilemma has led to proposals in some quarters that mathematics in the elementary school, beginning with the fourth grade, be taught by teachers who are prepared as specialists in mathematics. There appears to be increasing support for this proposal.

The concept of a degree in a specific discipline for all teachers has some potential side-effects that could be counterproductive. The typical requirement in mathematics for elementary teachers is one or two courses. But, since the early 1970's (earlier in some places), these courses have been courses designed for teachers. They can be solid content courses and are surely more appropriate than the precalculus or first calculus courses. There was a consensus in the mathematics community on the general concept of these specially designed courses and they represent a small but significant gain in elementary teacher preparation. Would taking proposals for subject matter majors for elementary teachers too literally result in the loss of even these modestly small steps in progress? It could.

Another problem addressed occasionally in the Holmes Group report is the phenomenon of the isolation of teachers. In 1975, a study by the National Advisory Committee on Mathematical Education of the Conference Board of the Mathematical Sciences, entitled *Overview and Analysis of School Mathematics, Grades K-12*, pointed out that a large proportion of teachers have never seen another teacher teaching since their own student teaching experience. The more recent *Second International Mathematics Study* shows that teachers' meetings in this country typically cover administrative or housekeeping details; the study contrasted this with Japan, where teachers' meetings typically cover teaching or curricular matters. Perhaps at the heart of this problem is the issue of <u>time</u>; time to share, time to plan, and time to interact with other teachers. Our teachers have not had that time. American teachers have not had a window on the world of teaching; rather, they have had a mirror that reflects their own experience with their own schooling, and with only their own experiences as a teacher. No one in the world today works in such splendid isolation as teachers. Even in advanced research, much work is done in cooperative situations. Schools will need to provide time, not just for individual thinking in research and planning, but the time for teachers to interact, to learn from one another, and to plan together.

From the Carnegie Task Force report, *A Nation Prepared,* I want to mention two major ideas. One concerns the initial preparation of teachers. The Carnegie report says that

> The undergraduate years should be wholly devoted to a broad, liberal education and a thorough grounding in the subjects to be taught.

It also notes that elementary teachers need solid undergraduate preparation as much as secondary teachers and must be able to demonstrate a substantive understanding of each subject they teach. This, the report maintains, may mean that elementary teachers will have to "organize themselves differently" and teach fewer subjects. Surely, the writers would concede that teachers cannot do this without support. School districts, administrators, and teachers must

restructure cooperatively. It may mean specialist teachers of mathematics teaching well down into the grades of the elementary school. The report goes on to say that

> Arts and sciences faculties must join their education colleagues, and, together with the leaders of professional and disciplinary societies, begin by undertaking a thorough review of the undergraduate curriculum for the education of prospective teachers....Arts and sciences faculties also need to give careful scrutiny to their undergraduate majors. These majors are typically constructed with the needs of other professions in mind.

The second major point, and one on which the Carnegie Task Force has taken a major initiative already, is that teaching should be established in all respects as a profession. To accomplish this, the Carnegie report proposed the creation of a National Board for Professional Teaching Standards. The board's primary functions would be to establish standards for high professional teaching competence and to issue certificates to people who meet these standards. This means certification by a professional body, not licensing--which is the domain of the states. These two need to be kept distinct, whatever may be the terms in current usage.

The National Board for Professional Teaching Standards has been incorporated. Ultimately, a majority of the membership of the board will be elected by holders of the certificates. That is the goal. Initially, the members are appointed. The board is not likely to succeed unless the standards it sets are high, it represents a broad consensus of those concerned with the goals of public education, and, above all, it represents the views of the developing profession itself. It must represent the views of the developing profession itself on the question of what standards of practice should be considered fully professional. What is envisioned is a profession organizing itself, developing its own standards, governing itself, and providing certificates for those who demonstrate by agreed-upon assessment methods that they meet the standards. The process is conceived to be voluntary.

There is a bargain implicit throughout the Carnegie report that forms an important element. The bargain is this: the profession, talking to society, says: "We are willing to develop the high standards that are demanded in this profession, to hold ourselves to them, and to monitor ourselves with respect to them." Society, for its part, needs to be willing to provide the conditions necessary for a true profession. The conditions include not just adequate financial compensation, but also an environment that provides teachers autonomy as decision-makers in their realms of expertise. This bargain is a remarkable social compact and is, in my view, feasible.

What about assessment? It should enable the board to judge the quality of the candidates in general education, in their mastery of the subjects they teach, in their knowledge of good teaching practices in general, and in their mastery of the techniques required to teach those subjects. To accomplish these objectives, the assessment techniques will have to go far beyond multiple-choice examinations. They will have to employ state-of-the-art techniques, and likely will be in large part performance-based.

The board is especially mindful of equity issues. The problem of the underrepresentation of minorities in the teaching force is deeply rooted and especially troubling, and will not be solved by the actions of a national board, however farsighted. But a national board with clear objectives related to the representation of minority teachers can do much to help.

The certification process envisioned by the task force that wrote the Carnegie report would be completely voluntary. There is no requirement that would be imposed on new teachers or teachers currently in the work force to participate. But the task force expects that many people will wish to do so because the certificate will be an unambiguous statement attesting that its holder is a highly qualified teacher.

There are challenges for everyone in the continuing initiatives in education today. If society wants professional teachers, it must be willing to provide the conditions to make that possible. There is a serious challenge to our teacher education programs, even at the initial level. What we have in these suggestions is a real challenge to course design in our colleges and universities. We will have to do a lot of redesigning, not just at the program level, but in the courses themselves and in the ways in which they are taught. Schools, too, must take responsibility for continuing, systematically planned teacher education. The education of teachers will be a continuous process, a seamless fabric going through college and on into the early years of teaching.

I would like to close by quoting two influential people who made the following remarks recently:

- Lewis Branscomb, formerly the chief scientist at IBM and now at the Kennedy School of Government at Harvard University, said, "There is no way we will have good schools unless we are willing to trust the teachers. After years of teacher-bashing, we must entrust education to the teaching profession."

- Governor Thomas Kean, of New Jersey, said, "Our task must be put in the context of overall school improvement, but teaching, great teachers, are the key to that process."

We have immense support for what we are about to do. We have opportunities that we have never had. The climate is right. Yes, there are dangers; there are the risks (these always go along with real change), but we have the best opportunity that we have ever had to make significant, positive changes in teaching, in the profession of teaching, and, most important, in the schools and in education itself.

I hope you have a very productive conference. We appreciate your participation and hope you will share your ideas. We all can learn together. The ideas you share will play a critical role in the work of the Mathematical Sciences Education Board. The issues we will address here are of extreme importance to the board. They are to all of you. Thank you--and enjoy the conference.

THE VISIONS AND THE CHALLENGES

THE ISSUE OF REFORM: WHAT HAVE WE LEARNED FROM YESTERYEAR?

Thomas J. Cooney
University of Georgia

As I understand the central issue before us, we are concerned with the question of how the National Council of Teachers of Mathematics' (NCTM's) *Curriculum and Evaluation Standards for School Mathematics**, currently being developed, could or should impact on mathematics teacher education programs. I think this question and the issues in which the question is embedded are not only highly relevant to our professional interests, but are, ultimately, primary to our professional activity. My experiences, both as a teacher and as a teacher educator, suggest that the task ahead is significant and awesome.

A Brief History of Reform

We should keep in mind that there is a long history of mathematics educators expressing concern about the teaching and learning of school mathematics. At the turn of the century, E. H. Moore urged that schools abolish the separation of algebra, geometry, and physics. During the same period, John Perry emphasized the importance of applications and laboratory-teaching techniques in the teaching of mathematics. Following World War II, the Commission on Post-War Plans pointed to serious shortcomings in Americans' mathematical knowledge (NCTM, 1970). Kline (1958) questioned the underlying philosophy of much of the modern mathematics movement. Euphoria reigned during the pinnacle of that movement, with some claiming considerable success in promoting curricular reform (see, for example, Adler, 1972). Later reflections, however, were less sympathetic, suggesting that the teaching of modern mathematics was

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*References to the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* are based on the Working Draft dated October 1987.

sterile and notation-bound (see, for example, Rising, 1977). Good and Biddle (1987) have argued that observational studies that detail carefully what happened in classrooms during the modern mathematics movement are virtually nonexistent, thereby making it difficult to determine just what the nature or effectiveness of the reform movement really was. These points provide some historical perspective for our current situation and some sense of the problems associated with previous reform movements. I recall well Harold Brody's admonition that "Ignorance is the mother of educational innovation." It is important for us to understand that our current effort at reform through the *Standards* is but one of many efforts to reform mathematics education. I hope we have learned from the lessons of yesteryear.

I think it is important to consider the times in which recent reform movements have occurred. In the 1960's, there was considerable belief in the "reasoned" man and in the notion that intellectualism could lead society toward the resolution of its problems--educational, economic, and societal. As a young practicing teacher, I remember the advice that permeated most professional meetings: "Teach the structure of mathematics and all else will fall into place."

But something went awry. Politically, the country became less confident that the science that put man on the moon could solve its pressing social, economic, and educational problems as well. In society, the notion of accountability emerged. In education, the buzzword was "relevant." And so, in the 1970's, we saw the emergence and proliferation of competency-based educational programs that were mired in the framework of behavioral objectives and couched in the seemingly infallible slogan: "Practice makes perfect."

As Alan Osborne predicted at a 1970 NCTM meeting, we left our decade of renaissance and our flirtation with Camelot and began an era of anti-intellectualism manifested eventually in the "back-to-basics" movement. We were never really sure what "back to basics" meant, but it was certainly something different from the intellectualism that characterized the 1960's. And so, in the late 1970's, we had the lunacy of children--my child--doing a page or two of long division problems and then checking them on a $9.95 calculator. We began to see what Romberg (1987) has described as antiprofessionalism, in which teachers were denied the opportunity of becoming true professionals because their tasks were becoming increasingly "deskilled." Teachers became less the decision-makers and more the implementers, maybe even the technicians, of mandates from above. While once we could have been accused of having an educational system that could be described as "each age in his cage," we now began to see an educational system that featured "each age on the same page."

But the pendulum had swung too far, and people from many walks of life began to sense an impending disaster if something were not done. Witness *A Nation at Risk* (1983) and the volumes of comments that it spawned. Specific to mathematics education, witness studies such as the *Second International Mathematics Study* and the resulting reports, and the recommendations given in *School Mathematics: Options for the 1990s* (1984).

The middle school curriculum represents a particular concern because of its "flatness" and the fact that it fails to include many new topics (Flanders 1987). This is particularly obvious when the curriculum is compared with middle school curricula in other countries, particularly France and Japan. The effects of the back-to-basics movement with respect to middle school mathematics are revealed when one compares the results from the *First International Mathematics Study* with those of the *Second International Mathematics Study*, particularly the achievement in arithmetic, which dropped 6 percentage points (see McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers, and Cooney, 1987). A study by Miwa (1987) on the achievement of middle school Japanese students underscores further the need for reflection on our middle school mathematics programs. Miwa presented the following results:

Table 1
Achievement Items for Japanese Fifth- and Sixth-Grade Students

Fifth Grade

Find the value of X which satisfies each X x 4 - 2 = 6	(85.8% correct responses)
5/6 + 3/8 = X	(80.8% correct responses)

Sixth Grade

When we substitute a positive number into [ ] of the following expressions, the greatest is a.[ ] x 1 1/2 b.[ ] x 1/2 c.[ ] - 1 1/2 d.[ ] - 1/2	(63.0% correct responses)
We buy apples for A yen and oranges for B yen, and hand a 1000 yen note. How much change do we have?	(61.2% correct responses)

Various studies by Stevenson and Stigler (Stevenson, Lee, and Stigler, 1986; Stigler, Lee, and Stevenson, in press; and Stigler and Perry, 1987) leave us with the impression that elementary schools in

Taiwan and Japan are more academically oriented, that their students are more motivated, that their teachers have greater support for the time they need to prepare lessons, and that their students learn because of effort, whereas our students learn because of ability. In short, the American teachers' task of teaching elementary school mathematics is much more difficult than that of their Japanese or Taiwanese counterparts.

In light of the various reports on the status of American education and studies such as the *Second International Mathematics Study*, we can hardly reach any conclusion other than that reform of some sort is sorely needed. The need for reform is considerably deeper than altruism on the part of the educational community or society more generally. The long-overdue recognition of the connection between our nation's economic well-being and the state of our educational system, particularly as far as mathematics education is concerned, suggests that the fiber of our nation's economy is very much related to the success of our educational system. Jennings (1987) refers to this connection as the "Sputnik of the 80's," in terms of its impetus for reform. No longer can society view education and competitiveness in the international marketplace as disconnected happenings. Thus, we need to consider the issue of reform, the form it might take, and the means by which the *Standards* can influence or drive that reform.

The Notions of Standards and Reform

Uninterpreted, the term "standards" should give us some pause. It suggests universal applicability, regardless of the context or circumstances in which the standards are to be applied. Such application can have the potential to constrain and confine mathematical activity that cries for flexibility and creativity. In my view, any attempt to consider standards for mathematics education must be tempered with a good dose of wisdom and humility when such standards are applied to increasingly complex educational settings. Used as a heuristic for reform, a rebellion against the status quo, the *Standards* can provide guidance for significant improvements in mathematics education. Used literally with insensitivity to local conditions, I fear that the result could be another instance in the annals of mathematics education of reform foiled from the top down.

Allow me to address the question of what shape reform can take. The Cambridge Conference on School Mathematics (1963) focused on curricular reform by addressing the sequencing of topics, but dismissed the practicality of classroom teaching and related teacher education problems as issues that could be resolved when the time came to do so. It was assumed that the "top professional experts" were in the best position to design curricula for both the practitioner and the consumer because they could judge best what mathematics was needed for the "next course" in mathematics. It was

a classic instance of reform suggested from the top down. In contrast, the membership of the NCTM Working Groups that developed the *Standards* represented a cross-section of classroom teachers, supervisors, teacher educators, mathematicians, and researchers. The issue of reform from the top down, however, still lurks on the horizon.

Do we see reform as "paper reform," as was the case with the School Mathematics Study Group and the "modernization" of school mathematics? I would hope not. To me, reform should be considered a humanistic enterprise rather than a matter of paper reform. Reform needs to be based on human innovation and activity. Freudenthal, in his plenary address at the 1980 International Congress of Mathematical Education, concluded that:

> Curriculum development viewed as a strategy for change is a wrong perspective. My own view, now shared by many people, is educational development. (Freudenthal, 1983, p. 6.)

Freudenthal emphasized a broad perspective of educational development, one that includes research and teacher education. For him, reform is not a matter of paper, but a matter of people.

A humanistic orientation suggests quite different strategies for teacher education than does reform conceived of as paper reform. A humanistic orientation emphasizes the teacher as a decision-maker who determines what mathematics students are capable of learning and what strategies are appropriate, given the mathematical maturity of the students. Can you imagine any greater task for teacher education than educating teachers to make such decisions?

If reform is viewed from such a perspective, how can the *Standards* influence and drive reform? Romberg's use of the metaphor of "vision" in the introduction to the *Standards* seems quite appropriate: a vision not just of curriculum, but of instruction as well. Despite the fact that Romberg states correctly that the *Standards* were not "written as criteria to be used in observing whether teachers' actions during instruction are appropriate," there is much embedded in the *Standards* that has significant implications for instruction. Romberg's use of the verbs "examine," "represent," "transform," "apply," "solve problems," and "communicate" gives an undeniable tone of a certain philosophical orientation toward instruction. In fact, this philosophy is manifested explicitly in the following statement in the introduction:

> In summary, in our view, instruction should be based on problem situations....They (instructional situations) should be amenable to individual, small-group, or large-group instruction, involve a variety of conceptual domains, and be open as to the methods to be used. (p. 10.)

In the K-4 standards, we find the following statements:

> The major classroom emphasis should be on establishing a climate that places critical thinking at the heart of instruction. (p. 26.)
>
> Teachers should focus on the development of inductive reasoning, such as that required in extending patterns, by providing situations which require children to make generalizations. (p. 26.)
>
> A spirit of investigation and exploration should permeate instruction. (p. 44.)

In the 5-8 standards, it is stated that:

> Teachers need to provide a caring environment in which students can feel free to explore mathematical ideas, to ask questions, to discuss their ideas, and to make mistakes. (p. 51.)

