

**UNITED STATES DEPARTMENT OF EDUCATION
NATIONAL MATHEMATICS ADVISORY PANEL MEETING**

FRIDAY, APRIL 20, 2007
SUMMARY

The National Mathematics Advisory Panel met in open session at the Illinois Mathematics and Science Academy, 1500 W. Sullivan Road, Aurora, Illinois 60506, on Friday April 20, 2007 at 8:50 a.m., Chair Larry R. Faulkner presiding.

PANEL AND EX OFFICIO MEMBERS PRESENT:

LARRY R. FAULKNER,	Chair
CAMILLA PERSSON BENBOW	Vice Chair
DEBORAH LOEWENBERG BALL	Member
A. WADE BOYKIN	Member
DOUGLAS H. CLEMENTS	Member
SUSAN EMBRETSON	Member
FRANCIS "SKIP" FENNELL	Member
BERT FRISTEDT	Member
DAVID C. GEARY	Member
RUSSELL M. GERSTEN	Member
TOM LOVELESS	Member
LIPING MA	Member
VALERIE F. REYNA	Member
WILFRIED SCHMID	Member
ROBERT S. SIEGLER	Member
SANDRA STOTSKY	Member
VERN WILLIAMS	Member
HUNG-HSI WU	Member
DANIEL B. BERCH	Ex Officio
JOAN FERRINI-MUNDY	Ex Officio
DIANE JONES	Ex Officio
GROVER J. "RUSS" WHITEHURST	Ex Officio

PANEL AND EX OFFICIO MEMBERS NOT PRESENT:

NANCY ICHINAGA	Member
JAMES SIMONS	Member
RAY SIMON	Ex Officio

STAFF MEMBERS PRESENT:

TYRRELL FLAWN	Executive Director
IDA EBLINGER KELLEY	
MARIAN BANFIELD	
JENNIFER GRABAN	
KENNETH THOMSON	
ROBERT GOMEZ	

CALL TO ORDER:

Chair Faulkner opened the session at 8:50 a.m. and welcomed everyone to the open session of the National Math Panel. He thanked the Illinois Math and Science Academy (IMSA) for hosting the open session, the sixth meeting of the National Math Panel. He stated that signing services were available, but there were no indications from the audience that they were needed.

WELCOME REMARKS BY JANICE KROUSE, CURRICULUM AND ASSESSMENT LEADER AND MATH FACULTY MEMBER, ILLINOIS MATH AND SCIENCE ACADEMY

Dr. Krouse stated that she joins the Panel and the audience in recognizing the significant consequences of a quality mathematics education for the children of this country, as mathematics and critical thinking skills profoundly affect their lives and their ability as responsible citizens to shape the human future.

At the Illinois Math and Science Academy (IMSA), the staff takes their role in influencing tomorrow's leaders very seriously. The quality of the engagement between teacher and student, and between the student and the mathematics, cannot be underestimated. It was for these reasons that the charter mathematics faculty and Presidential Awardees of the Illinois Mathematics and Science Academy invested their time, talents and energy into authorizing a pre-calculus curriculum, named Mathematical Investigations, for their students. With ongoing revisions and updates, Mathematical Investigations, known as "MI", is still taught here today.

Charter math faculty and author of MI, Chuck Hamberg, often said, "If you stop when you get the answer to a problem, you miss half of the mathematics." It has been noted that one of the strengths of MI is the space given to students to solve a problem "85 different ways." It is that very notion of curiosity that drives learners to their full potential. Dr. Krouse stated that it is their job as educators to believe in that potential and to create conditions in which it can be realized. What, then, is the role of the teacher in the MI classroom?

Mathematical Investigations (MI) invites learners into the science of mathematics through carefully crafted questions and problems. Students observe patterns and phenomena, make conjectures, test their hypotheses on new problems, and analyze their results. All the while, students are engaged in conversations with peers and teachers about mathematics.

