

National Mathematics Advisory Panel

Adoption Meeting, March 13, 2008

Panel Members' Five-Minute Comments on the Final Report

Camilla Persson Benbow

National Math Panel Vice Chair

Patricia and Rodes Hart Dean of Education and Human Development

Peabody College, Vanderbilt University

Let me begin by saying that it was an honor to be asked to serve on the Math Panel and be able to assist our strong and effective leader, Larry Faulkner. And, for me, it has been a simply amazing experience. But I have never worked so hard on a committee in all of my professional life. No wonder, we were asked to cover a lot of ground: content, learning, instruction, assessment, and teacher education—and we were to do it all in less than two years. And, we did it all, even though we began our journey starting from such different places, different perspectives, and different backgrounds. Yet by the time we reached the end of this adventure, we had pulled together. We had hammered out a consensus on issues where agreement is hard to achieve. We all came to hear the signal emerging from all of the noise in the research base. And, we could hear that signal, even if faint at times, because we reminded ourselves that when we are making recommendations for policy, which was our task, the research evidence that enables one to do that must come primarily from experimental and quasi-experimental designs. I am proud of what we accomplished. So, I hope that, while our journey comes to an end today, another journey begins for others—that others will initiate the dialogue necessary for implementing what we have learned in the past two years and for moving forward the agenda of making our schools into evidence based organizations. I think our collective work should be seen as a model for how this can be done.

In addition, for someone who leads a leading college of education and human development recognized for its work in special education and someone who has worked with mathematically gifted students for her entire professional career, it was personally gratifying to see that we made recommendations that did not just apply to the typical student in our classrooms, if there is such a person, but also recommendations applicable to those who differ significantly from the norm. Our recommendations spanned the range from benefiting those with learning disabilities or at-risk to the gifted students. With regard to the gifted, there was support for allowing students to accelerate, if they so choose, and some indications that enrichment can be beneficial as well especially when paired with acceleration.

I led the task group on Assessment. So, let me comment there. To me, this was a critical assignment as what we measure often drives instruction. It is akin to the budget of many organizations. We have our strategic plan but the budget is the strategic plan. How we spend the money actually shows where we are heading and what we are doing, whether intentional or not. In education, what we measure is what we value and what people will do. We felt that high stakes tests, like NAEP and state tests, could do a better job of measuring those skills and concepts that really count, that we think are critical to success in algebra—for example, fractions and whole number operations. Moreover, we came to the conclusion that current tests need to be improved in quality.

My last observation: we could not resolve cleanly many of the big debates in math education. The research base just was not there. Over and over again, we lamented the thinness of the evidence. We can blame only ourselves. We have not invested sufficiently in educational research to build a solid research base. I hope we will become serious about this too.

Deborah Loewenberg Ball

Dean, School of Education and William H. Payne Collegiate Professor
University of Michigan

It has, overall, been an honor to serve on this panel. I brought to the work of the Panel my several professional selves and expertise—experienced elementary school teacher, teacher educator, researcher in mathematics education and teacher education— but, today, I'm speaking as the dean of one of the leading schools of education in the country. I have been thinking a great deal about the role of schools of education—together with schools, school districts, school leaders, as well as the rest of the universities they inhabit—in reading this report and taking action. I take my responsibility for this—and I'm sure my fellow deans do as well—very, very seriously.

I want to make three categories of comments briefly. One, I want to comment on the things that stand out most to me about our report. I want to comment briefly on things that will deeply disappoint me if they are the product of what we've done, and I want to comment about the things this report can enable.

The things that stand out to me about our report are, first, that when you look at the table and see the diverse people who populated this Panel, the fact that we've been able to vote unanimously to adopt that report and to reach the significant areas of agreement that we have is a remarkable feat and one that I think shouldn't be overlooked. I think, second, this report puts to rest some important myths that have plagued our efforts to make improvement in mathematics education. One important example is to argue over whether effective mathematics teaching is either teacher-directed or student-centered. As long as we reduce teaching to simple dichotomies such as this, we fail the children of this nation because we do not actually work on instruction; instead we simply argue about it in slogans. This accomplishes nothing. Instruction is unquestionably crucial to improving students' opportunities. The evidence is clear. But what exactly are the elements of skilled instructional practice deserves serious study. Finally, what stands out to me is that there is a pressing need to build on the agreements that this panel has forged, to develop the knowledge and the will and the action to actually make progress on mathematics education in this country to work on instruction, to work on the delivery mechanisms, and to equip our nation's teachers and those who work with them to use the knowledge that we've been able to identify about mathematics content and about learning.

Now, what would disappoint about me about our report? It would disappoint me deeply if this is reduced to yet another math wars story. This is not a math wars story. This is a story in 2008 about the areas of agreement that we are able to discuss based on the research that's been done up to this point. It would disappoint me if people spent their time looking for all the areas of disagreement among panelists. Certainly there were many, and if people spend all their time trying to dredge up the areas on which we didn't agree, we won't be able to use this report in the way it deserves and demands. It will disappoint me if the report is reduced to simplistic slogans or messages about calculators or teaching styles, and it will disappoint me if our report is not used to make progress, and I actually hold all of us as panelists and all the communities who have interest in math education accountable for doing the things I just said.