In a separate section on "Instruction" (p. 53), the following prescriptions are given:

> Students should be actively involved in the learning process, investigating and exploring individually and in groups.
>
> Relevant situational contexts should motivate instruction. Students should experience ideas in context--real world and/or mathematical.
>
> Teachers should be facilitators of learning, not merely dispensers of knowledge.

The 9-12 standards devote a section to the topic "Patterns of Instruction" (p. 90). The following statements appear in that section:

> The role of the teacher should shift from one of dispensing information to one of facilitating learning.
> In order for students to internalize the view of mathematics as a process, a body of knowledge, and a human creation, they need many opportunities to experiment with ideas, develop strategies, formulate and communicate conclusions, apply fundamental skills, and interact in groups.

The *Evaluation Standards* support the same instructional theme, in that assessment is viewed as an integral part of instruction and should be based on multiple and varied kinds of evidence and on continual dialogues between teacher and students. The position is taken that learning is not a matter of collecting, but a matter of constructing. Indeed, the evaluation task force proclaimed that:

> Because assessment is such an integral part of instruction and, hence, is basic to the attainment of the standards, teachers need to know as much about assessment as they do about the content they teach. (p. 139.)

The message across both the curriculum and evaluation standards is unmistakably clear: Instruction is a fundamental aspect of the *Standards*. The implication for teacher education in educating teachers to teach as suggested in the *Standards* is, in my mind, the ultimate challenge for mathematics teacher educators. To accomplish this, two significant obstacles must be addressed: teachers' conceptions and students' conceptions of mathematics and the teaching of mathematics.

The Influence of Teachers' Conceptions

Whether or not teachers implement the full intent of the *Standards* and not just the mathematics identified in them depends on how the intended curriculum is filtered through the teachers' beliefs and conceptions of mathematics. Research over the past several years on teachers' beliefs provides strong testimony that teachers' conceptions make a difference in how mathematics is taught (see, for example, Thompson 1982, 1984; McGalliard, 1983; Kesler, 1985; Brown, 1985; and Brown and Cooney, 1986). I will not review the research on teachers' beliefs, although I believe such a review would reveal many tantalizing metaphors for teacher education. Rather, I choose to discuss the work of the Dutch mathematics educator Fred Goffree as a way of conceptualizing how teachers interact with curricula.

Goffree (1985) has identified four different perspectives that seem to characterize primary school textbooks (although they probably characterize texts at other levels as well): the mechanistic view, the structuralist view, the empirical view, and the realistic or application view. Their names are suggestive of the philosophical intent of the books. Related to these perspectives, Goffree identified three types of teacher use of textbooks:

(1) Instrumental use. The textbook is followed to the letter; learning should occur along the sequence of the learning tasks presented.

(2) Subjective use. The teacher first makes a constructive analysis of the material and then elaborates on the material based on personal beliefs and knowledge.

(3) Fundamental use. The curriculum material is analyzed constructively, but now the underlying philosophical view of mathematics education is taken into account as well. (p. 26.)

As Goffree suggests, these concepts of teacher use, combined with the four different types of mathematics textbooks, can provide a basis for describing how teachers interpret different types of curricula. Consider, for example, the dramatic change, and probably related trauma, associated with asking an instrumental user of a mechanistic textbook to teach an application (realistic)-oriented curriculum in a fundamental way.

A study by Stephens and Romberg (1985) that involved the innovative curriculum materials called RIME (Reality in Mathematics Education) illustrates the problem. A recurring theme throughout their analysis was the difficulty teachers faced when they were asked to teach atypical content in atypical ways. The authors provided the following teacher and student quotations:

> In RIME, there is a fair chance that someone will put forward an idea, or give you an answer, which you haven't anticipated. That puts teachers on edge, when they first teach RIME. (Remark by one of the experimental teachers.)
>
> Why are we doing this? Is this part of a games period? How are you going to assess what we are going to do in this activity? (Student remark.)
>
> They (students) expect a certain kind of approach to education in general, and that includes mathematics. Students expect the teacher to be in charge and to give clear directions, to give lots of work for students to do. There is little expectation that they will have to motivate themselves or to show initiative in what they do. (Teacher remark.)
>
> [A difficulty is] setting the story and getting the students in the right frame of mind to do the lesson; that is, getting the students to accept a different form of teaching. (Teacher remark.)

In terms of Goffree's analysis, teachers were asked to move toward a realistic curriculum with a fundamental perspective in preparing lessons. As was clear from the comments, students and teachers were not accustomed to such an instructional orientation.

Similarly, preservice teachers have certain conceptions about how they ought to teach mathematics. Secondary preservice teachers provided the following diary entries in reflecting on their own teaching experiences:

> Activities must be done in a class in which the teacher has total control because we all know that, when unruly children are given a chance to move around and talk in the classroom, they will go crazy and no learning will take place.

> Right now, I'm teaching in an authoritative way, meaning I am not allowing the students to come up with alternative ways of working problems.
>
> I always have the fear that someone will ask a question that I don't know the answer to.
>
> When you're up there teaching, you're nervous and you just want the kids to hear what you have to say, so it's difficult to listen to what they have to say.
>
> It's hard to keep from doing everything yourself when you're up front.

A common perspective among preservice teachers seems to be that teaching mathematics is primarily a matter of providing a broadcast. The most prevalent word used by our secondary mathematics methods students to describe their teaching is "present." "If only I can find the right way of presenting mathematics," says the intern, "life in the classroom will be o.k." When the presentation goes awry, as it typically does for the neophyte, it is easy for the preservice teacher to reach the conclusion that students lack sufficient internal motivation to receive the broadcast; their antennas are not up.

The notion of presentation embeds the notion of authority. It was revealing that the Middle School Task Force thought it appropriate to quote Steen (1986) who said, "above all else, it [the mathematics curriculum] must not give the impression that mathematical and quantitative ideas are the product of authority or wizardry" (p. 64, Working Draft). The issue of authority is central. Those familiar with Perry's stages of intellectual development (Perry, 1970) and their adaptation to mathematics education will recognize the importance of moving teachers through the sequence of a dualistic to a multiplistic to a relativistic perspective.[1] Unfortunately, there is evidence that algebra and geometry teachers communicate a dualistic/multiplistic perspective about mathematics to their students (McGalliard, 1983; Kesler, 1985). Owens (1986) found that preservice secondary mathematics teachers' orientations were generally a mixture of dualistic and multiplistic conceptions, with occasional traces of relativism. Meyerson (1977) demonstrated some success in moving secondary mathematics methods students from a dualistic perspective to a multiplistic or a relativistic one. The relevance of these findings to the *Standards* is that dualistic teachers emphasize the importance of authority--be it theirs, the textbook's, or famous mathematicians'--when teaching mathematics. Teachers who adopt a broadcast metaphor as a means of teaching mathematics, a metaphor based on the importance of authority, cannot possibly subscribe to a fundamental use of texts, nor can they "present" mathematics as a problematic subject to be created and explored. The realization that

preservice and inservice teachers hold such conceptions should, at the very least, suggest that teachers' philosophies and orientations toward mathematics require attention beyond what mathematics they "know." In light of Romberg's observation that the culture of schooling impedes the professional development of teachers, this concern about teachers' conceptions is of no small significance.

This is particularly true with respect to the use of technology. The *Standards* advocate extensive use of technology as a means of exploring mathematics. The stated assumption is that all students will have ready access to calculators and that teachers will have a computer available for daily classroom use. But if we think that the issue of using technology is solely a matter of availability, we are sadly mistaken. Schofield and Verban's (1987) insightful analysis on teachers' use of computers, which were readily available, paints quite a different picture. Their analysis suggests that teachers' attitudinal considerations, for example, the perceived challenge to their competence, the challenge to traditional means of evaluation, and a general lack of ability to integrate computers and mathematics in a fundamental way (to use Goffree's term) are significant barriers to computer usage. I see the problem as one of addressing teachers' conceptions of not only what mathematics is, but also of how they envision their role as teachers of mathematics, a problem clearly within the domain of mathematics teacher education programs.

The Influence of Students' Conceptions

A second factor to be considered with respect to realizing the *Standards* is the students' conceptions about what constitutes appropriate teaching of school mathematics. In a case study I conducted with a beginning mathematics teacher (Cooney, 1985), I found that the teacher experienced considerable difficulty when students found that his teaching and their expectations, both of what mathematics should be and of how it should be taught, did not coincide. His introduction to insurance in a general mathematics class in which dice and probability were used was viewed by the students as the act of an uncaring teacher because, if he really cared, he would be teaching them to add, subtract, multiply, and divide. My own experiences as a classroom teacher, especially recently as a teacher of secondary school geometry, suggest that the class moves less smoothly when lessons deviate from students' conceptions of what constitutes conventional classroom practice; witness Romberg and Stephens' study with the RIME materials.

Sizer (1984) noted that a successful class is one in which students and teacher agree on what they are doing and on how to do it. It is not always easy to achieve such agreement, particularly when reform is the primary objective. Students and teachers bring very different expectations, perspectives, and agendas to the

classroom. Consider Holt's (1964) lucid description of the defensive strategies students use to protect their own self-images at the expense of understanding the mathematics being taught. Krummheuer (1983) observed that students may be involved in the same activity as the teacher, but think about it in quite different ways. Hoyles (1982) reported that students want security and structure in their work; they want to "get it right."

When our children ask for help in studying mathematics, there is often the qualifier, "Dad (Mom), could you just tell me the answer?" When students' concerns, likes, and dislikes are not congruent with those of the teacher, some negotiating must be done in order to maintain a successful classroom environment. I remember well on my return to classroom teaching the episode in which we needed the quadratic formula to solve a geometry problem. When asked if they could recall the formula, the students manifested the usual disassociation with what had been taught the previous year in algebra class. As one young lady stated particularly well, "Well, we had it, but you can't expect us to remember it--we weren't tested on it." Given these pressures, it should be no surprise that many teachers try to create successful classroom environments by compromising whatever reforms may be intended in order to accommodate student expectations.

I suspect that students gravitate toward a mechanistic curriculum and appreciate teachers whose interpretations of the text are quite predictable. If you believe the contrary, listen carefully to the negotiations that take place between students and teacher when test time arrives.

Conclusion

When I think of the question, "What education should a mathematics teacher have?" I often recall an article by Trevor Fletcher, Her Majesty's Inspector of mathematics teaching in England, entitled, "Is the teacher of mathematics a mathematician or not?" (Fletcher, 1979). I find it an intriguing article, especially appropriate for our discussion of the *Standards*. In essence, Fletcher answers the question in the affirmative, using the following logic. A mathematician has a broad knowledge of mathematics and a specific area of expertise in it. So, argues Fletcher, is it the case with teachers of school mathematics. They, too, must have a general knowledge of mathematics. But they also must have expertise in curriculum and instruction that allows them to convey the notion that mathematics is a subject to be explored and created. It is important to realize that this special knowledge is rooted in a philosophy of mathematics for, as the mathematician René Thom stated in his address at the 1972 International Congress of Mathematical Education in Exeter:

> Whether one wishes it or not, all mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics. (Thom, 1973, p. 204.)

It is not difficult to identify the philosophy of mathematics behind the *Standards*. The *Standards* reflect a remarkably consistent tendency to conceive of mathematics as a subject that is not only replete with problems, but also is itself a problematic subject. One cannot conjecture, explore, transform, and perform all of the other action verbs used throughout the *Standards* and still maintain the notion that mathematics is a subject handed down from on high. It is difficult to imagine that any other issue could speak more directly to mathematics teacher education than that of how the philosophy set forth in the *Standards* can be engendered in teachers.

The *Standards* call into question how much we "lie" to students when we teach mathematics, particularly in the face of the finding from the *Second International Mathematics Study* that 50 percent of the eighth-graders surveyed believed that learning mathematics is basically a matter of memorizing rules. I do not mean the fact that we teach students that 2 + 3 = 6, but, rather, the impression they receive that there is no mathematics to be discovered by anyone except only the world's most brilliant and talented mathematicians. I regard this as a serious matter, for teachers are strongly influenced by their mathematical experience at both the college and precollege levels. Both mathematicians and mathematics educators cannot escape the responsibility they have for shaping their students' philosophies of mathematics, no matter how implicitly or subtly those philosophies may be communicated by their instructional methods, the means by which they encourage students to learn mathematics, and the means by which they assess their students' learning of mathematics.

George Polya had a long history of teaching mathematics through exploration, conveying concomitantly the belief that mathematics is not just a collection of symbols devoid of meaning save for their own cyclical, symbolic referents. It is in the Polya tradition that the mathematical education of teachers should occur. No longer is it acceptable, if it ever was, for the "right mathematics" to be taught from a basically broadcast perspective. Too often, students confuse the message with the means by which the message is delivered. When students admire teachers for their depth of knowledge, they also tend to adopt their teaching styles. Bush (1983) found that much of what preservice teachers believe about teaching stems from their experiences prior to formal entry into a teacher education program. This is disturbing if one considers that research suggests that true problem-solving episodes are a rarity in the teaching of school mathematics. We run the risk of a cyclic process of mathematics being studied and then taught in a manner antithetical to the intent of the *Standards*.

How can we educate mathematics teachers to acquire the kind of professionalized knowledge to which Fletcher refers and which is central to the realization of the *Standards*? The question is immensely complex, as anyone who has spent even a moment listening to teachers or students talk about their mathematical experiences realizes. What evidence we have does not point toward additional study of higher mathematics as a sufficient condition for resolving the problem. Owens (1986) found that preservice secondary mathematics teachers' study of higher mathematics, or what Freudenthal (1973) describes as "sterilized courses of further training in abstract mathematics" (p. 73), only contributes to preservice teachers' conceptions that mathematics is essentially an exercise in manipulating symbols. The preservice teacher sees school mathematics as basically equation-solving in various forms. As Owens observed, the college curriculum attempts to "enlighten" the teacher mathematically not by expanding his or her conceptions of mathematics, but by the wholesale introduction of new ideas. This has led Freudenthal to observe that:

> Educational programmes and methods are influenced by a belief which is natural for every mathematician, that mathematical education is education to become a mathematician. (Freudenthal, 1973, p. 73.)

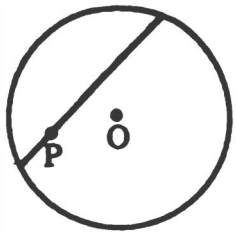
Owens concluded that the preservice mathematics teacher has neither the constructs nor the incentive to provide the kind of transformation needed to see school mathematics as something other than what Whitehead (1929) calls "exercises in intellectual minuets."

Let me be clear. The value of advanced study of set theory, analysis, or abstract algebra by teachers who will implement the *Standards* is not in question any more than one can question the centrality of deoxyribonucleic acid in human physiology. What is in question is the practice in mathematics teacher education of dichotomizing the study of advanced mathematics on the one hand and of general pedagogy on the other so as to limit the teachers' mathematical experiences to only those involving the study of wholesale new mathematical ideas. Teachers need experiences constructing the same mathematics that they will be teaching. Permit me a personal illustration.

When I was teaching high school geometry a few years ago, I taught the theorem:

> If two chords intersect in a circle, then the product of the lengths of the segments of one chord equals the product of the lengths of the segments of the second chord.

My planning was thorough, and I thought the students were reasonably responsive. The theorem was couched in the context of an axiomatic system, with numerical examples to be completed by the students. For some reason, I then posed the following question:



Which chord through point P in circle O will give the largest product of the lengths of the two segments?

The reactions were quite interesting. For the most part, the students' facial expressions expressed the view that it was, indeed, a strange question. After all, it did not seem to fit the model of what they knew would be assigned as homework. Second, and most important, they had no idea of the answer. Those brave enough to venture a response suggested that it must be the diameter since that would be the longest chord. After several minutes of discussion, one student volunteered that it did not matter what chord is drawn--the product of the segments would all be the same. The students seemed satisfied with this, if only to permit them more time for doing their homework.

The next fall, I presented the same question in a methods course for preservice secondary teachers in which we were concerned with various instructional strategies. These students had no idea of the answer either. They, too, suggested that it might be the diameter, although some conjectured that it might be the chord through P that is perpendicular to the diameter. We decided to examine various special cases in order to determine the chord in question. First, we assumed that the circle had a radius of 2 and that P was the midpoint of a radius. We then considered three chords: the diameter, the chord perpendicular to the diameter, and the chord that formed a 45° angle with the diameter. In each case, we determined the length of the two segments and found that their product was 3, to the students' amazement. A conjecture was formed and then a proof was sought. I had the distinct impression that the methods students would not soon forget <u>their</u> theorem and the means by which it was discovered.