Ideas, probing questions, insights, and supporting arguments emerge daily. Through these conversations students forge connections within and among mathematical concepts in ways that make sense to them. They utilize various forms of technology to explore and test their conjectures. Most importantly, Dr. Krouse stated, they are not forced to merely absorb a neatly packaged explanation given by the teacher.

Dr. Krouse explained that there is a delicate balance of timing that must be maintained of when to let the students grapple with a new or difficult idea, and when to intervene, to help them make necessary connections and to see the big picture. There is a need for enough self-confidence and mathematical prowess to let the students watch the teacher grapple with a challenging problem so that they can see him or her as a model problem solver, even if that means the teacher makes a mistake in front of them, something that the traditional teacher wouldn't dream of. There is a need to be able to answer students' questions with questions that lead students to the answers they thought they couldn't get.

Dr. Krouse explained that then, somewhere in the midst of the grappling and questioning, the synthesis begins. Students respond to the teacher's probing and challenging questions by refining their understandings of complex ideas. Ultimately, the forging of connections consummates in closure of sound mathematical ideas that students can transfer and apply to tomorrow's questions.

These explorations are often aided by various forms of technology, including the TI-89 Titanium/CAS graphing calculator, Mathematica, Geometer's Sketchpad, Fathom, and the Internet. Dr. Krouse believes that technology enables students to actively pursue questions about

mathematical constructs that otherwise would be unattainable. Further, today's students are engaged with technology so frequently, that to deny them this resource in their learning is asking them to divorce their natural environment from their schooling. Fluency with emerging technologies in problem solving will continue to be a critical, necessary and expected skill for our students.

Dr. Krouse reported that with more than 850 students taking the Advanced Placement BC Calculus exam over the last seven years, the program has a collective average of over 4.6 on a five-point scale. Intel Finalists, Siemens winners, and inventors of Papal, Mosaic and YouTube are among their alumni.

Dr. Krouse explained that their program has had impact outside of their school, when in 2003, IMSA mathematics faculty were called on as pedagogical experts to help a neighboring district to determine criteria by which a mathematics program would be selected for their high school. IMSA faculty also went through a similar process to find an appropriate program for their honors students, and MI was chosen for that group of students.

OPEN SESSION

Chair Faulkner opened the public session with introductions of new members of the National Mathematics Advisory Panel: Douglas H. Clements, professor of early childhood, mathematics and computer education at the University of Buffalo, State University of New York; Susan Embretson, professor of psychology at Georgia Institute of Technology; and Bert Fristedt, professor of mathematics at the University of Minnesota. Chair Faulkner then proceeded to the public comment session.

PUBLIC COMMENT:

HENRY BORENSEN, PRESIDENT, BORENSEN & ASSOCIATES AND FOUNDER, HANDS-ON EQUATIONS

Dr. Henry Borenson is president of Borenson & Associates, Incorporated and founder of Hands-on Equations. Twenty years ago, as a middle school math teacher, he was concerned with the difficulty students were having learning algebra abstractly. He wanted to find a way to simplify the concepts, and make them concrete, visual and accessible to all grade school students.

After two years of experimentation working with children, including those who were learning disabled, he developed Hands-on Equations. Dr. Borenson explained that this is a system that uses game pieces, a flat laminated balance, and a specific sequence of ideas to enable students as early as the third grade to physically represent and solve algebraic linear equations. These types of equations are typically taught in the eighth or the ninth grade.

Since 1995, Borenson & Associates has conducted more than 1,500 Making Algebra Child's Play workshops throughout the United States. In these workshops teachers of grades three to eight learn how to introduce the concept of a variable, the concept of an equation, the subtraction and addition property of equalities, and other key algebraic principles.

A key part of these teacher workshops, Dr. Borenson explained, is a student demonstration with local fourth and fifth grade students. Teachers attending the seminars have seen how, in three lessons, fourth and fifth grade students, including so-called low ability students, can learn to solve an algebraic linear equation such as $4x + 3 = 3x + 9$.