Finally, I'm going to comment on a few things I think this report can enable. First, I think it can enable the leveraging of collective will to begin building a much more common curriculum in this nation in mathematics. The founding creators of our school system—the common school reformers— hoped in the 1840s to build a common school system. We still haven't achieved that. In mathematics in particular, we have significant equity issues in our country, significant differences in opportunity to learn. Does anyone really believe that mathematics in Idaho is different than in Louisiana? We clearly—and I'm disappointed about this—are not yet ready to follow our colleagues in the rest of the world in building a national curriculum. But we could use this report to take the steps forward that would enable us to say that there is a common set of topics and skills that are foundational for kids' success and we're going to teach them to every child in every school, in every community, in every state, in this country. And as an elementary school teacher, I take as vitally important our identification of competence with fractions as being essential to students' progress.

A second thing this report can enable is recognition of the central role of teachers. The report highlights the skilled professional work that teaching is. It makes clear that we need to take the report and work to build the kind of significant, disciplined knowledge about teaching practice that we need to have the effective educational system we so badly want. This can't be done without teachers, and without taking more seriously the intricate work that teaching is. This means we need to design and carry out major research on instruction. I'm struck by the need for us to develop understanding of the instructional practices that enable teachers to teach complex mathematical ideas, skills, and practices to students, to build their confidence and study skills, and their interest. I was impressed by our failure to show what it takes to teach complicated mathematics explicitly to students. There simply wasn't the research base for us to do that. Of course, we also need similar research on teacher education. What, specifically, enables teachers to develop the knowledge and skills needed for their work? In no other field would we dare to think that common sense and a bit of being smart could enable you to do such skilled practice. We wouldn't think that about plumbing. We wouldn't do that in medicine. We wouldn't think that about hairdressing. And yet, somehow, in teaching, we continue to think we're going to solve the teacher quality problem by finding smart people and simply putting them with our nation's children. This notion undercuts teachers, but also students. This report makes clear and shows us the way that we're going to need to work to build the instructional methods and the methods of training teachers, 3.7 million of them, to be able to do that.

Third, I think this report enables us to make fast progress on one of the most straightforward parts of the teacher quality problem, and that is teachers' mathematical knowledge. No one could disagree that teachers need mathematics to teach. How could they teach if they didn't know what they were teaching? But the report finally makes clear that it's not simply in the numbers of courses that elementary school teachers take that will enable them to be effective with students. They need knowledge of mathematics useful for the mathematically demanding work of teaching. Let's stop making a run at the wrong solution for a critical problem. Let's work with all deliberate speed toward ensuring that elementary school teachers have the mathematical knowledge they need to hear their students, to teach the content clearly, to be precise, to teach them to reason and to solve problems and to have the skills they need to do this with every one of their students. This is something you can read as agreed upon by this panel.

And, finally, this report can be used to build the research capacity that we need around this country in schools of education, in research firms, in schools, that could enable the same kind of progress that we made in the medical profession almost a century ago. We need practice-based, practice-oriented, usable research that enables practitioners to actually have a repertoire of proven methods that reliably help students to learn and which they can use as appropriate in particular situations based on skilled professional judgment.

No report like this would have been possible without the leadership provided by our chair, co-chair, and executive director. I also want to acknowledge the amazing support we had from the consulting firms who worked with us. Some of us, most of us, actually, had day jobs during the last two years, and without the help we had, we would have had great difficulty in identifying the resources we needed to scrutinize and examine in order to reach the conclusions we have.

A. Wade Boykin
Professor and Director of the Graduate Program
Department of Psychology
Howard University

It has been both an honor and a privilege to serve on the National Mathematics Advisory Panel for the last two years. Quite frankly, I am genuinely thankful for the opportunity to have served in this capacity. It has been truly a learning experience, a mind expanding, and eye-opening experience for me.

I took part in a remarkable process. We started out as a collection of professionals who functioned from differing disciplinary perspectives, brought to bear differing intellectual priorities, saw the issues from differing conceptual frames, spoke from a variety of professional lexicons, yet were able generally to find common ground, to converge our efforts with respect to the pursuit of discerning what will lead to better mathematics learning and achievement outcomes for America's children.

Yet beyond this, it is also crucial to acknowledge that within our society persistent math achievement gaps do exist. These gaps cannot be explained away via SES, income level, or availability of material resources. However in looking to close these gaps, research has accumulated which clearly suggests there seems to be promise in paying close attention to the dynamics of classroom life in terms of the daily transactions between teachers and students and among students themselves. These transactions can be largely understood in terms of cognitive, as well as social, motivational, and affective considerations, and there is promise that math outcomes to a notable degree are linked to alterable, changeable rather than fixed factors that manifest in the course of classroom transactions. These changeable factors prominently include student engagement, effort and efficacy. Moreover, these changeable factors are impacted upon by the quality and quantity of teacher and peer classroom support.

I am also struck that many promising ways to raise math achievement and close gaps actually have been available in the research literature on learning processes for quite some time. But for whatever reasons, these research findings have not substantially been translated into educational practices in America's classrooms. This matter requires future concentrated and concerted attention.

But all in all, my esteemed colleagues have put forth considerable effort, expended considerable intellectual sweat. I believe our work over the last two years has been a successful enterprise. Although there is still a lot not yet known about enhancing math outcomes, I believe we know a lot more about the Foundations for Success than when we started on this collective journey just two short years ago.