Knowledge about teaching mathematics in similar ways constitutes one aspect of Fletcher's "professionalized knowledge." It provides the teacher with the background knowledge necessary to teach mathematics in a nonauthoritarian manner, using a construction metaphor rather than a broadcast one. It provides the basis for teaching mathematics in a way consistent with Goffree's fundamental use of realistic textual material.

Yes, teacher education should consist of substantial study of higher mathematics and of general pedagogical techniques that emphasize such things as maintaining an appropriate learning environment, preventing or dealing with discipline problems, and being aware of what students are doing, that is, Kounin's (1970) "withitness" (or, in the vernacular of the practitioner, using peripheral vision). But teacher education also must provide contexts in which teachers study the content that they will be required to teach in a way that embodies the philosophy that permeates the *Standards*. Education on the content of the *Standards* without

the accompanying experiences to reinforce the *Standards'* philosophy will doom us to failure as surely as we have seen the failure of reform movements in yesteryear. It requires teacher education not only to persuade teachers to teach students according to the philosophy that "A child's mind is a fire to be ignited, not a pot to be filled" (source unknown), but also to engage in the symmetric issue of teacher educators teaching teachers with the same philosophy. Such a conception of teacher education requires considerable introspection, determination, and a good dose of patience and fortitude on the part of us all. The stakes are high, but the rewards are many. What we must realize is that the task is formidable but feasible, costly but affordable, and, most importantly, controversial but necessary.

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[1] A dualistic perspective is rooted in the acceptance of authority as the arbiter of truth. Such a view of mathematics leads to the conclusion that mathematics is nonproblematic and consists of a collection of true propositions apart from the context in which they were developed. A multiplistic perspective recognizes the plurality of "answers," but as a collection of discrete entities without structure. Perry sees relativism as the recognition of a plurality of perspectives, but with accompanying interpretations, each being sensitive to the frames of references within which knowledge is developed. Multiple perspectives are legitimized, appreciated, and evaluated taking into account these frames of references.

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MATHEMATICS TEACHING IN SCHOOLS: IMAGINING AN IDEAL THAT IS POSSIBLE

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The current reform documents propose an ideal for mathematics teaching in our schools that is based on what we know about mathematics, about learning, and about environments conducive to learning or doing mathematics. This paper is based on what I know about mathematics teaching.

I was asked to discuss indicators of ideal mathematics teaching. Later, I would like to comment on the relationships among the ideal, the possible, and the realistic. But, to address ideals for a moment, if I had to pick one indicator of an ideal mathematics teacher, it would be a measure of whether that teacher could give students at the grade level he or she is teaching a mathematically legitimate and comprehensible explanation for why the procedures students are using are appropriate or not, or why the answers they are giving are correct or not. In other words, my ideal teacher would not need to use "the answer book," nor would that teacher think it acceptable to refer students to the answer book. This is an indication of good mathematics teaching because of the nature of mathematical knowledge and the procedures used in the discipline to verify whether knowledge is true.

In order to teach mathematics, a teacher needs to be confident that what he or she is teaching and what the students are learning make mathematical sense. This is different from being confident that you "know how to do it," although it probably assumes some degree of procedural knowledge. When the teacher asks a mathematical question in a classroom setting, and a student gives an answer, the student ought to be called upon to explain how the answer was reached. If the answer is wrong, the teacher ought to be able to provide a counter to the student's explanation that will cause the student to recognize the error. For example, if the teacher asks, "Which is the larger number, four-sixths or three-fourths?" and the student answers, "Four-sixths, because it means four pieces, and three-fourths only has three pieces," the teacher might come back with, "What about one-half and two-tenths?" This second problem gives the student a most accessible fraction (one-half) to think about, and gives more data from which to develop a general principle. I do not mean to say that the teacher should leave the conclusion to either of these

problems to the student, but that counterexamples are a more appropriate vehicle for discussing mathematical verity than reference to answer books. Repeating the algorithm: "Get a common denominator and compare the numerators" has no meaning for the puzzled student. It might result in a correct answer, but it will not result in learning how to compare fractions.

What does it take for mathematics teachers to wean themselves and their students away from answer books and algorithms, and replace them with public mathematical conjecturing and arguing among students about plausibility? Based on my attempts to do this every day over the past six years in a fifth-grade classroom and my observations and conversations with other teachers making similar attempts from kindergarten through high school, I would say that it is immensely more difficult than I ever imagined it would be, but that it is possible.

Establishing whether ideals are possible is a matter of experimentation, but turning ideals into realities, in actual classroom settings, is a political matter. Schools in our society are about accomplishing many more--and sometimes conflicting--goals than engaging children in learning mathematics. Different groups have different ideas about what constitutes good teaching, and different ideas about the sorts of goals that schools should be trying to accomplish. These conflicting goals, and the environment, the conditions, and the distractions of everyday life in classrooms make it difficult for teachers to keep their focus on mathematically respectable ideals, even when they believe in them.

Because of the sorts of institutions that schools are, we also must consider what is realistic at a very mundane level. If there are 200 students gathered together in one building (which can be a small number, even for an elementary school), for example, someone needs to worry about how they are all going to manage to eat lunch. The teacher is faced with the job of organizing students' inquiry and their engagement with mathematical ideas in such a way that it does not interfere with their getting to the lunch room on time, because someone is waiting there to serve the food. There are many such logistics that must be arranged when a large number of people are living and working together in a small space, and they almost always interfere with making engagement in the subject matter a top priority. Engagement in subject matter in a school setting is not impossible, except perhaps in some of our most shameful urban schools, but it is difficult to manage along with everything else. It does not simply "happen" because students are presented with interesting problems to work on. Another practical problem which any teacher will tell you about is that even the most enticing computer software or video program is not helpful when the machinery either

does not work or is not available at the appropriate time. When it works, it is wonderful, and good teachers welcome technological tools that can make them better. But when there is a problem with the machinery, and no one to help, one becomes acutely aware of the difference between possibilities and realities. If we espouse ideals which do not take account of these realities, we do teachers a disservice, for it is they who will be blamed if our ideals are not put into practice.

At the other end of the spectrum from such mundane issues are questions about what teachers need to know to engage children productively in mathematical activity (and the related, perhaps even more difficult question of how to get the people who know these things to work in schools. What would a teacher need to know in order to do on a regular basis the kind of ideal teaching I have described? There are a number of things, such as knowing:

- how to get a large group of students in a small space interested and engaged in doing intellectually challenging work;
- how to manage a rather complex set of interactions, both between teacher and students as a whole class and among students as they work together in problem-solving groups;
- how students think about mathematical phenomena and knowing how to respond to that thinking in ways that are both supportive and challenging;
- how to listen to students and how to organize the classroom so that students can express their thinking and listen to one another with respect;
- where the mathematics teaching and learning processes are headed, not in the linear sense of one topic following another, but in the global sense of a network of big ideas and the relationships among those ideas and between ideas, facts, and procedures;
- a variety of ways in which to represent big ideas to students, drawing on concrete, pictorial, verbal, and contextual as well as abstract modalities;
- how to assess student understanding and being able to represent that assessment in terms that students, parents, and administrators can understand and accept.

More probably could be added to this list, but the above are difficult requirements already. It seems reasonable to question whether it is realistic to expect that every mathematics teacher, from kindergarten through teacher preparation courses in college,

could know how to do all of these things. And another reality we must acknowledge is that many teachers teach five different groups of children five different subjects for five hours a day five days a week. It requires an enormous amount of intellectual and physical energy to have them all be engaged in exciting mathematical discourse, even once the students have been educated to take some responsibility for their own learning, which in itself is no simple job. I do this with fifth graders for one hour every day, and it is exhausting. Those of you who teach graduate students--presumably the most talented and motivated learners--know how difficult it is to keep a good, focused, problem-oriented discussion going for a few hours a week.

My list of what an ideal school mathematics teacher would need to know how to do is based in part on my own teaching and in part on a research project that I have been doing at the Educational Technology Center at Harvard University. In that project, I have been observing and interviewing a group of secondary school mathematics teachers in a wide variety of high school settings who have chosen to experiment with technology designed at the Educational Development Center at Newton, Massachusetts (a member of the Educational Technology Center consortium) to support the process of "guided discovery" in classrooms. The software used is "The Geometric Supposer," which enables students to explore geometrical relationships on computers inductively. Generally, the students work in pairs, meeting once or twice a week in a computer laboratory, and their findings are processed during regular class sessions. This setting certainly has aspects of the ideal in it.

But the teachers who experimented with the Supposer were faced with a serious conflict. The culture of the schools in which they were working had not prepared either the teachers or their students to feel secure that, if the students followed their own intellectual road maps, they would learn what they are supposed to know. Yet the new technology was seductive--to students and teachers alike--and drew them along mathematically interesting paths that did not coincide with the routes through the subject defined by the textbook. Students went off on mathematically productive tangents that no one could track. As they made conjectures that they wanted to prove, teachers were barraged with questions. Even teachers went off on tangents as the Supposer captured them in interesting mathematical puzzles. This was both exhilarating and frustrating; the participants enjoyed what was happening, but they were not sure what connection it might have with what they had come to know as learning high school geometry. They were faced, at a very practical level, with how to "guide" the inquiry process once students were engaged in it.

The situation the teachers experienced was something like that of a tour operator in Paris whose bus had been replaced with a collection of glitzy motor scooters in the middle of the Place de la Concorde. Many of the "tourists" could see places they wanted to ex-

plore, but did not know how to get to them. Others did not even know where to go or how to begin to make choices. All of them were complaining because their expectations for the tour were not being met, while at the same time they were anxious to jump on a scooter and take off. To make matters worse, the cameras that were to have recorded where everyone had been were left on the bus. The theme that dominated the teachers' thinking over the course of the year was how to make a situation like this into one that would fit into the culture of schooling without losing the excitement and engagement that the Supposer engendered.

What an evaluator might want to look for in a classroom characterized by such excitement and engagement, in order to judge the quality of the mathematics teaching and learning, would be quite different from what one would look for in a more conventional setting. Three basic questions--or clusters of questions--suggest themselves:

- First, how does the teacher treat the "knowing" of mathematics? Is it all to be listened to, practiced, and remembered, or are there elements of what comes to be known that are arrived at through a process of reasoning about mathematical entities? Are students expected to make conjectures and then try to prove to their teacher and their classmates that what they have said makes sense? Are they given the linguistic, representational, and technological tools to enable them to construct such arguments?

- Second, how does the teacher move around in the mathematical terrain that is appropriate to the grade level? Is the teacher able to respond to an individual student's ideas in a way that values and challenges them, and also to maintain the interest of the rest of the class and not stray too far from the teaching goal? Is the teacher able to build on the connections students invariably will make among the intricate web of ideas that constitute mathematics, or are learning opportunities missed by adhering too closely to a linear list of goals? Is the teacher able to present mathematics in a way that is coherent, but also responsive to the diversity of interests and skills that present themselves in any group of students?

- Third, is the teacher able to make use of the tools available for teaching and to make those tools accessible to the students? Are curriculum materials being used to their fullest advantage? Are the calculators and computers that are available being used in ways that engage students in mathematical activity? Are connections being made among different concrete representations of a mathematical idea and between the manipulation of concrete representations and symbolic strategies for performing mathematical operations?

Even if all of these questions are answered affirmatively, one will have encountered a mathematics teacher who has a substantial set of relatively novel problems to be considered every day because we are far from having ascertained how to make good mathematics teaching happen routinely. Therefore, rather than trying to decide which results of this kind of teaching we want to measure, I would like to propose an intermediate indicator. Given the state of our practical knowledge about mathematics teaching, it seems that the most meaningful indicators of ideal mathematics teaching among people who are trying to achieve it on a regular basis in the schools should be an assessment of whether teachers are grappling with the appropriate problems. Perhaps, in the future, we will have solved these problems and determined how to educate novices in order to put those solutions into practice. At that time, we will be able to develop a more conventional set of indicators. But, at the moment, an appropriate indicator of whether or not a mathematics teacher is moving in the direction of supporting the kind of mathematics learning that all of the reform documents embrace might be whether the following are among the problems he or she is facing:

- managing the social structure of the classroom, including large group, teacher-led lessons, small group activities, and individual work on problems, in a way that supports inquiry and coherence;

- keeping track of what content is taught and determining how to move through the appropriate mathematical terrain at a compatible pace;

- assessing student learning in a way that takes into account both individual understanding and issues of equity, and negotiating the terms of assessment with students and other concerned parties.

The mathematics teachers with whom I have worked who are better educated and more experienced than their colleagues and who would be regarded by all of us as good, if not ideal, mathematics teachers at all grade levels feel almost overwhelmed by these problems continually. If they are lucky, they have someone nearby with whom they can commiserate. If they are not, they have a reformer who has never tried to do what they are doing who asks why they are experiencing difficulties.

TOWARD A NEW VISION OF LEARNING AND TEACHING*

Albert Shanker
American Federation of Teachers

I would like to share some thoughts that are not yet the topics of national discussion and debate among teachers and other educators across the country.

We have gone through a number of years of educational reforms; most of you have experienced them in your own states. My perception of these earlier reforms is that, if you look back to the period from 1976 to 1980, the teaching profession and public education were in considerable difficulties. Annual ratings of the public schools on the Gallup poll were going down quickly. Our support constituency of parents was becoming an ever smaller percentage of the voting population, dropping from 55 percent to 21 percent. The nation was facing a host of other problems. We went into a period of stagnant economy, so the public was not so generous as it once was, and the nation had a number of other pressing agendas, such as reindustrialization and rebuilding the infrastructure. Also, both Presidents Carter and Reagan agreed that America had disarmed unilaterally and that it had to have a substantial increase in military spending.

Education, therefore, lost a good deal of political influence because of these many other agendas. There were also fights on tuition tax credits, where we lost in the House and won in the Senate. Even today, with people feeling a little better about education, the latest Gallup poll shows 41 percent of the public in favor of vouchers or tax credits for private and religious schools and 41 percent opposed. We have a public divided over public education and it may be giving public schools one last chance. Now, a new wrinkle on tuition tax deductions and credits has been added through state, rather than federal, action. Minnesota permits them and Iowa now has them, through legislation that was tacked on to a teacher salary bill to ensure more teacher support.

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*This text was taken from the transcript of a luncheon address that Mr. Shanker delivered during the conference reported in these proceedings.

Another new approach is reflected in the Thatcher educational reform bill in England. You may be sure it will be talked about here and will become a part of our political discussion. There are a lot of pieces to the Thatcher plan and one piece is this: if the parents of any of the children in any public school decide that they want to vote on whether or not they like the way the school is being run, the government has a procedure for it, very much like a collective bargaining action. If the majority of the parents say they do not like the way that a school is being run, that school can be removed from the authority of the local education agency, and the parents will be able to elect their own board of education for that school alone. The parents also will have the right under the national law to fire and hire any staff members they want.

I make these preliminary remarks as a backdrop because, when the wave of education reforms came along, I did not like most of the things that the reformers said. They were quite mechanical; they were very regulatory; and they were all "top-down." I shall point out later some of the other reasons I did not like them. But I also did not like the extreme softness of America's schools in the late 1960's and 1970's, when many schools permitted students to decide whether or not they wanted to learn particular subjects. But I came very close to embracing these reform proposals and, publicly, I was very positive toward them, mainly because they gave us some political support which we desperately needed. We needed the support of the public, government, and industry.

The way to get that support is not necessarily to agree with everything that is being said, but at least to listen and respond constructively. Representatives of government and industry were coming to us as friends of public education, saying that they wanted to help it. None of the reports issued at that time advocated tax credits or vouchers; they were calling for greater resources. The reports were not very perceptive and did not make clear-cut proposals. How could they? They were written by people who did not work in the schools. It was a failure on our part that we did not go to the authors. If we had done so, and had had some good ideas, we most likely would have had a voice. But that is what happens when you do not take charge of your own profession. Someone else does--and they did.

So I made some friendly statements, but not because the substance of the reform proposals was particularly good. Then what happened? We got fat legislative books promoting more rules and regulations, teacher testing, student testing, no automatic promotions, minimum competency tests at graduation, definition of the number of hours per subject--and many more things. These laws were based on the rather

simple notion that, if you put together a few ingredients, you will make major differences and breakthroughs. One element is to have good teachers; I am certainly in favor of that. It also was discovered that many teachers were leaving the profession and that those coming into it might not be of the quality we wanted, unless the incentives were changed. Essentially, it was a package that mandated high standards, abolished automatic promotions, defined curricula, and called for a lot of homework and good and harder-working teachers--as if a shopping list could be put together and reform would take place. None of us would be against those things in principle, but we have to ask whether they are likely to be successful.