In a study to determine teacher confidence level in teaching algebraic linear equations to their lowest achieving students, Barber and Borenson (2006) discovered that only 17 percent of 751 teachers, from grades three to eight attending a Making Algebra Child's Play workshop, felt they would be successful using the traditional abstract teaching methods, while 98 percent expressed confidence of success if they were to use the Hands-On Equations and materials. The study is shown on Appendix A of his handout.

In an ongoing series of studies of Hand-on Equations involving multiple student characteristics and multi-site replications, supervised by Dr. Larry Barber, formerly director of

research at Phi Delta Kappa, an international association for professional educators, the program has found significant pre- to post-test gains for second grade gifted students, sixth grade regular students, and ninth and tenth grade low-achieving students.

Dr. Borenson reported that recently Hands-on Equations completed a study involving four fifth grade inner-city classes with 111 students. The combined mean increase went from 44.8 percent on the pre-test to 85.3 percent on the post-test, a highly significant increase. On the three-week retention test for fifth grade inner-city students, with no instruction in the interim, the mean was 78.6 percent. When compared with a pre-test score of 44.8 percent this increase was found to be statistically significant with a t-value 13.71. That study can be found in Appendix B.

Dr. Borenson asked the Panel to consider recommending Hands-on Equations as a supplementary program that is effective in introducing grade school students to basic algebra.

PUBLIC COMMENTS QUESTION AND ANSWER PERIOD:

Dr. Fennell asked Dr. Borenson if the research he referenced would be made available to the Panel. Dr. Borenson stated that it is in the handout.

PUBLIC COMMENT:

PATRICK THOMPSON, PROFESSOR, MATHEMATICS EDUCATION AND DIRECTOR OF RESEARCH, ARIZONA STATE UNIVERSITY

Dr. Thompson stated that his testimony will focus on five of the Panel's charges. He feels the Panel has a significant task responding to a list of charges that take skills as the primary component in mathematics learning, when the notion of "skills" is not well defined. He asked how they were defining skill, either as a child's ability to reliably perform a procedure when told to perform it, or as a child's ability to have developed sufficient knowledge and appropriate flexibility of thought to solve most problems of a particular genre of problems, even those that might have subtle differences from others he or she might have seen?

The difference in definitions and the different viewpoints related to them will affect the Panel's recommendations. Dr. Thompson feels it is important for the Panel to be clear on what students should learn, and to justify that stance according to its consequences for future learning.

In regard to charges three and four of the Panel, processes of learning and effective instructional practices, Dr. Thompson offered an example from a current research project on effective models in secondary mathematics teachers' instruction. The project involves creating teaching tools for Algebra I that would help make concrete for teachers the teaching and learning process they had envisioned. The project also hopes that the students involved will display proficiency in algebra because they understand the ideas and not because they had memorized the prescribed procedure.

The students in the study were not in an honors program, and were taking Algebra I at ninth grade. Their computation skills were weak, and they had no understanding of fractions. Their experience in mathematics was that teachers showed them procedures they were supposed to remember until the next test. They did not enjoy math.

The study's immediate question was where to begin the lesson for a group of students with low skill levels. The students could either be re-taught the lessons or move on. The study chose to move on and to begin the year with no review. The leaders of the study used as a goal to guide their instruction design being able to meaningfully engage students with significant mathematical ideas, as well as to prepare them to pass the mandated tests.

The study focused on central ideas prior to calculus curriculum such as variation, covariation, rate of change and functional relationship. The appendices Dr. Thompson shared with the Panel contain examples of the kind of work that should be expected from the students.

Dr. Thompson closed by saying that the nation suffers not from a lack of research, but from a lack of imagination, especially at the levels of policy and politics. Problems also arise from

recruitment and retention of students in secondary math courses.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Dr. Benbow asked what they actually did in the classroom to engage the students given that the students did not have the basic skills mastered. Dr. Thompson responded that they focused on beginning with literal symbols to represent mathematical phenomena. They focused on ideas of variable and variation so that variables stood for measures of things that changed. The discussions were not about how to complete but how to represent. Computations flowed from that, because once students had a representation, they were able to compute something.