Douglas H. Clements

Professor, Graduate School of Education
University at Buffalo
State University of New York

Flannery O'Connor said that "stories are considered not quite as satisfying as statements, and statements not quite as satisfying as statistics; but in the long run, a people is known, not by its statements or its statistics, but by the stories it tells."

We on the National Math Panel reviewed thousands of studies and believe that our report's statements and statistics are usually satisfying and definitely useful. However, we were necessarily limited by the daunting scope of our work, and other research approaches—as rigorous in their disciplines as those we reviewed—are also necessary components for full scientific knowledge of mathematics education. The field needs to follow comprehensive research frameworks in its future research and development efforts to tell a complete story.

Technology is a case in point. The rigorous research we reviewed points to some effective approaches and some important cautions. But the full story reveals other effective approaches and, more importantly, reveals why some are effective and some are not.

A main story you will read is that students need to simultaneously develop conceptual understanding, procedural skill, and problem solving ability. This story must be told and retold—accurately—to end the unfortunate habit of false dichotomies—the simplistic black/white divisions that harm our children's mathematical education.

I hope the story that is eventually told about this National Math Panel report is that U.S. education became more student-centered, in the broader and more powerful sense often seen in East Asian countries. That is, that teaching is not just about what teachers do, but more about how teachers can encourage students to engage in effective learning activities. Learning ultimately depends on what students do, and the teacher and all who support that teacher at every social-political level need to structure all aspects of the teaching-learning context to maximize students' engagement with mathematics.

This is a vision for America's future story. Our country now needs the courage and will to realize this vision, understanding that profound efforts—and changes—will be needed at every level of the educational enterprise.

If we do these things, we will have more personal stories such as Chaundra's. At the beginning of her preschool year, when asked, Chaundra did not know how old she was. After just months of participating in a research-based, technology-enhanced math curriculum, she told her teacher, "I am four. Soon I'll be five. Five! That's only two less than my sister is now—she's seven."

Susan Embretson

Professor, Graduate School of Psychology
Georgia Institute of Technology

My contribution to the National Mathematics Advisory Panel (NMP) was primary with the Assessment Task Group as I am a specialist in educational and psychological measurement. My comments, therefore, will concern the findings from this group.

We examined two general areas: 1) Test Content and Performance Standards, and 2) Item and Test Design. Test content was a natural focus for the NMP due to the charge of the other task groups, such as Concepts, Knowledge and Skills. In contemporary educational measurement, views of the scope of the mathematics domain are translated into test blueprints that define the representation of various types of test content. Other task group members from Assessment will probably comment on the major findings and recommendations in this area.

The other area that was explored was item and test design. Interestingly, these terms have a different meaning in contemporary educational and psychological measurement. For example, test design concerns selecting items for optimal statistical properties to measure competency. That is not the aspect of test design that was examined by the Assessment Task Group. In fact, there was no reason to believe that examining the statistical aspects of test and item design would yield any important findings. In general, the last decade has been characterized by widespread use of sophisticated item response theory models in educational testing to equate tests and to provide optimal information about competency.

Instead, the Assessment Task Group focused on the substantive aspects of item and test design. Mathematics test items such as word problems can be quite complex, with multiple sources of difficulty. The student must determine the mathematical problem and then apply the appropriate concepts and algorithms. However, both mathematically relevant and mathematically irrelevant aspects of items contribute to their difficulty. The Assessment Task Group was interested in how these sources of difficulty were involved in NAEP and state year-end tests.

Fortunately, the NAEP Validity Study (NVS) was finished shortly after we identified item design as an interesting issue. The NVS findings suggested that on both NAEP and state tests, non-mathematical aspects of items were prevalent and were not identified by the statistical methods. The Assessment Task Group also examined items from these tests and examples are presented in the report that illustrates

some of the problems that were identified. We recommended that much more attention should be paid to substantive aspects of item design and that items should be examined by persons with high levels of expertise to assure that mathematical content predominates as the source of difficulty for students.

One general feature of item and test design was also examined. The Assessment Task Group reviewed the literature on the multiple choice (MC) versus constructed response (CR) item formats. In the MC format, the student selects from several response alternatives. In the CR format, the student must produce an answer. It should be noted that there are many types of CR item formats, ranging from tasks in which the students grids in the answer to tasks which require the student to explain mathematical principles. Although the MC format is the mainstay of educational assessment, the CR item format has been used widely in recent years.

The Assessment Task Group searched widely for relevant studies and, surprisingly, relatively few studies comparing MC to CR have been published. Those that have been published do not support items in the CR format as measuring a different competency than items in the MC format. In fact, when differences between the formats are obtained, such as item difficulty, the findings depend on other design features of the items. Thus, it appears that the focus is not whether to use MC or CR items, but how to design items to measure the specified aspect of mathematics competency at a particular level of complexity.

It has been an honor to serve on the NMP. I hope that the recommendations coming from all task groups will be considered to further the development of mathematical competencies in our children.

Francis (Skip) Fennell

Professor of Education
McDaniel College

First, I appreciate, very much, the opportunity I have had to serve on this panel. This has been all of the following – a pleasure, at times a challenge, something I will remember – always! Here are some elements of our work that are important to me – as a panelist and as someone who has worked in the field of mathematics education for over 4 decades. These are presented as talking points, with a lead word or statement to frame the comment.