First, we need to ascertain where we are. If we were educating most of the children in this country successfully--if, say, 80 to 85 percent were doing quite well and we had to find ways of improving the other 15 to 20 percent, then something like the above list might be a reasonable strategy. That is, we would be saying that the system is basically good; most of the products are fine; we have a little problem with the quality of 15 to 20 percent--a minor quality control problem--but, overall, the system seems to be working well.

In fact, quality control was the obsession of the day. I can illustrate it best by a story about the Frenchman, the American, and the Japanese who were captured by a terrible enemy and told they have only an hour to live. They were given one last wish. The Frenchman said he would like to sing his national anthem, and he was told that he could have his wish. The Japanese said he would like to give his lecture on quality control for the last time, and he was granted his wish. Then the American said he wanted only one thing, and that was to be killed before the Japanese gave his lecture on quality control.

But where are we really? Let us look for a few minutes at some of the results of the National Assessment of Educational Progress. Take the literacy assessment of 17-1/2-year-old youths who are presumed successful. They have not dropped out of school; they are soon to graduate high school. We are not talking about the 20 percent who did drop out. The good news is that they can all read exit signs; in case of fire, they will know where to go. If they open up a package, they can read simple instructions; they can read simple books and some newspapers. But, when it comes to reading an editorial or a news analysis in *The Washington Post* or *The New York Times*, less than 40 percent of those "successful" 17-1/2-year-olds who are still in school could handle it. The hardest task of all in this category on the National Assessment tests was to manipulate about six pieces of information on a bus timetable. One might ask why that is necessary when a telephone call to the busline will provide such information. But we must think of this as the ability to do such things as open up the world almanac and understand a population or other chart or to interpret a spread sheet. I do not have to convince this audience that this is a worthwhile skill. But only 4.9 percent of the prospective graduates can read a simple table of that sort.

Let us move on to writing. This is very important because it is not just mechanical; it involves persuasion, expression, and the organization of ideas. The writing task was not Shakespearian; it was to write a letter to a prospective employer, convincing him or her that you should get the job. It was designed to see if students could use critical thinking and apply rules of evidence to bolster arguments. If an employer is looking for someone reliable, it will impress him or her to be told that the applicant has held three jobs and has never missed a day's work, even coming in when sick. If the employer wants someone who can handle money, the student needs to be alert to point to experience such as working in a pharmacy and being the treasurer of the Boy Scouts troop. A letter that shows a little persuasion, a little ability to muster evidence, is required. Of these successful students who were tested, only 20 percent could write such a letter at the adequate level.

Not to be able to understand a serious newspaper, not to be able to take a chart that contains a few numbers and words and make sense of it, not to be able to write a persuasive letter adequately is very alarming. Does anyone really believe that the system works? Remember that these are not the 20 percent who drop out of school; they are the 20 percent of the 80 percent who are successful. Essentially, the conclusion that has to be drawn is that the system by and large is not working, that it is not a simple matter of improving it only for those who are either deviant, or who did not have good teachers, or who went to a school that was particularly ineffective. The failures are not the result of an abnormality; the failures are the ordinary. In terms of reasonable expectations of what we need in our society, of what we want to produce, success is the extraordinary.

I would like to ask the authors of these reports if they really believe that if you put a teacher in the classroom who is a little better than the one there now, provide a textbook that is a little better, and do a little more homework, those changes will result in an improvement from 4.9 percent to 75 percent. Maybe, by tightening up a bit, an increase from 4.9 percent to 6 to 10 percent might be achieved, but, after that, it is unrealistic to project a jump from 4.9 percent to 75 percent because a better teacher is being put in the classroom or a better book is being used.

Let me use another piece of evidence to show why the "tightening up" approach will not work. It will not work because we have already conducted the experiment. Did we ever have schools that had excellent teachers, a well-defined curriculum, no automatic promotions, family support, and a lot of homework? Of course, we did. I went to a school like that in New York City. That is what the schools were like in the 1930's and 1940's. We had wonderful teachers who could not work anywhere else. They earned four or five degrees during the Depression because there was nothing else to do. They took their examination in New York, Chicago, or elsewhere, and then waited eight years to be appointed to work as substitute teachers for $2 per day. They were brilliant people and the selection was such that, if you

did not work out, you were not retained. There were no unions then, not in the sense that we have them today. What was the result? Was it good education? It was great; I am an example! But looking back to 1940 and 1941, for whom was it great? Twenty percent of the youth in this country graduated from high school in 1940. 1953-54 was the first year in which a majority of young people graduated from high school in this country. Isn't it interesting? In 1940, we were educating 20 percent of the children; now, we are still educating 20 percent, but we are keeping the rest a lot longer. Those who are staying longer are learning more; they are better off than those who left. But, that is where we are.

Essentially, what this tells us is that we now have reached a point where we can develop a hypothesis. If you look at England and read that country's current material about education, you find that about 20 percent of British youth are succeeding. It is hard to get such figures from France. We have affiliates who meet with French officials several times a year. The French used to say to me, "There are absolutely no problems in our schools; no child leaves illiterate." Then, under Mitterand a few years ago, an attempt was made to remove subsidies from parochial schools. About one million people came to a rally about the number of illiterates graduating from public schools. Then we started having honest discussions.

It seems to me that there are only two hypotheses which will explain the failure to reach so many children over such long periods of time. One is that God or Darwin only makes 20 percent of us intelligent. Maybe there are another few percent we could reach if we tried a lot harder, but that would be all. I am not ready for this hypothesis and I doubt if you are.

Then there is a second hypothesis. The results we are getting are not reflections of the students, nor are they reflections of a lack of effort by the people in the system. The results are the reflection of a very faulty process of production--in other words, of the way the schools are organized. The situation is comparable to going to an automobile manufacturer 15 years ago and asking why one million cars per year are produced, but 350,00 of them have to be recalled and rebuilt. We thought that was the result of mass production until the Japanese came along and showed us that, if you do your homework first and use a different system that involves the employees, and so forth, a system with radically different results in terms of successful productivity can be developed.

Another way of thinking about this is that, for about two thousand years, people went to medical practitioners hoping to be cured; often, they were killed--killed by the fact that the medical profession only recently discovered the practitioner should wash his hands and sterilize his instruments. That was not a result of viciousness or evil. It was just ignorance and the standard operating procedure of the profession.

If we do not accept the theory that only 20 percent are intelligent, then we have to ask ourselves: are there other things similar to the nonsterilization of instruments or the nonwashing of hands that we are still doing in the schools? Are there factors in the ways in which we handle children in school that, instead of helping them, hurt them? Are there things we do that lose the interest of a large number of students? Are there things that, instead of being functional, are radically dysfunctional?

I want to spend a few minutes talking about something that is almost never talked about and which is, to me, at the core of why we need professionalism. I do not view professionalism as the business of creating a bureaucratic hierarchy which results in some people getting more money. Over the years, although we have talked a great deal about what constitutes good teaching, we may not have talked about it enough. We ought to talk more about it--about what constitutes good materials, good textbooks, good lessons, and good incentives. There is not very much thinking about learning and there is not a lot of very detailed thinking about what the schools do to build or destroy the self-esteem of children. Basically, if the child concludes he or she is no good or not intelligent and, ultimately, decides not to become involved, that is the end of it. Nothing can be done if a child decides to give up. So, keeping the flame alive in a student becomes an absolutely necessary condition for any sort of education.

Let us look at a few things that happen routinely. Last fall, two million new children went to school and entered the first grade. In essence, we tell these children, "You're all six years old and you're in the first grade," and the children start making comparisons among themselves. In a sense, by the way we sort them and put them in classrooms, we are telling these children that they are supposed to be the same. Then they begin to look at each other, to see who is faster, stronger, smarter, and so forth. Now, are they all six years old? No, they are not, because the way that children enter school is through an arbitrary date. If a child's birthday is before a certain date, he or she goes to school this year. After a certain date, it will be next year. This means that we have taken a whole year's age range of children; the oldest child in the class is likely to be a year older than the youngest. A year makes a tremendous difference at the age of six. The difference is evidenced by the development of major skills such as the use of language and numbers, physical coordination, and so forth. It is not like the difference between being 60 and 61. It is much more like the difference between 25 and 40--it is big!

So what do we find? If we look later on to see which children have dropped out or which ones are not doing well, there is fairly substantial evidence to show that they are the ones who were younger at the beginning of school. The oldest person in the class feels stronger, smarter, and faster, even though all sorts of tests might indicate that this person is not so well endowed in many ways as others in the class. Of course, this is not an absolute rule. The

youngest child who overcomes such a handicap is like anyone else who overcomes a handicap--stronger for it. The statistics to support this are quite persuasive. It is akin to putting a heavyweight boxer into a ring with a lightweight boxer and saying, "Go to it; you're both boxers." Now, I have never seen the younger children in a classroom tell the teacher that "The reason I can't answer this is because I'm a year younger than he is, so you shouldn't ask me the same question--or you should use a different marking system."

Why do all of the students have to come to school on the same date? It is because that is when the teachers start talking. If some of them were to wait until they were a little older or more mature, until their birthdays caught up to the other birthdays, it would be like arriving in the middle or at the end of the movie, so we cannot do that. It has to be on one particular date.

One of the questions we have to ask is: Can we build a learning environment that does not create unfair competition at an age when children usually cannot handle it? It was better in the old days when groups of children were admitted to school twice a year. Of course, that requires more paper work and movement, and that goes against administrative convenience and creates problems with keeping track of large numbers of children. If there were three or four semesters, it would be easier, but there are other ways of dealing with the problem. Obviously, each child cannot start school on his or her birthday if the teacher has started the program already. There would have to be a totally different organization. But think of how it is now! When children come in on the first day, they have the teacher at a disadvantage. They know the teacher's name, but the teacher does not know their names. Unless the teacher is very skilled, children can play a lot of games. Many teachers are driven out by that first day of school; they realize they cannot handle it. It would be quite different if part of the class were there and other children arrived on their birthdays, without knowing anyone. Then, there would be a different kind of atmosphere.

Let us move on to the next problem. This problem is where I am the teacher and, after I have talked to the students and they have done some reading and other things, I call on them to answer questions. Some of them always have their hands raised. School is great for these children; they would come to class on Christmas day. They are ahead of their classmates and they shine.

Then there are a few who sometimes answer, and sometimes do not. And then there are the children who never raise their hands; they are constantly engaged in what is constitutionally prohibited--prayer in the schools! They are praying that I will not call on them. And, every time I do call on them, they either turn red and green or they guess wildly at the answer and everybody laughs at them. After they have not answered or have answered incorrectly a few times, the other students start making up names for them. What am I doing when I call on such children? I know what I think I am doing--getting pupil participation; getting their attention. But to call on a child once in

the morning and once in the afternoon, for five days, in front of all of the other pupils, with the child never getting the right answer, would be called public humiliation by an impartial visitor from Mars.

Fortunately, that has not happened too often to most of us; that is why we are here. But it has happened to most of us at some time and, when we think back to such an occasion--when we were called upon in front of people we respected and were unable to deliver the correct answer--it was a very painful experience. For that to happen regularly--once, twice, three, and four times a week--is enough to convince a child that school is not for him or her. Children decide this very early. This probably is what happened at a very early age to a large part of that 60 to 80 percent who are unable to perform when they leave school. We worry about the dropouts who leave school, but we do not worry about the 80 percent who dropped out in their heads when they were very young and are just sitting in class, going through a ritual.

That is the second item: Can we create a learning environment in which children are not humiliated publicly, in which learning during the early years is relatively private rather than exposed to the entire group? We will come back to that.

The third item is that there is essentially a single method of teaching and learning throughout most of the western industrial societies and most of their schools. That is, the teacher talks and the children listen, or they read a textbook or write in a workbook. Those are the main ways of teaching and learning. There are certainly exceptions, but those are still the main ways. If you cannot learn in those ways, you are unlucky.

In the recent past, there were no other techniques, but, today, there are video tapes, audio tapes, and peer tutoring, although the latter is used very infrequently. There are many ways of teaching and learning, but we do not use them. A lot of people could not learn in these ways and could not endure school; they dropped out because they could not sit still for five or six hours a day, listening to someone else talk. Or they are not sponges who absorb words that someone else is saying. Does that mean such people cannot learn? No; it only means that they cannot learn in that way. Basically, what the results of the National Assessment of Educational Progress tell us is not that these children are stupid, and it does not tell us that their teachers are doing a poor job of organizing their material, or that their textbooks are no good. These results show that the number of people who can sit still and absorb words, either from the written page or from someone else's mouth, and respond by turning them into complex and meaningful pictures and patterns which help to organize experience, is very small. That is all that they tell us. They do not tell us that, if we used other methods, we would not reach these children. We have all heard of people who dropped out of school and later became millionaires or were elected to public office; they are very bright; they go to the

theater; they read; and they are people you enjoy being with. You realize that you are in the presence of amazing people, but these were not people who could learn in a way that we typically teach them.

A final example. Most children enter school in September, but the final grade is not given until the following June. Well, if this is September, and it is a nice day outside, and the final mark will not be given until June, a lot of us will decide not to do our homework tonight. What we require of children is that their characters be so well organized that they will realize that every little thing they do not do each day ultimately will have a cumulative effect which will be disastrous. Now, that is something we would like to develop in people. However, suppose I were to give each of you your salaries for the year on the first day of school. How many of you would have any money left in June? It is the same characteristic that we are asking of children in terms of their investment in studying each day. Most teachers, if they were given their salary a year in advance, would go on strike. Even though they could invest it--if they had it, they could even make money on it--they do not want it because they do not trust themselves to have any money left when they need it. So what happens? Toward the end of October, some of these children who thought they had plenty of time discover that they are falling hopelessly behind. Now, every time they are called on, they are embarrassed. What do you do if you are hopelessly behind at the end of October? Do you sit there and become humiliated every day, or do you drop out? If you drop out, when can you drop back in again? Not until next September. And then you drop back in with students who are one year younger, after the school has told you that you should always be with students your own age.

Is it possible to organize things differently? Let me share with you the story of my youngest son, Michael, who graduated from high school as an average student in an above-average school, so he felt he was no good and decided not to go to college. He went to work in a French restaurant, washing dishes. Six months later, he was taught how to make salads. Six months after that, he started making soups. About a year later, he came to me and said, "Dad, I've decided what I want to do with my life." I asked, "What's that?" and he replied, "I'd like to go into the CIA." I looked at him and he said, "No, it is not what you think. I want to go to the Culinary Institute of America. If I'm going to be in this business, I might as well be a chef." So I said, "All right, I'll get the application for you." He got in. I was very worried because I knew he thought it was a hands-on vocational school and I knew that one had to learn nutritional content, culinary French, contracts with vendors, hotel management, restaurant management, labor relations, and so forth. It is a very demanding program; it is not all cooking. Even the cooking is difficult. After he had been there for a week or so, I thought it was time to go by and have dinner with him, to encourage him to stay the course. So I called him and said, "Michael, I'm going to be driving by Hyde Park. Can we have dinner?" And he replied, "No, we can't, dad; I'm sorry." "Why not?" He answered, "I'm up past

midnight, writing up my notes and studying." I said, "What do you mean, you've only been there a week and a half?" He said, "You don't understand; the semesters here are only three weeks long." Well, a semester three weeks long! He told me that, if students are 15 minutes late for class, they are suspended for that three-week semester because they have already missed a major part of the course. The three-week semester concentrates the student's mind and it concentrates the teacher's mind. No teacher will tell a joke that is more than 10 seconds long unless there is a real pedagogical purpose to it.

While on this topic, let us consider the young people who are dropouts. A fellow meets a lovely girl. They drop out and run off to Ft. Lauderdale together and they know it is forever, but, a few weeks later, they break up. With a three-week semester, they could drop back in school every three weeks. Also, what happens if one fails? Think of the big debate we have had throughout our history. Do we promote students automatically, or do we hold them back? Both options are undesirable. To move a pupil ahead automatically when he or she is lost is a terrible thing. But research shows that to hold them back does not accomplish anything either. So, essentially, we have two answers, neither of which works. What do you do when you have two answers that do not work? You have to find a different way of thinking about a problem. My son did fail one course, but it was not devastating because it meant taking three weeks of one subject over again, which was not a big problem. He was not with students who were a year younger than he was. They were only three weeks younger.