PUBLIC COMMENT:

KEVIN KILLION, DIRECTOR, THE ILLINOIS LOOP

Mr. Killion has a degree in mathematics and has been a research vice president in a marketing agency. He has written several commercial/statistical analysis products, and he operates a business in market and media analysis. He became involved with math reform when he observed the difficulties his own son was having. Today he serves as director of the Illinois Loop, a 12-year-old organization of parents, teachers, school board members and others. The Illinoisloop.org Web site is a valuable source for what is going on in schools and they have logged more than 600,000 visitors.

Mr. Killion began his comments with a statement about standards. He feels that calling one category of math programs standards-based is a ploy that tarnishes other programs as somehow being without focus. The word “standard” has 19 definitions. Similarly, there is no single standard for math.

Mr. Killion stated that schools are constantly told to embrace change and teachers are exhorted to be agents of change. But he feels the reality could not be more starkly different, as everything has already changed. The Illinois Loop Web site provides extensive information about how math is taught in Illinois school districts, from Addison to Zion. This resource is well used by parents in tracking what districts are doing.

In Chicago, some 290 schools use constructivist math programs in early grades. They have only been able to identify five conventional Chicago Public Schools that use practice-and-mastery math programs. Another five charter schools offer Saxon Math.

In 118 suburban K-8 districts in five counties, constructivist products form the math foundation in 77 percent of those districts. Illinois Loop has identified only six districts that make use of the math programs most recommended by practice-and-mastery reformers, such as Singapore Math or Saxon Math. Mr. Killion reported that when districts are unhappy with their math programs they merely stick with constructivist math and substitute one program for another. He feels that they are not the agents of change they say they are. These districts are firmly mired down with a philosophy that they refuse to abandon.

In the course of his work at the Illinois Loop, Mr. Killion receives hundreds of messages from parents. Many of them are concerned about constructivist math programs in their schools and what these programs are doing to their kids. One parent stated that more than 40 percent of parents pay tutors up to \$50 an hour to teach their kids properly. A Naperville mom fears that when her daughter finishes in this school system, she will be well experienced in arts and crafts, but she will lack the ability to make change.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Dr. Siegler asked Mr. Killion that, if the comments he hears are representative of parental views, what does he think is keeping school board members who want to change the current system from being elected. Mr. Killion answered that school board election issues are too numerous to talk about in that setting. But he did say that these are real opinions representative of hundreds of others

they receive through the Illinois Loop. Parents are suffering with what is going on with their kids.

PUBLIC COMMENT:

JACK ROTMAN, PROFESSOR, LANSING COMMUNITY COLLEGE, MI

Mr. Rotman has been a professor at Lansing Community College in Michigan for 34 years. He is the chair of the developmental mathematics committee of the American Mathematical Association of Two-Year Colleges (AMATYC). He was a contributing writer for their 2006 standards document, *Beyond Crossroads*.

Mr. Rotman had three questions for the panel, which were the basis for his remarks. One, are sufficient and necessary conditions present in the schools to provide mathematics learning for all students? Second, are there barriers outside of the education system that substantially limit the learning of mathematics for some groups of students? Third, is there a plan for a system, which provides a second chance for students who did not learn sufficient mathematics in K-12 schools?

On the first question, Mr. Rotman asked are there sufficient and necessary conditions present. At the most basic level, he stated that students must stay in school and pay attention to benefit from the curriculum. The nation's dropout problem is well documented and studies show that seven percent of the students are absent on a given day and that was only for unexcused absences. For the students who are in school, he feels we need to be concerned about whether they are actually attending class. An optimistic study estimated that students attend class 65 to 75 percent of the time.

When students are in class, he feels we need to look at how the teachers are teaching. In a study of various methods of teaching, the only method that increased student attention was the debate/discussion method. The group learning methods only increased attention a little bit.