Validation: Recognition and support for the importance of focus and coherence within the PreK-up to algebra curriculum – as noted by the work of Conceptual Knowledge and Skills task group and also noted and affirmed in the work of the subcommittee on Instructional Materials. States and districts must strive for greater agreement regarding which topics will be emphasized and covered at particular grades. Only then will publishers produce programs that include a clear emphasis on the material that these states and districts agree to teach in specific grades.

Validation: That the curriculum must simultaneously develop conceptual understanding, computational fluency, and problem solving, and that debates regarding the relative importance of these aspects of mathematical knowledge are misguided. Furthermore, teachers should emphasize these interrelations; conceptual understanding of mathematical operations, fluent execution of procedures, and fast access to number combinations together support effective and efficient problem solving.

Recognition and Caution: Recognizing that the Critical Foundations are but a subset of a full PreK-up to algebra curriculum (this is the caution part), but knowing how important, how foundational, work with whole numbers, fractions, and particular aspects of geometry and measurement are as prerequisites to algebra. Knowing that the benchmarks will serve as useful guideposts for educators and parents as we strive for focus and proficiency with foundational topics, regardless of where a child lives in this country.

The Graduate! How does this reference to the Dustin Hoffman classic fit? Do you remember the scene, “Ben, it’s about plastics!” Well, fast-forward that DVD. Now it’s teacher, teacher-leader, teacher-educator, AND, it’s about fractions (defined here as fractions, decimals and percents). Do them well. Develop them. Understand them. Know how they are inter-related. They link so critically to higher-level mathematics. The work of the Conceptual Knowledge and Skills, Learning, and Assessment Task Groups and the Teacher Survey ALL point to the important role fractions play for all students. It’s about fractions!

Sense Making: Yes, context does matter when solving problems. More research is certainly needed, but given the constant demands from students re: ‘when am I ever gonna use this stuff’ the findings regarding real world problems in mathematics present a first step in recognition of the importance of context, albeit when solving problems involving contexts.

YES, Effort matters: All children must not only be provided with the opportunity to learn important mathematics, but we must recognize that the effort students put into learning makes a difference – a difference in their achievement and, importantly, in their own self-efficacy.

Teacher Educators Take Note: While teaching well requires substantial knowledge, existing research on aspects of teacher education, including standard teacher preparation programs, alternative pathways into teaching, support programs for new teachers (e.g., mentoring), and professional development, is not of the rigor or quality to permit this Panel to draw conclusions about the features of professional training that have effects on teachers’ knowledge, their instructional practice, or their students’ achievement. If this is not a call for research in mathematics teacher education, I don’t know what is!

What MUST Happen: It is essential to produce methodologically rigorous scientific research in crucial areas of national need, such as the teaching and learning of mathematics. More research is needed that identifies: (1) effective instructional practices, materials, and principles of instructional design (2) mechanisms of learning, (3) ways to enhance teachers’ effectiveness, including teacher education, that are directly tied to objective measures of student achievement, and (4) item and test features that improve the assessment of mathematical knowledge. This is a major call to the field of mathematics education. Our work needs to be validated and research – high quality research is a must.

FINALLY, Importantly, this Panel has worked extremely hard for close to two years. The work has not been easy. The findings, the story, the “take-aways” from this effort MUST NOT be reduced to some sort of treaty or compromise in the so-called Math Wars or yet another shop-worn story about reform vs. traditional mathematics. To do so trivializes this effort and disrespects my colleagues (here) and all those associated with this Panel. This work is about the important foundations that lead to algebra, and about learning, teaching, and assessing mathematics. These Foundations for Success are the necessary ingredients for every student in every classroom in this country.

Bert Fristedt

Morse-Alumni distinguished Teaching Professor of Mathematics
University of Minnesota, Twin Cities

Our report is addressed to a variety of audiences. I’ll focus on two: the preparers of books for K-12 math education and the creators of NAEP and the various state tests.

It is important that the coherence and focus encompassed in the Critical Foundations for Algebra portion of our report be reflected in the organization of and emphases in K-8 school materials and in the types of items on assessments at various grades. I am aware that there are other important aspects of K-12 math education besides algebra and the paths leading to it. For these topics— data, probability, trigonometry,

and geometry beyond the aspects mentioned in the Critical Foundations—coherence is also essential, requiring well-considered sequencing of topics.

As indicated in the instructional materials portion of our report, tables of contents in textbooks should reflect a coherent organization. In particular, teachers, and especially math curriculum coordinators, should be able to discern from tables of contents a clear path through the items mentioned in the Critical Foundations for Algebra, both within grades and also from grade to grade. Even with good tables of contents, clear paths toward desired objectives can be severely obstructed by distractions in textbooks, which are only tangentially related to the essential mathematics at hand, even if the distractions themselves are quite interesting. For instance, in an example about children arranging some collection of objects, it is the objects, possibly in some arrangement on a table, which might warrant a picture or diagram, whereas a picture of the children themselves can cause loss of focus on the math.

With respect to instructional materials, our report is very critical of the large numbers of pages in some books. The comments I have made about coherence and the undesirability of tangentially related distractions are intertwined with the length issue.