What this shows is that, by rethinking problems that are part of the daily school structure from the point of view of their impact on the students and on their feelings about themselves and their willingness to be engaged, solutions can be found for most problems. Often, the solutions are things like washing one's hands or sterilizing one's instruments. There is nothing deep about any of these suggestions. Maybe doing some of these things will not have miraculous results; we do not know. But they are new ways of thinking about these issues. The angle of approach is correct; that is, we ought to be thinking about the things we were unable to learn in school, no matter how hard we tried. And when we finally did learn them later, under what circumstances did we learn them, and how? What was the approach? By thinking back to such a point, can we understand why we were unable to learn? Why do we not spend enough time thinking about those experiences that acted as blocks to our own learning?

We also have a problem with the organization of curriculum. John Dewey observed that one sees children looking very inquisitively at things that interest them, but that school manages to turn interesting things into subject matter. So I will share with you the story of that great educational philosopher, Father Guido Sarducci. He does a comic routine where he stands in front of an audience and says, "I have opened a college. How many of you don't have a

baccalaureate degree?" Half the audience raises its hands. He says, "At my college, you can earn a baccalaureate degree in one day." They all laugh. They think the whole thing is a fraud, but he says, "No, this is real education. You're going to take the courses, and you're going to take the final examinations, and you'll do it all in one day. I want to tell you how I do it. I go out and find people who have been out of college for two or three years and I ask them, 'When did you graduate? Two or three years ago? Did you take Spanish when you were in college? What do you remember from your three years of Spanish?' and the person answers '¿Como esta usted? Muy bien.' 'Is that all you remember?' 'Yes.' All right, that is my curriculum for three years of Spanish. So I teach it to you; I give you the final examination; then we go on to American history."

Why is that funny--and sad and true? It demonstrates that a lot of material is covered in school, but that we do not develop understanding. We concentrate mostly on factual, short, and multiple choice answers. I was reflecting on some educational experiences that I had had outside school, and I wondered, "What would happen if a teacher in school were given the assignment to teach children about birds?" One would teach them either with a number of flashcards illustrated with birds or one would put a bird chart on the wall, showing pictures of many birds, placed in different categories such as mountain, plain, and water birds. Some might be categorized in terms of migration or parts of the country where they are found. When that was finished, the students would be given an examination and two things would happen. One, they would forget about birds a few weeks after that, à la Sarducci, and, two, they would probably end up hating birds.

So I thought of a different experience I had had--through the Boy Scouts bird study merit badge. One actually has to go out and see 40 birds and keep a record of them. And what happens when you go to find 40 birds is that you realize you will not be able to see so many birds where there are only a few trees. You find you will have to get up at 5:00 a.m. and, at sunrise, you will have to be at a watering hole. You are afraid to do that alone, so you ask a few friends to go with you. Off you all go and, as soon as you start looking through the binoculars, something else becomes apparent. Seen through binoculars, birds do not look the way they look when they are in a museum. In nature, they have a red crest, a certain shape, a tail bobbing a certain way--something called field marks. Then you start looking through a standard handbook with your friends and you say, "There it is, that red crest." And your friends say, "No, it can't be; the book says they're native to Texas and we're in New York." So you keep looking. It may take several months before you find the 40 birds. But do you know what else happens? After several months of bird-watching, you are able to walk down the street and see a little movement in a tree which nobody else sees and you develop a sense of knowledge, of power, that becomes a part of you. I have not known anyone who learned about birds this way who hated birds, forgot about them, or stopped trying to learn about them.

So that is another item we must consider because, if all we have is the meager Guido Sarducci curriculum, we might as well ignore it. Somehow, we must put curricula together, organize information, and present it so that learning is much more like studying birds in nature and it becomes a part of the children. Otherwise, we will continue with the present failure rates.

I have a few more things to add. What might a school look like if we were to make one where children were not learning mainly from lectures or textbooks, if they were not all starting on the same day, if they did not have to sit still and be quiet, if they were not exposed to public humiliation, especially at the earlier grades, if there were privacy, if their time were not planned a year in advance--a school incorporating all of the items I have mentioned, as well as others? It probably would look far more like a Boy Scout troop. Think about it! Boy Scouts have hundreds of different pieces of curriculum. There is one scoutmaster and 40 to 60 young people. How does one scoutmaster handle the learning experiences of 40 to 60 children? One thing he cannot do is to give a lecture on how to tie knots. Only one or two people want to do knots that day. He teaches by saying to one child, "See if you can do this by using the handbook." To a few others, he says, "Why don't you see if you can learn it from him?" Essentially, it is a school where the adults advise the youngsters. Such a learning environment could be replicated in the schools, using adjuncts such as computers, audio tapes, video tapes, computer instructions, and adults who can do some helping; there also would be cooperative learning. A variety of learning techniques could be used, with people working mainly in small groups, looking for answers together. This would not be a memorization or fact absorption process; a process of true discovery would be created, which is what involves children. Children know what is artificial.

If such a learning environment were created, certain things would happen to teachers. There would be teams of adults, instead of a self-contained classroom. You could use volunteers to help. Volunteers, under our present system, can only be a distraction. Children ask, "Who is that in the back of the room?" Or, worse than that, the volunteer might be a witness to something untoward that happens. So, the way things are organized now, teachers have difficulty incorporating volunteers. However, in a Boy Scout troop with 40 to 60 youngsters, a parent or volunteer can be trained easily over a period of time to help at least one or two children. Those volunteers can be helpful and they are welcome, but not in the school system.

According to Goodlad[1], teachers now spend about 80 percent of their time dispensing information. Here is one reason only 20 percent of our children are able to write a decent letter. Because they are not asked to write very much. Why aren't they asked to write very much? Because it takes a long time to mark a set of papers. And it is often impossible to do the next thing that should be done after marking the papers (which, by itself, does not do the child much good). This is to sit down with Johnny and ask, "What's

this essay about?" "Well, it's about so-and-so." "What you just said is wonderful. I think it's better than the first sentence there. Look at it, do you agree with me?" Johnny says, "Yes." "Well, would you change it that way? Now Johnny, look at this sentence down here. If you read that to the class, do you think most of them would agree with you?" "No, they wouldn't." "Then why do you say a thing like that." "Because of these reasons...." "Then, why don't you put them in there?" "All right, I'll do that." The child has to be coached individually for a few minutes. If a writing exercise is done, someone reads it, then reviews it with the student, and the student redoes it over and over again, then eventually there will not be only 20 percent who can write. But how can that be done now? If there are 30 children per class, and 5 periods per day, that comes to 150 children. It takes 25 hours to mark a set of papers and coach the children if you allow even 5 minutes for marking and 5 for coaching. The solution seems to be smaller class size, so do we reduce the class size by half, from 30 to 15 students per class? Instead of America having 2.2 million teachers, there would be 4.4 million. And where do we get that 4.4 million if we are having difficulty replacing the 2.2 million with qualified people? Would 50 percent of our college graduating classes go into teaching, even with higher salaries? Would other sectors permit that or would they just outbid education? Reducing class size alone will not do it. As I have said, teachers need to be taken out of the self-contained classroom to work with colleagues and given the opportunity to work with children who need individual help. This cannot be done as an add-on; it can only be done by restructuring schools and the teaching profession. It cannot be done by making teachers work "harder" or through some additional programs.

It is irrational to think that we can go from 4.9 percent to 75 percent by making only minor reforms. What we have is a structural problem. And what we need is a community of educators that gets away from many of the traditional questions and responses and starts to discuss the issues and the points of learning to which children respond, such as what involves them, what engages them, organizational materials, what in the present system impedes learning, and so forth.

The stakes are very high. State and local governments, politicians, and industry have put a lot of money into education in the past few years. The nation has been told there is a reform movement going on and it expects results. I am not optimistic about the success of most of these so-called reform measures. Nor do I much trust the commercial standardized tests that are being used to measure performance. I am much more optimistic about some of the more structural and fundamental reform experiments that are going on, but in all too few places. But they will not show "results" quickly, nor should they be measured in our silly, conventional ways. Sadly enough, a structural view, a reform of education from the point of view of how children learn, is not even popular with educators. And all but teachers seem caught up by the prevailing tests. Will we

stop making the standard responses and start more real reforms before this reform movement is judged a failure?

I leave you with this thought: We must remember that, if we do not work out our own reforms, we will find ourselves in a struggle to fight privatization of the schools. Privatization will not make education any better. Most private schools are like most public schools, only private schools are able to choose and reject their students. But public education would be gone and, with it, the kind of public visibility and, yes, accountability that lead to efforts to do better for all students. It would be very hard, if not impossible then, to reinvent public education. And that would be a tragedy for this democratic nation.

Reference

[1]Goodlad, John I. *A Place Called School*. New York: McGraw-Hill, 1984.

PROFESSIONAL ASSESSMENT FOR PROFESSIONAL TEACHERS

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In the past year, Lee Shulman's research group at Stanford University developing prototypes of measures to assess teachers has done some preliminary work on new means of assessing teachers, based on a view of teaching as a professional activity. This paper describes that work in breadth and touches lightly on some of its implications.

Our work acquires perspective when placed in a larger context. One of the tasks of the Carnegie Task Force on Teaching as a Profession was to establish a National Board for Professional Teaching Standards; among the charges of this newly formed board is one to develop standards and means for assessing teachers and for granting certification. Such an assessment probably will consist of a combination of written tests, assessment center exercises, documentation of supervised performance, and direct observation of teaching. At Stanford, we have designed and tested preliminary models of what some of the assessment center exercises, and the center itself, might look like. Our work entails a good deal of basic research and is intended both to increase the knowledge base for teaching and to extend the conception and the range of tools for assessing teachers. The most concrete products of our research will be a library of prototypes for the board to draw on as it continues to build a workable assessment procedure.

We have designed 10 to 15 exercises in two domains: high school history (specifically, the U.S. Constitution and the formation of government) and elementary school mathematics (fractions, especially equivalence as taught in the fifth grade). Each exercise takes between 45 minutes and 3 hours and asks the candidate to perform in or talk or write about a situation that teachers would encounter in their work.

In a real assessment center, a number of local candidates might spend two days in an unoccupied school, taking four or five exercises each day administered by other (probably board-certified) teachers. In the summer of 1987, many of these exercises were field-tested under similar conditions. In the fall, we are working on scoring techniques and other analyses of the field-test data. In the winter, we will begin to design exercise prototypes in two new areas--high school biology and elementary school literacy (reading and writing); to explore documentation and attestation procedures; and to develop instructional materials to enable candidates to prepare for the

assessment. We also will continue to study the impact of the assessment on minorities and ways in which to increase the number of qualified minority teachers.

In the 10 mathematics exercises in the field test, candidates were asked to demonstrate a range of knowledge and skills. In one exercise, the candidate is given a standard textbook, a topic, and 30 minutes to work; he or she plans a day's lessons, then discusses the plan with an examiner, including such items as the main points, the significance of the material, examples that might be used, previous knowledge required by the students, and what they might find hard or easy about the lesson. In another exercise, the candidate is presented with four vignettes of a tutoring situation and discusses ways of responding to each student's questions and difficulties. One exercise describes three algorithms commonly used with fractions and asks the candidate why each one works, what advantages or disadvantages it carries, and what alternative procedures might be useful. Another exercise stipulates that the candidate bring a lesson plan to the assessment center, where she or he discusses the plan with an examiner, teaches the lesson to a group of six students who have been coached for the exercise, then reflects on the lesson, and finally discusses what happened with the examiner. Additional exercises include such tasks as critiquing a videotaped portion of a real mathematics class; discussing instructional uses of a standard mathematics manipulative, a computer program, and a collection of everyday objects with potential for mathematics applications; describing alternative classroom routines; analyzing and critiquing a textbook; and others relevant to the teaching of elementary mathematics.

The design of these exercises is based on a variety of sources. Within the established knowledge base, we have relied on Stanford University's Knowledge Growth in Teaching studies of the past four years, on our own project's Wisdom of Practice studies of elementary teachers expert at teaching mathematics, and on other research in teacher knowledge--in mathematics, Leinhardt's and others' work at the Learning Research and Development Center at the University of Pittsburgh, and Romberg's and Carpenter's work at the University of Wisconsin-Madison, for example. We have commissioned several papers, subcontracted with other institutions, and held two conferences--on assessment technologies and minority impact--to inform ourselves in particular areas. We also formed expert panels in each content domain and a local teacher advisory board, all of which met regularly, participated in our research, and gave us continuous guidance.

Our vision of the professional teacher for whom this assessment is designed corresponds to the view expressed by the Mathematical Sciences Education Board in its Curriculum Framework. The profes-

sional teacher is able to learn new subject matter and new methods for teaching old subject matter. This teacher is a complex reasoner, problem-solver, and decision-maker, not just an actor or actress; he or she not only performs, but also gives a thoughtful, justifiable performance. The ideal teacher represents and adapts academic content in ways that are understandable and interesting for the students. This vision requires the teacher to possess the usual knowledge--of content, of general pedagogy, of children, of contexts--plus knowledge of how to synthesize and adapt them under continually changing circumstances, plus the ability to rationalize her or his own actions and judgment.

Of course, this vision of the teacher implicit in our assessment exercises holds certain implications for the institutions and programs that prepare candidates for teaching. Two of these implications are very general, but fundamentally important. First, the teacher's special way of knowing content for instruction implies a more intimate connection between subject matter and pedagogy and, by extension, between disciplinary departments and schools of education. Second, this teacher is not to be trained in effective techniques only, but also must be educated for understanding and provided with significant opportunities to synthesize and apply this understanding. There is little doubt that teacher education institutions will adapt their programs to help prepare their students for board certification. This shift carries great potential for improving teaching as well as considerable responsibilities. The board must design an assessment in such a way that preparing to pass it will, in fact, make a candidate a better teacher. Teacher education programs must respect the spirit and not just the letter of reform by aiming to educate teachers rather than simply coaching them to pass the test. Educational institutions in general will have to find ways in which to enable increased numbers of minority candidates to meet higher standards in the teaching profession.

In summary, the board's assessment and certification processes will be worthwhile only to the extent that they encourage individual teachers, the teaching force as a whole, teacher educators, and their institutions to achieve higher professional standards.

SUPPORTING THE CHANGES

THE PROFESSIONAL DEVELOPMENT OF OUTSTANDING MATHEMATICS TEACHERS

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My study of the professional development of outstanding mathematics teachers sought to identify the activities that these teachers value as contributing to their professional development and in which continuation at the present stages of their careers is important. The outstanding teachers are 34 winners of the 1983 Presidential Award for Excellence in Teaching Mathematics. The participation of 57 randomly selected members of the National Council of Teachers of Mathematics (NCTM) was included in order to test whether the awardees' views are qualitatively different from the views of other persevering teachers. To supplement quantitative data, questions were asked about incentives (Lortie 1975), moonlighting, professional colleagues, career turning points, thoughts of leaving, and special work accommodations.

The decision to use NCTM members (instead of a random selection of secondary mathematics teachers) as the comparison group followed Maslow's (1971) research philosophy and the theoretical framework of his study of self-actualized persons: To investigate professional development, one must begin where there is evidence of professional orientation. NCTM membership was selected as a baseline, voluntary activity that manifests a mathematics teacher's desire to grow professionally.

Ratings on 19 formal and informal professional development activities and 2 on classroom teaching (remedial mathematics and advanced placement or gifted mathematics) were sought. Participants were asked two questions: How important is it to you to continue this activity? How much do you think this activity has contributed to your professional growth? Responses corresponded to the following: 1 = not at all; 2 = very little; 3 = to a slight extent; 4 = to a moderate extent; 5 = to a great extent. Awardees' mean ratings (on the 5-point scale) are higher, standard deviations smaller, and participation in each activity greater. Awardees participate in more of the 21 activities (17.8) than the comparison group (11.9). Mean ratings above 4.0 were obtained from the awardees for 15 activities that contributed to professional growth and 16 on importance of continuation, and from the comparison group for 8 activities that contributed to professional growth and 3 on importance of continuation. The fewer comparison teachers who participate in honorific activities (such as writing for publication and consulting) rated them higher than the awardees, who gave the highest ratings to activities that are open to participation by any teacher.

Activities that the awardees consider important to professional growth correlate well with three career stages defined by Lee and Pruitt (1983) which are similar to the career levels proposed by the Holmes Group (1986). These relationships are shown in Table 1. Table 2 summarizes the mean ratings, standard deviations, and percent of participation by the awardees and the comparison group in responses to the questionnaire.