On the second question, Mr. Rotman asked whether barriers outside of schools limit opportunities. While he knows the Panel has discussed the concept of stereotype threat (one of those barriers), he encourages them to consider broader viewpoints of these issues, including critical race theory.

Critical race theory is the assumption that racism is embedded within the social structure so that information is analyzed from that viewpoint. The theory suggests that the achievement gap is really an opportunity gap, and a more radical view sees standardized testing as a means to justify differences.

Also, some researchers have documented a default trajectory in certain types of communities towards dropping out. In addition, some regions have schools that are separate but not equal due to policies such as school choice and other issues. This segregation results in a situation where the Lansing high schools are 70 percent minority, while the Lansing area itself is only 35 percent minority.

Mr. Rotman also encourages the Panel to consider other barriers that exist outside the education system. For example, mathematics still faces the barrier that it is acceptable or even desirable to be "bad at math." He pointed to the lack of role models encouraging math.

On the third question, Mr. Rotman asked about the presence of a backup system, or a second chance. While there is a community college system, he feels that it is hardly a systematic plan for helping people catch up in math. Outside of the work of AMATYC, he does not see much being done at this level. Mr. Rotman suggested the Panel consider community colleges as part of the mathematics educational system and that they be included in the dialogue. They provide a recruiting ground for mathematics and science fields.

Mr. Rotman summarized that he hopes the Panel will work to establish minimal conditions for learning, look at barriers to learning outside of the schools and include community colleges in the discussions.

**PUBLIC COMMENT:
KEN INDECK, ILLINOIS ASSOCIATION FOR GIFTED CHILDREN**

Mr. Indeck is a high school math teacher with nearly three decades of experience and he spoke as a representative of the Illinois Association for Gifted Children. He stated that his remarks would be primarily anecdotal because it is important for him to communicate the realities as viewed from within the school system.

Mr. Indeck stated that one of the hallmarks of gifted education is the notion that one size does not fit all. In Illinois the same content benchmarks are used to assess all students. For the bottom third of the academic spectrum, these benchmarks are a stretch. For the top third, students often surpass them.

Last year, Mr. Indeck was talking to a school administrator about some curricular improvements they could implement for bright students in their school. Before Mr. Indeck finished, the administrator stopped him and said it will not help the school meet Adequate Yearly Progress (AYP). The administrator stated that they needed to focus on raising the scores of the students who will “help us.”

As a parent he was thrilled when his son's third grade math teacher told him how proud she was the entire class had completed both the third and fourth grade material. But he was shocked when he found that the fourth grade math teacher was teaching the fourth grade curriculum, knowing that the students had already been through and mastered that content. This happened because she was unable to teach the fifth grade material. Half that class lost interest in math. By sixth grade there were a handful of students who were still excited about math and ready for algebra, but they were not allowed to take the course because the junior high did not offer it.

Mr. Indeck envisions four entwined approaches to improving the current state of affairs in math education. First, he advocates for the use of best practices. Acceleration is important, but it must use a coordinated sequence to be effective. Few high school math teachers are knowledgeable about differentiated instruction and fewer still are skilled in its implementation. For many high schools the gifted curriculum is synonymous with AP course offerings. But that is just a starting point according to Mr. Indeck, and students should also be exposed to age-advanced concepts, a rich environment that helps them see connections to other topics in the curriculum, and where they are allowed to explore how those connections can be put to use making the world better by improving people's lives.

Second, he would like an approach that encourages and supports the educators who take reasonable professional risks. The current practice of looking for significant improvement over short stretches of time does not realistically encourage a teacher to switch from one set of techniques to another.

Third, Mr. Indeck feels it is essential to provide significant support for research, particularly research regarding instructional practices. He feels educators need to know more about how grouping students and sequencing topics influence learning. He also feels it is important to develop broader assessment practices that extend beyond recalling facts and solving one or two step problems. Mr. Indeck stated that to maintain the nation's leadership in the areas of science and technology it is essential to support mathematics education and research in mathematics, science and applied fields within academia and industry.