While word problems constitute an important part of mathematics, the instructional materials section of the report also advises, for math textbooks, relatively few applications where the primary challenge is posed by the science or social studies content. On the other hand, learning—and it is not an easy thing to learn—learning how to convert relationships described verbally into mathematical symbolism is a central feature of mathematics.

The distinction I have just mentioned between math-focused problems having words and those having words for which math is peripheral is even more important in connection with assessments, since for broadly given assessments it is certainly the case that there will be students at the same level mathematically whose general cultural, science, or social studies backgrounds are vastly different. It is appropriate that some items on state assessments and NAEP be on the difficult side, but the difficulty should arise out of the mathematics itself, rather than some puzzle-type setting or non-math knowledge that should not be expected to be taught in all classrooms.

On a more specific issue, I fully agree with the recommendation in the assessment portion of our report that probability not be assessed on NAEP at the Grade-4 level, since basic knowledge of fractions and their operations is required for even an elementary coherent understanding of probability. I say this as a mathematician who has a tremendous liking for probability and who has done probability research for several decades. A sketchy introduction to probability that ignores some subtleties of language can cause students to get long-lasting erroneous impressions. For instance, students might come to believe it quite likely that 5 heads will occur in 10 flips of a fair coin, whereas the actual probability of that occurrence is less than 1/4.

Dave C. Geary
Curators' Professor
Department of Psychological Sciences
University of Missouri

It hasn't always been fun, but it has been a pleasure to work with this group. It has been a long and difficult process over the past two years and so I will keep my comments brief and focused on two points:

First, it is clear that the report we are releasing today could not have been completed without an interdisciplinary team. Understanding how to educate millions of children in each and every generation, much less actually achieving this goal is arguably more complex than decoding the human genome. It is

important to recognize, and from now on to begin with, the assumption that not one of the academic or applied disciplines represented on this panel is up to this task without the expertise of the others. Neither educators, nor scientists, nor policy makers can independently develop and test programs that will educate American children to their full potential.

My second point does not apply to all educational researchers and certainly not to any of my colleagues on this panel, but I think we should reflect on why this country must constitute panels such as this one and others like it. On reflection I must conclude that the necessity of these panels arises because of a failure of schools of education in this country, and many professors in these institutions, to do what the country has asked of them: Produce quality educators for our children, and train them with sound, proven, educational practices that are scientifically research-based.

Schools are a public good and not a playground for trying the latest, untested ideas about teaching and learning. Schools of Education must take the lead on developing and scientifically testing educational interventions, and we need to hold them accountable for the success or failure of their work. Ultimately, when the country no longer needs a national mathematics panel or related panels, then schools of education have done what we have asked of them. The continuation of such panels will reflect a continuing failure of these institutions.

Russell M. Gersten

Executive Director, Instructional Research Group;
Professor Emeritus, College of Education, University of Oregon

NMP – Key Points

1. **Pioneering the Process of Rigorous Analysis of the Evidence Base Behind Statements Made:** As time goes by, this may be one of the two major contributions of this Panel, the serious attempt we all made to base our findings on rigorous experimental research conducted in the field. We used state-of-the-art techniques for analysis and reanalysis of hundred of published research studies on instructional practices.

For a variety of complex reasons, the standards did vary to from topic to topic, sometimes from author to author. However, Clearly, we need much more rigorous research on this topic, but our report shows that conducting this type of research is certainly possible and feasible. And dispassionate looks at research on hot button topics such as use of “real world” problems” can lead to honest and reasonable conclusions for the field.

2. **Regular Use of Formative Assessment Improves Students’ Mathematics Proficiency:** The evidence base was clear in that regular use of formative assessment to adjust and enhance instruction consistently leads to better mathematics achievement. The effect is larger and significant when teachers are provided with tools or enhancements to help them use this data.

This finding was true at all ability levels. These can include computer-generated suggestions for topics to teach a set of students with similar specific problems, placement suggestions, or even a “think sheet” that provides teachers with a set of questions to ask themselves when they are looking at the data.

To date, this finding is limited to one type of formative assessment– a proportional sampling from the year’s major objectives as specified in state standards. We need to study other types of formative assessments including those that accompany core mathematics curricula or those that involve more clinical analyses of students’ attempts to solve problems. This work is necessary and needs to be done.

3. **Students with Learning Problems:** It is no coincidence that for many of the topics we reviewed, there were actually more findings involving students with learning disabilities than for students of

average or above-average ability. There is a reason for this. Throughout the 1980s and 1990s, under the leadership of Martin Kauffman and then Louis Danielson, the Office of Special Education Programs of US Department of Education continually supported high quality intervention research, at a time when the paradigm was seriously challenged in the broad field of educational research. Thus, we can conclude with certainty that students with learning disabilities and other learning problems need to be taught with explicit instruction on a regular basis.

The next phase is figuring out exactly what explicit instruction is and how it “fits” the array of topics and proficiencies outlined by the Panel. Our current stab seems on the right track, but future researchers should help us define with precision what we mean by the term. Our current definition is far from perfect, but begins to provide a sense of what effective instruction for this group of students looks like: “the teacher provides clear models for solving a problem type using an array of examples, that students receive extensive practice using newly learned strategies” and perhaps most importantly, “students are provided with opportunities to think aloud (i.e. talk through the decisions they make and the steps they take) and with extensive feedback. Training teachers to become proficient in this mode of teaching is essential.