Implications of Findings

These data constitute a beginning step toward identifying valuable professional development activities for secondary mathematics teachers. School systems already provide in-service activities that are valued by some teachers during their skill-building stage. To meet the developmental needs of teachers who are beyond that stage, formal recognition must be given to activities that teachers in this study value as having contributed most to their professional growth: attending and participating in NCTM and affiliate group conferences, membership in those organizations, attending institutes, and advising student mathematics activities. Districts should seek ways in which they can encourage and provide opportunities to more teachers to teach in-service classes, engage in curriculum development (at a level beyond planning for courses they currently teach), write for publication, or do consulting work.

It may well be that the most distinguishing difference between the awardees and the comparison teachers in this study is the number of activities in which they engage and the higher energy level manifested therein. If participation alone in more professional development activities affects professional development positively, then school districts should consider incentives that encourage teachers to experience more such activities.

Table 1

Career Stages and Related Professional Development Activities for Mathematics Teachers

Lee and Pruitt (1983) Career Stage	Holmes Group (1986) Career Level	Teacher Activities
Stage I Survival skills, instructional methods, and management skills	Instructors	Take additional courses in mathematics *Read journals, esp. Math. Teacher *Join NCTM *Join NCTM affiliate group *Attend conferences
Stage II Increase professional competence, explore new concepts and teaching techniques	Professional Teachers	*Work on NCTM/affiliate committees *Attend institutes *Advise student math. activities (Math. clubs, teams) Assume chairmanship of the mathematics department *Engage in curriculum development *Teach university classes (given the opportunity) *Read other journals (e.g., Phi Delta Kappan) *Make presentations at conferences *Teach in-service classes
Stage III Self-confident, demonstrated effectiveness, continue to grow through competence and status among peers	Career Professionals	*Write for publication *Do consulting work

*Begin at this stage and continue throughout career (rated high in both contribution to professional growth and importance of continuation).

Table 2

Comparison of Mean Ratings, Standard Deviations, and Percent of Participation of Awardees and the Comparison Group
(In Descending Order of Awardee Ratings on Contribution to Professional Growth)

	Contribution to Prof. Growth						Importance of Continuation					
	Awardees (N-34)			Comparison (N-57)			Awardees (N-34)			Comparison (N-57)		
	Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%	Mean	S.D.	%
Attend conferences	4.7	0.6	100	4.0	1.0	86	4.7	0.6	100	3.8	1.4	84
NSF-type institutes	4.6	0.8	79	4.4	1.2	42	4.4	1.1	79	3.8	1.6	42
Membership in NCTM	4.5	0.7	100	3.8	0.9	100	4.8	0.7	100	3.6	1.3	98
Make presentations	4.5	0.7	97	3.9	0.9	42	4.5	0.7	97	3.4	1.3	40
Student math. activities	4.5	0.7	85	4.0	0.9	58	4.6	0.7	85	3.8	1.3	56
Math. dept. chairmanship	4.5	0.8	71	4.0	1.3	51	4.4	1.2	71	3.5	1.5	49
Read professional journals	4.4	0.7	100	3.9	1.0	89	4.5	0.8	100	3.7	1.2	88
Curriculum development	4.4	0.8	88	4.2	1.1	74	4.6	0.7	88	4.0	1.2	72
Teach adv. placement/gifted	4.4	0.8	88	4.0	0.9	49	4.4	1.0	88	3.8	1.4	47
Consulting	4.4	0.8	76	4.3	0.8	12	4.4	0.7	76	4.0	0.8	12
Teach in-service classes	4.3	0.9	97	3.4	1.2	37	4.3	0.8	97	3.1	1.4	37
Membership in NCTM affiliate	4.3	1.0	97	3.6	1.1	89	4.6	0.7	97	3.6	1.3	88
Writing for publication	4.3	0.9	71	4.6	0.9	9	4.3	0.8	71	5.0	0.0	5
NCTM/affiliate committee	4.1	1.0	62	3.5	1.3	40	4.1	1.0	62	3.1	1.4	39
Teach university courses	4.0	1.1	65	3.8	1.1	23	4.0	1.0	65	3.6	1.3	23
Take in-service classes	3.8	1.3	97	3.5	1.1	88	3.8	1.3	97	3.3	1.4	86
Teach remedial math.	3.7	1.3	91	3.4	1.4	65	3.5	1.4	91	3.1	1.6	63
Membership other prof. orgs.	3.6	1.2	79	3.9	0.9	68	3.9	1.0	79	3.8	1.4	67
Supervise student teachers	3.5	0.9	82	3.7	1.1	54	3.5	1.2	79	3.1	1.4	54
Community activities	3.5	1.4	65	3.7	1.2	58	4.3	0.9	65	3.9	1.2	56
Nonmath. student activities	3.3	1.3	85	3.5	1.2	54	3.3	1.3	88	3.1	1.5	53

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ENCOURAGING THE IDEAL TEACHER AT THE DISTRICT LEVEL

Jack Price
Palos Verdes Peninsula Unified School District

To become ideal teachers, mathematics teachers must go through three steps:

"I teach mathematics;"
"I teach children mathematics;" and
"I help children learn mathematics."

It is a difficult task for many and, for teachers to reach their full potential, they must have both financial and psychological support. There is nothing new about this idea. What is new are the ways in which local school districts can provide this support.

At one time, local school districts were far more concerned about the financial support for teachers. The districts wanted to provide materials and equipment, and they still do. However, helping teachers learn how to use new equipment or materials was not usually a component of the "new" curriculum. Earlier, National Science Foundation institutes had attempted to deal with this problem, but it was too massive for a national effort. Prior to that time, in-service training was seldom seen as a necessary adjunct to the introduction of a new curriculum and/or materials and equipment. It became apparent, though, perhaps as an outgrowth of the institutes or of curriculum writing, that staff development was a necessary ingredient of change. Then, staff development was viewed generally from the financial aspect. In order to persuade teachers to take in-service training, three inducements were used:

(1) released time from classroom duties;

(2) credit for advancement on the salary schedule; or

(3) extra pay for the extra time spent.

Little appeal was made to the inherent professionalism of the teacher.

But an interesting thing happened to some of the local school districts. They became old and poor. The three inducements no longer had the significance or the currency that they once had. Strangely enough, what turned out to be a better inducement was the

perceived value of the treatment. A case in point is the Miller Mathematics Improvement Program in California in the early 1970's. During the first year, teachers were paid to attend the program and credit was provided (self-pay). Later, no stipends were provided, but credit was available. Finally, after state funding ran out, teachers flocked to the continuation of the program--and they paid for it!

Today's teachers are no different. The ideal teacher today is still most interested in something of value, something that will help him or her to work better with the children. Now, we are much more aware of the psychological needs of teachers. In the Miller Mathematics Improvement Program, perhaps by chance or perhaps because of research needs, teams of teachers from the same school were required, so that the teachers would have someone with whom to discuss ideas or to share momentary failures. We had begun to meet the psychological needs of the teacher. In-class support is extremely important. In California, as a part of the reform movement, a mentor-teacher program has furnished the opportunity to some extent to provide this support from colleagues.

The necessity of having someone who cares cannot be underestimated. Many large school districts under constant bombardment about "administrative overhead" have reduced or eliminated their curriculum development/instructional improvement staff. In effect, they have eliminated research and development, professional development, quality control, and the opportunity to move their districts ahead programmatically.

By including teachers in planning, by letting them share their talents, by praising them for their good work, and by helping them to grow professionally, their development into ideal teachers will be encouraged. For this to occur, district boards and administrators must make a commitment to provide assistance and recognition to teachers; make plans that involve ideal teachers helping others to become ideal teachers; and work out a sharing of the costs with the individual schools and a sharing of the successes with all who contribute to them.

With these commitments (which cost very little money), local school districts will keep the ideal teachers they have and will encourage their other teachers to strive for the same high level of accomplishment.

ENCOURAGING THE IDEAL TEACHER AT THE STATE LEVEL

Ted Sanders
Illinois State Board of Education

From a close friend who is a minister, I know that, in preparing a sermon, one never tries to make more than three points. I have 17 or 18 that I want to make, so this paper may become lengthy. I found it difficult to think about the challenge that has been presented to me and keep my focus limited to the issues surrounding the support of teachers who are in service and, particularly, to addressing the very important topic of continued professional growth and development.

I also have great difficulty thinking about the ideal. I prefer Dr. Lampert's notion of talking about reality, about what is possible. I would like to share with you--in reality--some of the vision that we have in Illinois and what we are trying to do, at least from the state's perspective, to realize that vision. It is not sufficient to talk only about teachers who are in service; undergraduate and/or graduate teacher education programs must be strengthened as well. That is not necessarily in the realm of activities for a state superintendent other than that certification and program approval requirements tend to be reflected very directly in what happens at institutions. Today, as never before, we need to think more flexibly so that, from the state's perspective and from the credentialing standpoint, we foster new approaches to training teachers. These should not be ways that would move the state merely to endorse the Holmes and Carnegie notions of moving teacher training to the graduate level, but ways of thinking creatively about policies that would foster that and other approaches. This would encourage institutions to proceed in those directions, something at which we have not been particularly adept. What we are trying to do now is to suggest that both the length and the content of teacher training in Illinois should be driven by definitions of what teachers ought to know and be able to do when they enter the classroom. This is a major philosophical shift from our standpoint.

A second thing that we are trying to do in Illinois is to create a new institution that sits between the public school districts of our state and the institutions of higher education. We are calling them clinical schools because they appear by that name most often in the literature and are analogous to teaching hospitals. In these schools, teachers going through their clinical experiences learn in settings where the very best practice takes place. We have passed the legislation to move in this direction and a statewide meeting between my office and all of the deans from both public and private institutions in the state was conducted in October, 1987. We are excited about this new entity on our landscape.

We also have made the decision to lengthen the time required for clinical experience in Illinois. It will be a few years before this is actually in place, but we are moving toward a full semester of clinical experience so that the teacher-trainee will get a sense of the full rhythm of the school.

We also are committed to creating new support mechanisms during the initial years of teaching. We have been a little more cautious in this area than have other states such as Florida and California. In our 1985 legislative session, we were able to persuade the General Assembly to allow us to invest $175,000 in examining those initial years of teaching. Our goals were to ascertain what we might do in this area and to find new ways of putting support structures in place so that we continue to take advantage of the reality of the learning curve in those first years. In that quest, we worked collaboratively with Eastern Illinois University and the University of Illinois at Chicago to produce what I think is a fairly significant monograph--a set of commissioned papers that addresses some of the issues surrounding those initial years of teaching. From what we have learned, we will put new support mechanisms in place in our state.

Continued professional development is at the heart of what we must do. It is not easy to sell professional development to state-level policymakers or the governor and the state legislators. I spent several years working with the legislature in New Mexico, then six years as Nevada State Superintendent. During the years in Nevada especially, I went to almost every session of the legislature to ask for financial support for the continued professional growth of teachers. I came away from every session empty-handed.

In 1985, as Illinois' State Superintendent, the State Board of Education and I took to the legislature an educational reform package that contained a section on continued professional growth; much to my surprise, we were able to sell it. Keeping it sold is proving to be a different task, however, but the Illinois vision is based on a combination of several things which reflects what the state is trying to do to foster quality professional growth. First of all, we have announced that, as a matter of state policy, continued professional development is important. Rather than prescribe a state policy statement about the specifics of such growth, we have told every one of the 985 school districts in the state that they must collaborate with their teachers in designing a district policy on staff development. Some financial resources are being provided to implement this. The entire cost has not been underwritten, but some seed money has been furnished. As of the third year, $3 million per year has been invested in the support of such activities.

We also are endeavoring to encourage professional growth across two different dimensions, one of which focuses specifically upon the individual teacher, either in subject matter or in teaching skills.

But there is another very important dimension of staff development. This dimension appears in the work of Bob Bush, who was at the Stanford Research Institute for many years. In some of his research, he has described three classifications for schools, the highest of which he calls an "energized" school. These are good schools, and they are getting better. "Maintenance" schools are holding their own, neither improving nor deteriorating. Then there are "depressed" schools, which are on the decline. The characteristic that stands out in the energized schools is a principal who is engaged in collegial fashion with his or her faculty to identify problems and find solutions to them through the vehicle of staff development.

In our professional growth programs, we try to foster policies and activities that focus on both the individual and the school because both are important. We require that two other principles be observed. As a matter of state policy, we are requiring that teachers play an active and equal role in determining local staff development policies. That has not been an easy row to hoe. In many districts, things have gone very well; there has been open and equal collaboration. In other cases, there has been anything but a collaborative effort involving the faculty. The other principle we have tried to recognize is that staff development activities must be consistent with what we know from the limited research of how adults learn. We need to draw upon that body of knowledge.

To support statewide policies that go beyond individual districts and with financial support from the state, we have created 18 educational service centers. They are not really like the educational service centers or intermediate agencies that exist in other states. Our educational service centers have only one mission, and it is in direct support of teacher development. It is intended that the centers benefit from economies of scale and that they also blend the variety of resources available both within and outside our state into their mission of professional growth for teachers. Illinois is putting $18.5 million per year into these centers. Each one is governed by a body made up of practicing classroom teachers, district administrators, university faculty, and, in some instances, local school board members.

We also have been rethinking our certification renewal requirements. In Illinois, once teachers arrive at a "professional" level of certification, they have not been required to demonstrate any continued growth to renew their certification. We are in the process of reconsidering this in two different ways: (1) by possibly making it mandatory for teachers to show evidence of further professional growth as a condition of their continued certificate renewal, and (2) perhaps more importantly, by looking at teachers who are returning to the work force after having been out of it for a significant period of time. Interestingly enough, slightly more than half of the newly hired teachers in Illinois each year are individuals who were trained as teachers at an earlier time. Either they have been out of the

work force or they have been in it in another role and are returning to teaching. We are now requiring that, if a teacher has been absent from the classroom for a period of five consecutive years, he or she must participate in experiences that focus on subject matter competence; pedagogical skills will have to be renewed in one of the new clinical schools; and, during the first year back in the classroom, each returning teacher will have to work under a mentor-teacher.

We have tried to evaluate the role that school administrators play in staff development. As in many states, we have created and funded an Administrators Academy which brings a variety of training programs to practicing administrators. One of the training modules demonstrates how a principal can assess the professional growth needs of his or her faculty and develop a school-based staff development program. We are thinking very seriously about, and are engaged in testing, new initiatives that would restructure the teacher's workplace. At present, no one really knows exactly what is meant by restructuring that workplace. There are ideas about what it ought to include, but, in that restructuring, there is clear intent to empower the teacher in new ways. We are trying to engage some of our schools with the Ted Sizer Coalition of Essential Schools and other similar individuals or groups that are thinking about restructuring. We are proposing legislation that would allow us to set aside state requirements, if necessary, to encourage and foster that change. It is a very important companion piece, particularly with the Holmes and Carnegie vision of the new teacher. Any number of such teachers can be produced, but if we are unable to restructure the school as a desirable workplace for those teachers, they will have neither a successful nor a satisfying experience.

In Illinois, we are developing and attempting to validate indices that would measure conditions in schools for effective teaching and learning. Those indices would be used in our state recognition processes. Almost every state has procedures for sanctioning or approving schools. Generally, such procedures center on whether certain policies are in place, the condition of the physical plant, and so forth. We are reviewing the entire process with an eye toward including in it mechanisms for examining conditions for effective teaching and learning. We are trying to build new initiatives that recognize and reward good teaching. It would be remiss to talk about what must be done to encourage the development of ideal teachers and not talk about salaries and the value we place upon these people. Addressing the compensation question has not been easy, particularly at the state level, because one quickly runs headlong into conflicts with the district government structure, with organized teacher groups, and so forth. We may not be able to do much more at the state level than ensure a substantial increase in resources and/or foster different ways of viewing and using the teaching force. We can do some things that demonstrate, or encourage the community as a whole to think about, the value we place upon teachers. I used to

think there was little value in slogans, themes, and heroes, but I have come to believe that my earlier thinking was wrong. We have tried to do some things through a program that we call "Those Who Excel," to search out, identify, recognize, and reward teachers who excel. We have a commitment from the University of Illinois whose president has agreed to waive the tuition for either a master's degree or a doctorate for the teachers we recognize. He also has communicated with his colleagues in public institutions, telling them what a good program this is and suggesting that they make the same offer in the event that these teachers would like to enroll in their institutions instead. These institutions have responded positively. As a companion piece to this activity, I have raised the money to purchase the equivalent of a sabbatical leave for these teachers so that their salary can be paid while they study. In addition, they are given a $10,000 per year stipend. I have been criticized for removing good teachers from the classroom, taking them away from the students, but I think that this program will pay significant dividends in the long term.