Finally, Mr. Indeck feels it is crucial to educate the public about the educational process, and how hard the work is, so that they have a realistic set of expectations both for what schools can provide and how the educational growth of students can be documented.

Mr. Indeck feels the opportunity is there for our nation and the world to establish long-term leadership in economic strength and quality of life. That leadership is likely to come from students at the top end of the academic spectrum, who are well grounded in math and science and who recognize the connections between those subjects and the broader world around them. The notion that we are doing fine is not good enough.

Strengthening the educational system should prompt increased achievement for all, stated

Mr. Indek. Closing the achievement gap should not translate to holding hostage the education of our most able students. If we compare students' performance to their own capabilities, as the mission statements for most schools suggest, it is the bright students who fall short and are furthest from reaching their potential.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Dr. Schmid asked Mr. Indek at what kind of school he teaches. Mr. Indek responded that he teaches at a regular high school. He is not teaching gifted classes at this point, but at one time he was the curriculum and staff development coordinator of the Talent Development Program for High School District 214. Mr. Schmid asked why he was no longer teaching a gifted program and Mr. Indek responded that the position was eliminated because it doesn't help them meet AYP.

Dr. Reyna asked what Mr. Indek thought were the barriers to having two goals in mind at the same time – the adequacy goal and the excellence goal. Mr. Indek responded by stating that systems designed to get all students to a certain level have very little incentive, once students are at that particular level, to continue to move those students forward.

PUBLIC COMMENT:

**SARAH DELANO MOORE, DIRECTOR, MATHEMATICS AND SCIENCE,
ETA/CUISENAIRE**

Dr. Sara Delano Moore is the director of mathematics and science at ETA/Cuisenaire. ETA/Cuisenaire is a leading publisher of supplemental instructional resources for mathematics, science and literacy. For over 40 years her company has pioneered the development and effective use of hands-on materials or manipulatives to improve student-learning outcomes. Dr. Moore also is a fourth-generation teacher, although the first to teach mathematics. Her undergraduate education focused on molecular biology, so she is a scientist by training. She taught mathematics and science in middle grade schools, and in higher education, teaching both mathematics methods courses and curriculum courses. Dr. Moore's research in writing has focused on the use of award-winning and high-quality literature, alongside hands-on experiences to teach rich mathematics and science at all levels.

ETA's products and associated professional development training are grounded in the belief that children learn mathematics by doing mathematics in active, hands-on ways. This belief has a long research base to support it.

The three part learning cycle ETA uses to discuss instruction with manipulatives includes phases called concrete, representational and abstract. Jerome Bruner's [right?] work talks about a similar cycle as inactive, iconic and symbolic. Most recently Michael Batista used the terms action, reflection, and abstraction. In all cases the basic idea is that children must first have hands-on experiences with the math and then use the representational phase as a transition to the abstract, more formal mathematics.

Dr. Moore stated that there is no question that children need to be computationally fluent. She feels these children must also understand the mathematics behind the computational procedures they use. While she says she loved mathematics in school, she is not sure that she genuinely understood mathematics until she learned to use manipulatives to teach math.

While Dr. Moore stated that we do not know what problems students will need to solve as adults, she feels we can be certain they will need problem solving skills. They will also need the confidence they can solve problems successfully. Children learn by making connections between the familiar and the unfamiliar. The role of teachers is to guide children toward the connections we want them to make.

Dr. Moore stated that manipulatives provide a bridge between the concrete world of a child and the abstract concepts of mathematics. They may also serve as an enticement to learn math, which does not, on the surface, appear engaging. By using the manipulatives, literature, and other

active instructional resources, children can be drawn into the world of math and find success there. Every child must find meaningful success in mathematics and we must use every resource we have to ensure this happens.