I would like to thank my colleagues on the Panel and the researchers at Abt Associates— who worked with us on virtually a daily basis— for how much I learned from our joint work.

Tom Loveless

The Herman and George R. Brown Chair, Senior Fellow,
Governance Studies,
The Brookings Institution

I want to thank my colleagues on the panel for their professionalism and Larry Faulkner for his wise stewardship. I value the experience of the last two years and also the friendships that I have made.

1. Press accounts of the NMP report ending the math wars—I doubt it. We didn’t seek to do that. We didn’t wade into the arguments and say on this issue one side is right, on another issue one side is wrong. Math wars and reading wars are not just about best approaches, Reflect values and ideologies. Beliefs about what is knowledge is of most worth (Herbert Spencer), the role of teachers and students, education’s place in a democratic society. We are not going to settle such disputes, nor should we. The report represents our best effort at dispassionately summarizing what is currently know about mathematic education—much based on empirical evidence but also informed by professional judgment. Arguments about beliefs—which historically sit at the center of debates over what to teach and how to teach it—are best settled by elected bodies and representatives—in the case of education, that means legislatures and school boards.
2. The main message of the NMP: content is king. The NMP report defines the content of algebra and the skills and knowledge leading up to studying algebra. The NMP report finds that important tests, including NAEP, do not currently assess these skills and knowledge. Get the content right and then give tests that assess that content are, I believe, the two most consequential recommendations of the report.
3. How should the NMP report be used? There is something for everyone. Federal policymakers should immediately begin a review of NAEP and NSF projects in K-12 mathematics to determine whether they are in accord with the findings laid out here. State policy officials should examine whether their state’s math standards or curricular frameworks reflect the mathematics described here for K-8. School boards should do the same, and examine the chapters on how children develop mathematical abilities and what is known and not known about instruction—so that they

can sweep away policies that support fads and myths. Too often the beliefs of principals, math specialists and superintendents are based on little or unreliable evidence. Teachers can use this document to check the content of their courses, to support lobbying efforts to get stronger content into the classroom, and to protect themselves from unwarranted mandates. Parents can use this document as a guide to what their children should be learning.

4. Finally, more research is needed in the field of math education. This panel's report represents a first step but only a first step in improving the mathematics education of America's youth.

Valerie F. Reyna

Professor of Human Development,
Professor of Psychology, and
Co-Director, Center for Behavioral Economics and Decision Research
Cornell University

Buenos días, señoras y señores. Muchísimas gracias por todo su apoyo.
Good morning ladies and gentlemen.

Thank you for your help and support: the panel staff, my fellow members and leadership.

I would like to make a few comments as Chair of the Standards of Evidence Subcommittee.

First, it would have been easy for this Panel to give in to the seduction of mediocrity and compromise.

Low standards are easy. And it was touch and go for a while.

But, due in no small part to the steady leadership of our chairs, Larry Faulkner and Camilla Benbow, and to Tyrrell Flawn, we did the right thing in the end. I want to thank you so much for making that choice.

Today, we stand strongly united in support of scientific rigor. We stood up for standards. As you know, although much of the research we reviewed was eliminated because it was not relevant to our questions, the truth is that we were forced to eliminate a great deal of educational research because it was of low quality. So, one of our most important contributions going forward is this commitment to scientific rigor. Rigorous research generates the proven practices that improve achievement, and is ultimately the foundation for America's success.

Speaking of the future...we must continue to stand for standards in three ways:

#1. We must increase the amount of experimental research that tests hypotheses—to prove that some ideas about education are wrong. Disconfirmation is the source of progress in all sciences, including the educational sciences.

#2. We need much more research about the mechanisms of learning—how and why learning occurs. Learning is the alpha and omega of education. Learning is the destination we want to get to—the omega. Learning processes are how we get there—the engine of education. You cannot build an engine without understanding internal combustion. And you certainly cannot improve a process you do not understand.

#3. The next Director of the Institute of Education Sciences—a specialized position—must be an accomplished researcher: a clear-eyed, hard-nosed, bona fide scientist. It will be very hard to fill Russ Whitehurst's shoes, but it is imperative that his good work be continued.

In conclusion, on behalf of all of the wonderful folks who attended our meetings, who sent us comments, the parents, the professionals, and, most of all, on behalf of America's students, I would like to ask you all to stand for standards. And I mean both content standards and standards of evidence. Thank you, my

esteemed colleagues. There are no words to express my respect for you. Thank you for making the hard choices.

Robert S. Siegler

Teresa Heinz Professor of Cognitive Psychology
Carnegie Mellon University

While participating on this Panel, I've been deeply moved by the immense patriotism that's present in the United States. Panel members spent hundreds, in the case of Larry and Tyrrell probably over a thousand hours working on this report. We did so for zero dollars and zero cents. That's the sum total of what all of us together gained financially from participating. Economists would say that we're the worst idiots in the universe. We devoted all of this time and effort because we care so deeply about the future of this country and its children and are worried that without large improvements in mathematics education, that future won't be as bright as it should be.

The same patriotism was evident among the hundreds and hundreds of people who came to meetings throughout the country for no reason other that they were interested. Many testified, a much larger number listened, and an even larger number sent e-mails and letters. There's just incredible interest in the United States, broad and deep, in increasing our children's ability to do well in mathematics. I knew before that some people cared; I was amazed by how many and how deeply.