We also are purchasing these teachers' time in a unique way for one full semester so that they can serve as our ambassadors for teaching in Illinois. They are at the state's disposal and they are in great demand across Illinois by education and community groups that want them to talk about teaching.

In Illinois, if we are going to foster these goals for teachers, we also have to address the conditions of rural education in the state, particularly the conditions that exist in rural high schools. Our thinking about the rural high school as a place to work is very different in many respects than our thinking about general restructuring. Contrary to what you may believe, Illinois is a very rural state. In fact, 55 percent of the high schools in the state enroll fewer than 500 students. More than one third of them enroll fewer than 200 students. Our best teachers do not go to the inner cities or to the small rural high schools. We tried to address this issue several years ago, but lost it politically. However, it still is a very big issue. To get an idea of the problem, we can draw from a science classroom in a typical small rural high school--not a math classroom, but a science classroom. The following example is fairly typical, not an anomaly: a high school chemistry class being taught by a mathematics teacher who has roughly a minor in mathematics, with three hours of undergraduate coursework in chemistry--strictly lecture, no laboratory. Obviously, we must think about the rural high schools and schools in the inner city in different ways as we go about our restructuring.

Although it was not requested, I am unable to refrain from mentioning some of the things that I believe the federal government should be doing. There are at least four of them. The first is something that Illinois is doing already--either making grants to, or waiving tuition and fees for, those who want to prepare themselves

for teaching. We need substantial increases in direct student aid for persons who will staff our classrooms, particularly our mathematics and sciences classrooms. I also believe that we must reinvest in the National Science Foundation (NSF) types of institutes to provide once again the kinds of concentrated and intensive growth opportunities that they afforded for the existing teaching force. The current crop of classroom teachers in this country has been in the classroom for just over 14 years on average. I can think of no better way to provide opportunities for them from which they will benefit more directly--and here I speak from personal experience. No other experience was more meaningful to me in terms of my personal and professional growth, as well as my growth in mathematics knowledge, than the experiences I had at Washington State while working toward a master of arts in teaching degree supported by the NSF-funded summer institutes program. It is unfortunate that opportunities such as those provided by the NSF institutes are not available to the new generations of teachers.

There are two other new initiatives worth considering. One is to provide financial support for teachers to review their teaching techniques. From some of the laboratory work that has been done, we know that teachers can engage effectively in research and inquiry about their teaching methods; we ought to ensure that opportunities and financial support are provided for some of our teachers to inquire systematically into their teaching practices. We also ought to build financial incentives that support institutional collaboration, not just individual collaboration. The collaboration that occurred between Yale University and the schools in New Haven in the Yale-New Haven project is an excellent example. In some cases, Nobel laureates were paired with high school faculty to examine the problems that high school teachers face in their work. We need to build, support, and encourage that kind of collaboration. It must be formal, institutional collaboration, not merely informal cooperation where one college faculty member decides it would be a good idea to teach one period a day to fifth-graders and becomes involved with the school faculty in its work. The latter is very good but, when that individual goes, so does the collaboration.

The teaching profession is experiencing exciting times. In fact, these may be the best of times to be engaged in our profession. I am reminded of the friendship that developed between Thomas Jefferson and John and Abigail Adams. Although that friendship was fractured terribly during the Adams administration, it was repaired during their twilight years. Some beautiful letters were exchanged between John Adams and Thomas Jefferson, and between Abigail and Jefferson. In one of those letters, Abigail penned some words that are very appropriate today: "These are the times that a genius would dare to live. Great necessities call forth great leaders." That is precisely true of our condition today. You are the leaders who are called forth. May good fortune attend you in giving that leadership to mathematics education.

SUSTAINING THE CHANGES

A DISCUSSION OF THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS' GUIDELINES FOR THE POST-BACCALAUREATE EDUCATION OF TEACHERS OF MATHEMATICS

Donald J. Dessart
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In the spring of 1986, John Dossey, the president of the National Council of Teachers of Mathematics (NCTM), appointed a task force to develop guidelines for the post-baccalaureate education of teachers of mathematics (the PBETM guidelines). The task force was charged to develop a document that identifies specifically the desirable competencies to be achieved by the post-baccalaureate study of mathematics and pedagogy and to circulate the draft document to a broad sample of the profession for review and reactions.

Crisis in Mathematics Education

The results of national and international studies document that the United States faces a crisis in mathematics education. The mathematical and scientific communities are arming to face this crisis. Not only have groups within these communities been concerned with the content of mathematics education in the schools, colleges, and universities, but also they are pursuing actively reforms in teacher education and in the context in which teaching takes place. Such groups include the Mathematical Sciences Education Board of the National Research Council; the Committee on Mathematical Education of Teachers of the Mathematical Association of America; the Commission on Standards for School Mathematics of NCTM; and Project 2061 of the American Association for the Advancement of Science. Against this backdrop of keen interest in reform in mathematics education came two very significant reports: *Tomorrow's Teachers* (commonly referred to as the Holmes Group Report) and *A Nation Prepared: Teachers for the 21st Century* (the Carnegie Report).

At its initial meeting in St. Louis in December 1986, the PBETM Task Force reviewed the work of these groups and reflected on its implications for the work of the task force. One possible conclusion could have been, "Let's wait for the dust to settle before writing the guidelines!" The task force chose not to wait, but to forge ahead, taking into account the wealth of recommendations available.

Assumptions

In developing the PBETM guidelines, certain assumptions were made explicitly by the PBETM Task Force and other assumptions entered the guidelines implicitly. Some of these assumptions are given below:

(1) NCTM's 1981 *Guidelines for the Preparation of Teachers of Mathematics* represent the competencies necessary for initial licensure to teach. The PBETM guidelines were developed assuming that a post-baccalaureate teacher had satisfied the competencies of the 1981 *Guidelines*.

(2) Mathematics specialists are as desirable for the elementary grades as for the secondary schools. Such specialization probably will require some reorganization of the elementary schools, but should not require additional funding to implement when compared to a school staffed only by generalists.

(3) Grades K-8 and 7-12 are the most prevalent programs at teacher education institutions and precise grade specializations occur because of experience and practice; therefore, the guidelines reflect these programs.

(4) Differentiated staffing is the wave of the future, demanded because of academic and economic reasons.

(5) Problem-solving is becoming more and more an attitude or a frame of mind that a mathematics teacher brings to many varied teaching and learning situations.

(6) The potential uses of technology to improve mathematics instruction are in their infancy at this time.

(7) The competencies recommended in the PBETM guidelines can be gained in a variety of ways, including in-service education, professional meetings, self study, and workshops, as well as formal college courses. Formal college courses provide for in-depth study that is often not possible in other ways.

Categories of Mathematics Teachers

PBETM guidelines were developed for each of the following categories of teachers. It is felt that these categories are consistent with the trend toward differentiated staffing in the schools as well as being realistic enough to provide guidance for current staffing patterns.

(1) Mathematics Specialists in Grades K-8
(2) Mathematics Specialists in Grades 7-12
(3) Generalists with Mathematics Education Concentration in Grades K-8
(4) Generalists with Mathematics Education Concentration in Grades 7-12
(5) Generalists in Grades K-8
(6) Mathematics Supervisors in Grades K-12
(7) Mathematics Supervisors in Grades K-8

Each of these categories is defined more fully in the PBETM guidelines.

The PBETM Guidelines

The guidelines consist of two parts:

(a) a listing of the competencies to be attained, and
(b) descriptions of formal college courses to help attain the competencies. Guidelines are developed for each category of teachers given above.

The competencies fall into five broad classes:

(a) mathematics,
(b) problem-solving,
(c) methods and materials,
(d) technology, and
(e) mathematics education.

To illustrate these competencies, each of the five classes will be described briefly for the "Mathematics Specialist in Grades K-8." A complete listing of the competencies for all categories of teachers is in the guidelines.

The mathematics competencies consist of understanding and being able to explain simple number theoretic concepts, elements of probability and statistics, geometrical notions, algebraic properties of the real numbers, topics from discrete mathematics, the logic and reasoning underlying the mathematics of these grades, and events from the history of mathematics.

Problem-solving encompasses skill in reading and writing mathematics, problem-posing as well as problem-solving, and the ability to explain mathematical applications, including mathematical modeling. Problem-solving is pervasive and not limited merely to solving certain types of problems.

Competencies related to methods and materials include knowing and being able to locate varieties of commercial and teacher-made materials, the abilities to evaluate textbooks and computer software, knowing methods and materials for teaching reluctant learners as well as gifted and talented students, and understanding and being able to apply various techniques of tests and measurements.

Technological competencies include the abilities to understand and write programs in a structured language, such as Logo, Basic, or Pascal, and being able to implement appropriate uses of computers, calculators, and other technology in the classroom. The PBETM Task Force feels that the technological competencies will be those subject to the most change in future years, and that technology should be used to improve, but never replace, mathematical instruction.

Mathematics education competencies dwell more on the wider professional role of the mathematics specialists. They include understanding and being able to apply principles of curriculum planning, development, and evaluation in mathematics; understanding the psychological principles underlying the learning and teaching of mathematics at these grade levels; being cognizant of current research in mathematics education; and being familiar with current issues, such as those arising from international studies, the recommendations of professional associations, and current national trends in education.

The formal college courses recommended to help post-baccalaureate teachers attain these competencies are:

(a) Problem-Solving in K-8 School Mathematics,
(b) Technology in K-8 School Mathematics,
(c) Probability and Statistics for K-8 School Teachers,
(d) Topics in Discrete Mathematics for K-8 Teachers of Mathematics,
(e) Geometry for K-8 Teachers of Mathematics,
(f) Models of Teaching and Instructional Strategies for Grades K-8,
(g) Tests and Measurements,
(h) Psychology of K-8 School Mathematics,
(i) Current Curricular, Teaching, and Research Issues in Grades K-8, and
(j) Diagnosis and Remediation of Learning Difficulties.

Responsibilities of Professionals

The PBETM guidelines also include a discussion of suggestions for college and university faculties, local and district administrators, members of professional associations, mathematics teachers, and

parents to implement the guidelines. The guidelines are meaningless unless they can be translated into practice by those most affected by and concerned with quality mathematics education.

Summary

The PBETM Task Force believes very firmly that good mathematics teachers at all levels need sound backgrounds in both mathematics and pedagogy. High competence in these two areas is necessary for excellence in teaching. Furthermore, teachers need the active support of school administrators, fellow teachers, parents, and students to attain the competencies recommended. This support should include encouragement, released time, and financial assistance.

The PBETM guidelines represent a model that is recommended to achieve excellence. The task force believes strongly that it is not the only model, and that the PBETM guidelines should never be used to inhibit or impede creative thought in the search for excellence in mathematics teacher education.

* * *

[Copies of NCTM's PBETM guidelines can be obtained from:

National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 22091
(703) 620-9840]

A DISCUSSION OF THE MATHEMATICAL ASSOCIATION OF AMERICA'S GUIDELINES FOR THE POST-BACCALAUREATE EDUCATION OF TEACHERS OF MATHEMATICS

Calvin T. Long
Washington State University

There has been close liaison between the National Council of Teachers of Mathematics (NCTM) and the Mathematical Association of America (MAA) in producing the various guidelines of the last several years, so it is a pleasure for me to have the opportunity to make this presentation about our work. Our hope is that what we have produced in the guidelines is worthwhile and useful and will not be allowed to fade into oblivion.

Our efforts go back a long way to the old Committee on the Undergraduate Program in Mathematics (CUPM) and to various subpanels of that group, mainly the panel on teacher training, which produced its first report in 1961. Since that time, there has been a steady outpouring of reports from that committee. Finally, within the last couple of years, the Committee on the Mathematical Education of Teachers (COMET), which was a subpanel of CUPM, was deemed to be of sufficient importance that it was constituted as a separate committee, independent from CUPM, with the responsibility of recommending MAA stances with regard to teacher training and teacher education.

COMET represents a group of people concerned about the present state and the possible future of mathematics education in America who have a strong desire to improve the system and make it one of the very best. This attitude is a reflection of our parent organization, the MAA, and it has been delegated to us now as a full-time standing committee of the MAA. Our charge is that of formulating policy and guiding MAA in activities in this important area of teacher preparation. While I am reporting here on COMET's new *Guidelines for the Continuing Mathematical Education of Teachers*, such a report would be incomplete if I did not mention first the most recent report of the MAA panel on teacher training, entitled *Recommendations on the Mathematical Preparation of Teachers*. I also should mention a parallel document prepared by NCTM, entitled *Guidelines for the Preparation of Teachers of Mathematics*. Both of these documents deal with initial licensure to teach and describe the necessary ingredients for programs to train or prepare new teachers. They are rather prescriptive, and spell out with some care what we feel ought to be included in those training programs.

With regard to the MAA *Recommendations* and the NCTM *Guidelines* for undergraduate preparation, it should be noted that they are examples of significant cooperation between these two organizations. Both organizations were consulted in the preparation of both documents. I also serve on the NCTM task force to develop guidelines for the post-baccalaureate education of teachers of mathematics (the PBETM guidelines), and there is NCTM representation on the COMET committee. Another example of the meaningfulness of this cooperation is the fact that the NCTM guidelines were endorsed formally by the board of governors of the MAA and this endorsement, along with that of other groups, helped to provide the momentum that caused the NCTM guidelines to be accepted as accreditation standards by the National Council of Accreditation for Teacher Education-- a most important step.

There is no doubt that this cooperation, and that of the entire mathematics education community, will continue to be significant and important in the coming days of structural and curricular flux in American education that we all anticipate. That this is recognized by the leadership of both NCTM and MAA is evidenced by the fact that we have this significant involvement of members of both organizations on the two committees we have been talking about.

Now let me turn to the COMET *Guidelines*. In the first place, they are addressed to school administrators to assist in planning in-service programs for teachers, programs which we feel are extremely important for maintaining the vitality of teachers. They also are addressed to college administrators and departments of mathematics and mathematics education to assist in the design of teacher-training programs. They are addressed as well to teachers and district supervisors, to national and state governmental agencies, to professional societies, to regional and local educational organizations, and to everyone concerned with improving the effectiveness of mathematics education in America today. The *Guidelines* contain suggestions for in-service programs for all teachers, for master's degree programs for elementary school teachers, elementary school mathematics specialists, coordinators of elementary school mathematics programs, teachers of middle school and junior high school mathematics, teachers of high school mathematics, and for the graduate education of mathematics supervisors.

While changes in teacher training are taking place in response to such studies as the Holmes and Carnegie reports, it must be noted that the present guidelines or recommendations are designed with current in-service teachers in mind and are intended to provide these teachers with a fresh look at both mathematics and pedagogy. The changes resulting from the Holmes and Carnegie reports may well necessitate the reworking of both the existing undergraduate *Recommendations* and the new *Guidelines*. At the same time, the changes needed may be relatively minimal and the existing guidelines

should help in the structuring of programs consistent with the Holmes and Carnegie recommendations. For example, in connection with the valid concern that we not lose hard-won ground, we feel that any undergraduate major program devised for elementary school teachers in accordance with the Holmes recommendations should include the three or four undergraduate mathematics courses spelled out in the MAA *Recommendations* and the NCTM *Guidelines*. While endorsing the Holmes recommendation that the elementary mathematics major be abolished, we agree wholeheartedly that substitution of precalculus, calculus, or liberal arts mathematics courses for the courses in our existing recommendations would be totally unacceptable.

Since our report runs to over 90 pages, let me highlight several of its points and leave you to read the rest of the document in detail. The first thing I would like to observe is that, as of this writing, it is a draft. We expect to have the guidelines completed in early 1988. However, if you have strong feelings about any section of the *Guidelines,* suggested references, or other comments, I would be pleased if you would write them out carefully and send them to me at the Department of Mathematics at Washington State University.

Secondly, these guidelines are much less prescriptive and more suggestive than the 1983 recommendations of the MAA. Types of programs, ways of meeting the needs of teachers, and general mathematical content are proposed. These are intended to suggest promising approaches, but they may need to be modified to meet local situations. Thus, these guidelines indicate directions for continued program development rather than giving fine detail for present or future programs.

Thirdly, one of the strong points of the guidelines is the very extensive bibliography. However, you will note that we have few or no references for some courses. Obviously, some of the courses suggested depend on current literature. Others still need references; if you know of any, please send me detailed, complete citations.