Unfortunately, stated Dr. Delano, manipulatives are too often used as hands-on worksheets with teachers telling students exactly which piece to touch and where to place it as they act out the traditional algorithm. She feels that professional development is critical if teachers are to use manipulatives as the powerful tool research shows them to be.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Dr. Loveless asked about the research Dr. Moore mentioned that supports manipulatives, and where he could find a piece of research that is persuasive. Ms. Moore responded that there are a number of pieces of research, for example, on the use of base ten blocks and various models. This includes work by Karen Fuson and her colleagues and John Bransford. Dr. Loveless also asked if she would agree that the goal would be for students eventually to not depend on manipulatives. Dr. Moore responded that as children learn the math, the use of manipulatives self-extinguishes. They reach a point where they can use common algorithms and can do that work independently. The manipulatives serve as a tool to bridge between their concrete world and concrete thinking, and the more formal mathematics that they will need in life.

Dr. Reyna asked Dr. Moore if she was familiar with the research of David Uttal on the use of manipulatives. Dr. Moore was not. Dr. Reyna said that if Dr. Moore looks at Uttal's research, the Panel would be interested in hearing her thoughts about it.

PUBLIC COMMENT:

BARBARA WILMOT, NATIONAL MATHEMATICS CONSULTANT

Dr. Barbara Wilmot has worked in mathematics education from the elementary to the university level for 45 years, and has taught at Illinois State and directed a state professional development program. She is currently an independent consultant and administrator for a grant that supports and monitors central Illinois schools that do not make AYP year after year. She has worked with more than 100 districts and more than 1,200 professional development workshops in almost every state. Dr. Wilmot spoke on behalf of herself and for Learning Resources, which is a leading provider of hands-on classroom materials. She often uses their materials in her professional development sessions and has partnered with them to create a mathematics manipulative handbook, which is free to teachers.

Dr. Wilmot focused her remarks on the millions of students with language barriers or special needs, many of who are in mainstream classes. And because No Child Left Behind holds these students to the same level of expectation as other students, her concern is how to level the playing field for them in learning mathematics.

Dr. Wilmot shared three points supporting the fact that hands-on learning tools and related professional development help English language learners and students of special needs deepen their understanding of mathematics and increase achievement. The first point is that manipulatives allow students to build, model and create multiple representations of mathematical concepts and, therefore, help them meet benchmarks. Whether National Council of Teachers of Mathematics or state standards is the guide, "build," "model," and "create" are verbs that appear at almost every grade level. Other verbs such as "describe," "verify" and "generalize" also happen if engaging tasks are offered for students. She feels that it is difficult to meet these outcomes without using manipulatives.

Meeting benchmarks and developing a deep understanding require, Dr. Wilmot believes, that students explore multiple representations of mathematical concepts. Students are likely to fail if they only learn fraction concepts, for example, in one representational format.

The second point, Dr. Wilmot stated, is that manipulatives allow students with limited language abilities and/or special needs to understand simple and complex mathematical concepts and

to actually demonstrate their knowledge. Physical models also allow for assessment. Students can build the representation and demonstrate knowledge of ideas when they are not yet ready to communicate via symbols or words.

Dr. Wilmot's third point is that high-quality professional development is essential to learn how to integrate manipulatives and a variety of strategies and techniques into the curriculum to differentiate the instruction for each student. Many teachers believe that manipulatives are highly effective, yet few actually use them and fewer yet know how to use them correctly. Dr. Wilmot has found that at least 100 hours of professional development are necessary to make teachers comfortable with this.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Ms. Jones asked Dr. Wilmot to give the Panel some guidance on the definition of "high-quality professional development," or how to distinguish high quality from low-quality. Ms. Jones also asked if Dr. Wilmot could comment on the way professional development is best delivered and how federally supported teacher professional development should be assessed.

Dr. Wilmot responded that one-shot professional development does not work and we should do a better job of letting people know that. She added that it should be district-based and/or school-based, and long-term. There has to be support and administrator participation. And she feels that data, both on student achievement and teacher opinions, is important. Journaling and reflection by teachers is also vital.