There are many important lessons in this report. I'd like to call attention to two that I think are particularly important.

2 Priorities for Improving Math Learning

- I. Increase Preschoolers' Readiness to Learn Math
 - Many preschoolers enter school with a solid foundation: counting, numeral identification, magnitude comparison, simple arithmetic
 - Others don't, especially those from low income backgrounds
 - Early deficits in math knowledge have large, long-term consequences – through middle and high school
 - Even very brief interventions (about one hour) can produce substantial improvement in a broad range of numerical competencies
 - Several year-long curricula also produce large gains
 - Both types of programs should be implemented more widely

- II. Improve Elementary and Middle School Students' Understanding of Fractions
 - Fractions are fundamental to all higher math
 - Algebra teachers rate their students' understanding of fractions as poor; view this as a major obstacle to learning algebra
 - U. S. students receive instruction in fractions again and again – 3rd, 4th, 5th, 6th, 7th, and 8th grade – but many students still don't grasp
 - Lack of conceptual understanding is largest deficit. Most middle school students estimate that $12/13 + 7/8$ is about 19 or 21; many also say $.345 > .67$
 - Lack of conceptual understanding of fractions harms learning of math procedures, such as fractional arithmetic. Makes it like memorizing nonsense syllables
 - Research on how to improve elementary and middle school students' learning about fractions is urgently needed

Sandra Stotsky

Twenty-First Century Chair in Teacher Quality
University of Arkansas;
Member, Massachusetts State Board of Education

It has been my privilege and honor to serve as a member of this Panel. My comments are reflections on the significance of our report based on my professional interests in the K-12 curriculum and teacher quality. From my perspective, a basic goal of this report is to promote equity in the K-8 mathematics curriculum. We haven't stated this particular goal explicitly, but it is clearly implicit in our recommendations.

From this perspective, one might point to the two landmark reports by James B. Conant, *The American High School Today*, published in 1957, and *The Comprehensive High School*, published in 1967, as relevant historical predecessors to our document. He and the other members of a committee he chaired to study the American high school were also seeking to promote equity. At that time the question was how to academically strengthen public high schools in order to broaden access for their students to our institutions of higher education, especially elite ones whose student body then came largely from a longstanding network of private secondary schools. Conant, a president of a major university (Harvard), a scientist by training, and a former chemistry professor, was especially interested in increasing the opportunity to study advanced mathematics and science in our public high schools. Among the criteria his committee used for judging the quality of a high school was the availability of a calculus course and a strong course in physics. Capable students couldn't prepare adequately for some of our most demanding higher education institutions if these mathematics and science courses weren't even offered in the tiny public high schools that dotted our country. The focus of those two studies was on the specific content of the curriculum. That is also the major focus of our report, in large part because concerns about the specific content of the mathematics curriculum have received much less attention than matters of pedagogy in the past two decades.

The scope of the National Mathematics Advisory Panel's report is narrower than the scope of those two Conant reports a half century ago only in the sense that we focus on mathematics education in the schools. But the goal of our report is actually broader--how to strengthen both the elementary and the middle school mathematics curriculum in all our schools in order to democratize access to Algebra I, the gateway course to advanced mathematics and science in our high schools. I want to highlight what I see as five major interconnecting recommendations to accomplish this. First, we spell out what the specific components of Algebra I and Algebra II should be. Second, we describe what components of K-7 mathematics all students should master in order to do well in an authentic Algebra I course. Third, we outline what should be included in mathematics coursework for prospective elementary, special education, and middle school teachers of mathematics and what they should be tested on for licensure so that they are qualified to teach the foundations for an authentic Algebra I course or the course itself. Fourth, we urge that all school districts provide an authentic Algebra I course in grade 8. And, fifth, we recommend that schools prepare an increasing number of students for success in an authentic Algebra I course in Grade 8, if not earlier.

This is the equity issue: a regularly increasing number of American students should be prepared to take an authentic Algebra I course in grade 8 (or earlier), just as are large percentages of students in the highest-achieving countries on TIMSS. More of our high school students can then take the advanced mathematics and science courses in their junior and senior years that qualify them for admission to the most demanding institutions of higher education in this country.

Vern Williams

Mathematics Teacher,
Longfellow Middle School,
Fairfax County Public Schools, Virginia

Acknowledgements, Welcome:

US Secretary of Education, Margaret Spellings
Fairfax County Public Schools Superintendent Jack Dale
Vince Lynch, Longfellow Principal
Eugene Huang, Former student and current Longfellow math teacher
My fourth period class and other invited students

The debate over how to teach mathematics to our nation's students will continue but there should be no debate over its content. I never envisioned that mathematics content could ever be compromised or trivialized until I woke up one morning and discovered that some mathematics educators had decided that correct answers were overrated. Some of those educators also decided that Algebra I topics such as rational expressions and certain forms of factoring were also overrated and should be deleted from the course. Algebra, as taught in many schools, was redefined to include data analysis, pattern recognition and a host of other topics while some of the more rigorous familiar topics were deleted.

At our first meeting, I suggested to the panel that we define algebra and I commend the panel especially, the Conceptual Knowledge and Skills task group for doing precisely that. Students with a strong background in algebra as defined by the panel will be well prepared for the rigorous math courses that they will need to learn in high school and college if we are to compete globally in science, engineering, and technology.