Fourthly, one recommendation in the guidelines is that states should adopt licensing standards for mathematics supervisors. At present, few states have such criteria. We feel that they are definitely needed since few states have such criteria and because the choice of supervisors in many districts seems to be made on grounds other than demonstrated skill in mathematics education.

This is all I really want to say about the guidelines. They are much too long to discuss in detail here. However, there are several other things I would like to mention. From time to time, COMET has been asked by the MAA to prepare position papers on various issues, such as the Holmes and Carnegie reports, for example. These position papers have been submitted to the MAA board of governors and now represent the official position of the MAA. I would like to mention three such papers.

The first, the MAA *Statement on Retraining of Mathematics Teachers,* concerns the training of teachers from other disciplines to teach mathematics. By the way, this issue has been dealt with also by NCTM. I quote this not primarily because of that particular issue, but to indicate further the philosophy of the group that prepared the guidelines:

> Students at all grade levels deserve to be taught by fully qualified teachers. Yet many students are currently being taught mathematics by teachers with insufficient preparation. To teach any subject successfully, teachers must not only know the subject well, but also like it to the point of enthusiasm. Because of the importance of mathematics to the futures of all students, the problem of inadequately prepared teachers is of great national importance. For this reason, the Mathematical Association of America has adopted the following principles regarding the preparation and retraining of mathematics teachers:
>
> > (1) Students at all levels should be taught mathematics by teachers who enjoy mathematics and whose training meets or exceeds professional standards. These standards are presented in two documents: *Recommendations on the Mathematical Preparation of Teachers* (1983), available from the Mathematical Association of America, 1529 Eighteenth Street, N.W., Washington, DC 20036; and *Guidelines for the Preparation of Teachers of Mathematics* (1981), available from the National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091.
> >
> > (2) Teachers who lack adequate preparation should be provided with sufficient in-service training to provide them with both competence and confidence. The mathematical maturity needed by teachers with little or no mathematical background can normally be achieved only after in-service programs involving several years of carefully designed sequential courses. Short courses and workshops designed to meet emergency shortages are at best temporary expedients; they can provide teachers with stimulation, perspective, and incentive for further training, but they alone do not provide adequate preparation for the teaching of mathematics.
> >
> > (3) Institutions of higher education should work cooperatively with school districts and government agencies to address the mathematics teacher shortage. High-quality training and retraining programs consistent with the *Recommendations* and *Guidelines* cited above, must be established in all regions of the country. Funding for these programs must include appropriate financial incentives for teachers and teacher candidates.

(4) School districts, in concert with other agencies, should provide teachers at all grade levels with regular and substantial opportunities for continued growth. As professionals, teachers should work throughout their careers to keep abreast of the latest curricular, pedagogical, and technological advances.

A second position paper was addressed to college and university administrations and to departments of mathematics and mathematicians generally. The statement is entitled *College and University Responsibilities for Mathematics Teacher Education*, and I quote:

College faculty must become actively involved in the education of teachers if the teaching of mathematics in the schools is to improve significantly. Active leadership and support of college and university mathematicians, mathematics educators, and administrators is essential if our nation is to increase the number of qualified teachers and to strengthen their education. For this reason, the Mathematical Association of America and the National Council of Teachers of Mathematics have adopted the following recommendations for all individuals, in whatever department, who are engaged in teaching mathematics or mathematics education for current or prospective teachers:

(1) Colleges and universities should assign significantly higher priority to mathematics teacher education.

(2) All individuals who teach pre-service or in-service courses for mathematics teachers should have substantial backgrounds in mathematics and mathematics education appropriate to their assignments.

(3) Mathematics methods courses should be taught by individuals with interest and expertise in school teaching and continuing contacts with school classrooms.

(4) All individuals who teach current or prospective mathematics teachers should have regular and lively contact with faculty in both mathematics and education departments, e.g., by regular meetings, seminars, joint faculty appointments, and other cooperative ventures.

(5) All college and university faculty members who teach mathematics or mathematics education should maintain a vigorous dialogue with their colleagues in schools, seeking ways to collaborate in improving school mathematics programs and in supporting the professional development of mathematics teachers.

(6) Faculty advisors should encourage their mathematically talented students to consider teaching careers.

(7) Colleges and universities should vigorously publicize the need for qualified mathematics teachers and strive to interest and recruit capable students into the profession, e.g., by organizing highly visible campus-wide meetings for students to inform them of the opportunities, advantages, disadvantages, and requirements of a career in teaching mathematics.

(8) Tenure, promotion, and salary decisions for faculty members who teach current or prospective mathematics teachers should be based on teaching, service, and scholarly activity that includes research in mathematics or mathematics education.

(9) Faculty members in mathematics and in mathematics education who are effective in working with activities in the schools and in the mathematical education of teachers should be rewarded appropriately for this work.

(10) All institutions involved in educating mathematics teachers should provide specialized classroom and laboratory facilities equipped with state-of-the-art demonstration materials, calculators, and computers at least comparable to those used in the best elementary and secondary schools so that prospective teachers, like graduates from other professional programs, can be properly prepared for their careers.

Finally, I would like to comment on an item in a position paper that we were asked to draw up about the Holmes and Carnegie reports--the *MAA Statement on the Holmes and Carnegie Reports on Teacher Preparation*. Recommendation 7 in that paper reads:

> Prospective teachers in grades K-8 should major in an academic discipline. Those aspiring to teach at the elementary level should include in their programs of study the mathematics courses recommended in the MAA *Recommendations on the Mathematical Preparation of Teachers*, and prospective teachers of middle school and junior high school mathematics those specified for that level in the same *Recommendations*. Beyond this, undergraduate majors in mathematics or combined majors in mathematics and the natural sciences should be developed, especially for prospective elementary school teachers, so that eventually all mathematics in at least grade 3 and beyond is taught only by mathematics specialists.

Regarding this point, I want to make the following comment concerning a situation that prevailed about 30 years ago in Montgomery County, Maryland, and which I understand prevails to some extent today. A teaching technique used in some of the schools there at that time was to take approximately 80 third- or fourth-grade students and assign them to 3 teachers, in a team approach. One teacher was a specialist in mathematics and science, one in language

arts, and one in social studies. Using ability grouping and teaching only their own specialties, these three teachers were able to meet the students very particularly at their points of greatest need, and they were able to meet them very knowledgeably. To start very young children with a teacher who hates or fears mathematics or arithmetic almost guarantees that we will continue to have students who have picked up the teacher's attitudes and who often become lifelong haters of mathematics. If specialization is anathema to child development experts, then I suggest that the team-teaching approach is a way around this serious difficulty.

* * *

[Copies of MAA's guidelines can be obtained from:

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APPENDIX

THE TEACHER OF MATHEMATICS: ISSUES FOR TODAY AND TOMORROW

University of California at Los Angeles
Faculty Center, October 16-17, 1987

Friday, October 16

California Room

7:30 a.m. CONTINENTAL BREAKFAST

8:30 a.m. WELCOME
Juan Francisco Lara
Executive Director, CAIP;
Assistant Dean, Graduate School of Education, UCLA

8:45 a.m. NEW PERSPECTIVES ON THE EDUCATION OF TEACHERS
Shirley A. Hill
Chairman, MSEB;
Professor of Mathematics and Education,
University of Missouri - Kansas City

9:30 a.m. DISCUSSION
J. Myron Atkin, Moderator
Professor, School of Education,
Stanford University

10:00 a.m. BREAK

10:30 a.m. PROFESSIONAL ASSESSMENT FOR PROFESSIONAL TEACHERS
Rick Marks
Research Assistant, Teacher Assessment Project,
Stanford University

11:30 a.m. **DISCUSSION**
J. Myron Atkin, Moderator
Professor, School of Education,
Stanford University

Sequoia Room
12:00 noon **LUNCH**

1:00 p.m. **TOWARD A NEW VISION OF LEARNING AND TEACHING**
Albert Shanker
President,
American Federation of Teachers

1:45 p.m. **BREAK**

California Room
2:30 p.m. **OBSTACLES TO REFORM: WHAT HAVE WE LEARNED FROM YESTERYEAR?**
Thomas J. Cooney
Professor of Mathematics Education,
University of Georgia

3:30 p.m. **BREAK**

3:50 p.m. **NEW DIRECTIONS IN SCHOOL MATHEMATICS: IMPLICATIONS FOR EDUCATING TEACHERS**

Hacienda Room
K-4 Level
Ramona Jo DeValcourt
Elementary Mathematics Specialist,
Texas Education Agency
Paul R. Trafton
Professor of Education,
National College of Education
Naomi D. Fisher, Moderator
Associate Director, UCSMP Teacher Development,
University of Chicago

Playa Room

5-8 Level

Sheila Berman
Chair, Mathematics Department,
Patrick Henry Junior High School, California
Glenda Lappan
Professor of Mathematics,
Michigan State University
Peggy C. Neal, Moderator
Teacher, Clark County, Georgia School District

Sierra Room

9-12 Level

Marjorie Enneking
Professor of Mathematics,
Portland State University
Willie M. May
Mathematics Instructional Coordinator,
Chicago Public Schools
M. Kathleen Heid, Moderator
Assistant Professor,
Pennsylvania State University

California Room
5:15 p.m. COCKTAILS

Main Dining Room
6:15 p.m. DINNER

Saturday, October 17

Kerckhoff Patio
7:30 a.m. CONTINENTAL BREAKFAST

Moore Hall Room 346
8:30 a.m. PROFESSIONAL DEVELOPMENT OF OUTSTANDING MATHEMATICS TEACHERS
June M. Yamashita
Teacher,
Kailua High School, Hawaii

9:10 a.m. MATHEMATICS TEACHING IN SCHOOL: IMAGINING AN IDEAL THAT IS ALSO POSSIBLE
Magdalene Lampert
Teacher/Associate Professor,
Spartan Village School/Michigan State University

9:50 a.m. DISCUSSION
David Blackwell, Moderator
Professor of Statistics,
University of California at Berkeley

10:10 a.m. BREAK

10:30 a.m. ENCOURAGING TOWARD THE IDEAL - DISTRICT LEVEL
Jack Price
Superintendent of Schools,
Palos Verdes Peninsula Unified School District

11:00 a.m. ENCOURAGING TOWARD THE IDEAL - STATE LEVEL
Ted Sanders
Superintendent of Education,
State of Illinois

11:30 a.m. **DISCUSSION**
Marcia P. Sward, Moderator
Executive Director,
MSEB

Faculty Center
12:00 noon **LUNCH**

1:00 p.m. **EDUCATION REFORM IN CALIFORNIA: NEXT STEPS**
James W. Guthrie
Professor, School of Education,
University of California at Berkeley

Moore Hall
2:00 p.m. **NCTM'S GUIDELINES FOR THE POST-BACCALAUREATE EDUCATION OF TEACHERS OF MATHEMATICS**
Donald J. Dessart
Professor of Mathematics and Mathematics Education,
University of Tennessee, Knoxville

2:25 p.m. **MAA'S GUIDELINES FOR THE POST-BACCALAUREATE EDUCATION OF TEACHERS OF MATHEMATICS**
Calvin T. Long
Professor of Mathematics,
Washington State University

2:50 p.m. **DISCUSSION**
John A. Dossey, Moderator
President, National Council of Teachers of Mathematics;
Professor of Mathematics,
Illinois State University

3:30 p.m. **ADJOURNMENT**
Shirley Hill
Chairman, MSEB;
Professor of Mathematics and Education,
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MSEB/CAIP CONFERENCE
October 16-17, 1987

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Katherine P. Layton, *Beverly Hills High School, California*
Peggy Neal, *Clark County, Georgia School District*
Ted Sanders, *State of Illinois Superintendent of Education*
Calvin J. Wolfberg, *Pennsylvania School Boards Association*

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Lori Tuttle, *Program Assistant*

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1986-1987
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Professor of Mathematics
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University of Missouri-Kansas City
(mathematics education)

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Commissioner of Education
State Education Department
State of New York
(education policy and
administration)

J. Myron Atkin; 1989
Professor, School of Education
Stanford University
(education policy and
administration)

NAS David Blackwell; 1988
Professor of Statistics
Statistics Department
University of California-Berkeley
(research mathematician)

Gail F. Burrill; 1987
Chair, Department of Mathematics
Whitnall High School (Wisconsin)
(mathematics classroom teacher)

Iris M. Carl; 1989
President Elect, National Council
of Supervisors of Mathematics
Elementary Mathematics
Instructional Supervisor
Houston Independent
School District
(mathematics classroom teacher)

Responsible Staff Officer
Marcia P. Sward, Executive
Director

C. Herbert Clemens; 1987
Professor of Mathematics
University of Utah
(research mathematician)

Hirsh G. Cohen; 1987
Vice President,
Divisional Operations
IBM Research
(Liaison member, CPSMR)
(applied mathematics)

Clyde L. Corcoran; 1987
Mathematics Teacher
California High School
(mathematics classroom teacher)

F. Joe Crosswhite; 1987
Past President
National Council of
Teachers of Mathematics
Professor, Northern Arizona
University
(mathematics education)

Richard de Aguero; 1988
Director of Student Activities
Miami (Florida) Senior High School
(mathematics classroom teacher and
secondary school principal)

Morris DeGroot; 1987
Professor of Statistics and
Industrial Administration
Statistics Department
Carnegie-Mellon University
(Liaison member, CBASSE)
(statistician)

William J. Dennis, Jr.; 1988
Senior Research Fellow
Research and Education Foundation
of the National Federation of
Independent Business, Inc.
(business and industry)

John A. Dossey; 1989
President, National Council of Teachers of Mathematics
Professor of Mathematics
Illinois State University
(mathematics education)

James T. Fey; 1988
Professor of Curriculum and Instruction and Mathematics
University of Maryland
(mathematics education)

Robert Glaser; 1987
Director, Learning Research and Development Center
University of Pittsburgh
(cognitive psychologist)

NAS Andrew Gleason; 1989
Hollis Professor of Mathematics and Natural Philosophy
Harvard University
(research mathematician)

Neal Golden; 1988
Chairman
Computer Science Department
Brother Martin High School (Louisiana)
(classroom teacher)

Gene L. Hoffman; 1987
State Representative, Illinois House of Representatives
(state legislature)

Joseph R. Hoffmann; 1987
Consultant in Mathematics Education
California State Department of Education
(mathematics supervisor)

Kenneth M. Hoffman; 1989
Professor of Mathematics
Massachusetts Institute of Technology
(research mathematician)

David R. Johnson; 1989
President, National Council of Supervisors of Mathematics
Chairman, Mathematics Department
Nicolet High School (Wisconsin)
(mathematics supervisor)

Ann P. Kahn; 1988
President, The National PTA
(education policy and administration)

Jeremy Kilpatrick; 1987
Professor of Mathematics Education
University of Georgia
(mathematics education)

Joan R. Leitzel; 1987
Professor of Mathematics and Associate Provost
The Ohio State University
(collegiate mathematics faculty)

Peggy C. Neal; 1988
Mathematics Teacher
Burney Harris Lyons Middle School (Georgia)
(mathematics classroom teacher)

Henry O. Pollak, Vice Chairman; 1989
Assistant Vice President (Retired)
Mathematical, Communications and Computer Sciences Research Laboratory
Bell Communications Research
(business and industry)

Jack Price; 1988
Superintendent of Schools
Palos Verdes Peninsula Unified School District
Palos Verdes, California
(education policy and administration)

Anthony Ralston; 1989
Professor of Computer Science and Mathematics
State University of New York at Buffalo
(computer scientist)

Stephen B. Rodi; 1988
President, American Mathematical Association of Two-Year Colleges
Division Chairperson
Mathematics and Physical Sciences
Austin Community College
(two-year college faculty)

Frederick A. Roesch; 1989
Senior Vice President, Global Electronic Marketing
Citibank, N.A.
(business and industry)

Paul Sally; 1987
Professor of Mathematics
University of Chicago
(research mathematician)

C. Thomas Sciance; 1987
Director, Engineering Research
E.I. du Pont de Nemours and Co.
(business and industry)

Lynn Arthur Steen; 1989
President, Mathematical Association of America
Professor of Mathematics
St. Olaf College
(collegiate mathematics faculty)

Dorothy S. Strong; 1988
Director of Mathematics
Chicago Public Schools
(mathematics supervisor)

Calvin J. Wolfberg; 1988
Past President
Pennsylvania School Boards Association
(education policy and administration)

* Note: all terms end in June.