I feel that teachers of math at both the middle and elementary school levels will be pleased that the panel has suggested through the critical foundations and topics of algebra a focused and coherent body of knowledge and skills that will include computational fluency, conceptual understanding, and problem solving. Hopefully teachers will take from our report that it is not only acceptable but also crucial to give major importance to mathematics content and to require correct answers from their students.

I will now read verbatim the essence bullet from the Instructional Practices Task Group under the Principal Messages section of our report.

Instructional practice should be informed by high-quality research, when available, and by the best professional judgment and experience of accomplished classroom teachers. High-quality research does not support the contention that instruction should be either entirely "student-centered" or "teacher-directed." Research indicates that some forms of particular instructional practices can have a positive impact under specified conditions.

I hope that everyone takes from our report that classroom teachers should have a role in deciding their instructional practices.

Hung-Hsi Wu

Professor of Mathematics
University of California at Berkeley

I believe we have written a report that unflinchingly confronts the major issues of the day in math education. It does so with reason and scientific evidence, rather than with any fantasy about what should be but is not. Most importantly, it recognizes the central role played by mathematical content in our ongoing struggle with improvement in math education. See the first two bullets of the Principal Messages in the Report (page xiii). This recognition is a rare achievement among education documents, if not a unique one.

I have had time to reflect on why this panel managed this singular achievement when all others have failed. Certainly this panel has a rare combination of very knowledgeable scholars from diverse areas. But just as a school is only as good as its principal, I think a panel writing a report is only as good as its leadership. Our chair, with his able associates, Camilla and Tyrrell, helped us navigate very treacherous waters, and he has led us to safety. He may have been exhausted doing this, but we on the panel and the children of this nation can only be grateful for a job well done.

I am proud to be part of this report. But I have to admit that there were times, such as during the days of peak activities, when I cursed the panel everyday. Now that it is over, I think I will miss it, very much.

Ex Officio Members

Irma Arispe

Assistant Director for Life Sciences
Acting Assistant Director for Social, Behavioral and Economic Sciences
Office of Science and Technology Policy
Executive Office of the President
Washington, DC

On behalf of Dr. John Marburger, Science Advisor to the President, and the White House Office of Science and Technology Policy, I would like to congratulate the panel for your tireless effort and extraordinary commitment to good science.

The resulting products (the main report and the task group reports) will inform science policy deliberations and research agenda setting for years to come.

I am truly honored to have worked with and among you. We look forward to working with you further as colleagues, with the federal family represented here on the panel, and with the broader set of federal agencies that support STEM education research through our National Science and Technology Council, to translate not only the findings and recommendations, but the spirit and enthusiasm of this report into action.

Thank you.

Dan B. Berch

Former Associate Chief, Child Development and Behavior Branch and
Director, Mathematics and Science Cognition and Learning Program
National Institute of Child Health and Human Development
National Institutes of Health

First, I want to acknowledge that I am speaking here as a representative of the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) at the National Institutes of Health. We are grateful to the U.S. Department of Education for permitting us to participate in this effort from its inception, and we believe that the final report is highly responsive to the Panel's charge as delineated in the Executive Order.

In my remarks, I want to focus briefly on the Panel's recommendation calling for more Federally funded, high-quality research on designing instructional practices for improving the performance of low-achieving students. What I want to emphasize first is that there is a subset of these children whose impairments in mathematical learning are so severe and enduring, as well as unresponsive to routine instructional practices, that they can more appropriately be characterized as having an actual learning disability in mathematics. A colleague of mine from the United Kingdom, who is a highly regarded researcher in this field, mentioned to me after visiting the U.S. that he was struck by the comparative lack of awareness in this country that there are children who can in fact be classified as having a mathematical learning disability. Educators and parents need to recognize that not only are mathematical learning disabilities a reality, but they are as prevalent as reading disabilities, namely somewhere between 5 and 9% of school-age children. It is important to understand that these youngsters truly struggle with what would appear to constitute comparatively simple numerical skills, including various principles of counting as well as the retrieval from memory of even the most basic arithmetic facts. Moreover, in comparison with their low achieving but non-LD peers, children with a math learning disability possess an even more deficient conceptual understanding of fractions and decimals. These findings are all the more disconcerting, given that the learning of rational numbers is not exactly straightforward even for typically achieving middle-school students.

For close to a decade, my Institute, the NICHD, has been addressing these challenges by funding high-quality studies of the origins and development of mathematical disabilities, the cognitive and brain mechanisms that give rise to such impairments, and instructional interventions for ameliorating them. Some of the important advances that have emerged from this research are discussed in the Panel's report. Moreover, consistent with the Panel's recommendation, we are currently running a grants competition that will permit the Institute to fund at least five more years of innovative research in this field.

Finally, on a personal note, I must say that working with my colleagues on this Panel has been one of the most challenging, rewarding, and humbling experiences of my career. I submit that any perceived shortcomings in the final report can be attributed primarily to the lack of a sufficiently rigorous evidentiary base, rather than to a lack of expertise, effort, or commitment to excellence on the part of the Panel members. Moreover, despite what at times could certainly be characterized as spirited, vigorous, and impassioned exchanges and debate, in my opinion this group's collective sense of its overarching responsibility to produce a strong and impartial report superseded any individual biases or personal agendas that some may have initially considered bringing to the table.