PUBLIC COMMENT:

JANIE ZIMMER, BOARD MEMBER, NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS; RESEARCH BASED EDUCATION

Ms. Zimmer, who works with Research Based Education, spoke to the Panel on behalf of the National Council of Supervisors of Mathematics (NCSM), an organization for leaders in mathematics education where she is on the board. She discussed in her remarks the issue of equity, which is the opportunity for and the expectation that every child will be successful in mathematics and will have the opportunity to reach high levels of mathematical content.

Ms. Zimmer feels that schools and teachers do have expectations for a lot of our children, including allowing students into high-level math classes beginning with Algebra I, if they are prepared and ready for that rigorous work. At the same time, Ms. Zimmer stated, schools continue to sort and select which students will go into high-level classes and which students will go into the low-level or remedial Algebra I A/B classes. In many schools educators create classes into which they place students according to their performance on state assessments. Or they create inclusion classes that contain both general education and special education students, frequently without support. She asked if that is equity.

Ms. Zimmer feels that individualized education plans (IEP) send the message that a student does not have to perform at the same rate as other students. She asked if that is not holding students to a different expectation. Ms. Zimmer stated that some of her students are not at the level to complete the same high-level work, yet she asks how students who enter the ninth grade with fourth grade mathematics skills are able to complete the ninth grade algebra content.

Ms. Zimmer shared with the Panel that a school district of about 50,000 students in Maryland has grappled with this issue. All of their middle school students are placed in grade-level classes with added support for struggling students. In all 12 of their high schools, all incoming students take Algebra I as the minimum class. Students with IEPs or Section 504, Americans with Disabilities Act (ADA) plans are included in these regular classes.

In addition, she stated that high schools provide an extra support seminar as part of the schedule for students who need extra help. These classes are assigned two teachers, a math-certified teacher and a special education teacher. They have a student/teacher ratio of 10:1, and they are co-

taught by both teachers. Ms. Zimmer reported that the school has had much success with this program. All 12 high schools have achieved AYP in mathematics for their general and other populations. Overall in the district, the special education students of the extra seminar class had a pass rate on the state algebra data analysis assessment that was 17 percent higher than the general population for those algebra classes. That is, the group of the special education students actually outperformed the general population.

In addition, she stated that the special education students who were in the extra seminar class had a pass rate that greatly exceeded the pass rate of peer special education students who had not been placed in the extra seminar class, by 36 percent in one school and by 33, 27, 25, and 21 percent in similar schools.

Ms. Zimmer asked the Panel to look for other successful programs focused on equity. She stated that most special education students are not intellectually challenged but they are challenged in many other ways. She feels that mathematics educators have the responsibility to deal with equity, and need to grow and expand their understanding of the deep implications of this principle.

PUBLIC COMMENT QUESTION AND ANSWER PERIOD:

Mr. Williams asked Ms. Zimmer while all of the students took algebra in ninth grade, did some of the students take algebra in eighth grade and then geometry in ninth grade? Ms. Zimmer confirmed that and stated that the school system in question was Howard County Public Schools and that they do have a gifted program in place where a number of the students in seventh and eighth grade take algebra and geometry. They may come into ninth grade taking geometry or they may come into ninth grade taking Algebra II. Mr. Williams asked if that meant they have basically sorted the population starting in seventh and eighth grade. Ms. Zimmer confirmed that. Mr. Williams followed up by asking which test they used as a comparison, and if it was the Maryland State Algebra Test. Ms. Zimmer stated that it was the Algebra/Data Analysis test.

Ms. Jones asked Ms. Zimmer if the growth of the number of Huntington and Sylvan Learning Centers in that area that provide tutoring had any effect on the students studied and whether that was taken into account. Ms. Zimmer responded that she was not aware if that connection was made.

Dr. Reyna asked Ms. Zimmer if the data that she presented was going to be made available to the Panel. Ms. Zimmer responded that she could send it to the Panel.

Ms. Zimmer added that the co-taught classes were classes where there was a lot of professional development for the teachers. The special education teachers were brought up to speed on the content in mathematics, which she finds does not regularly occur and is a problem across the nation.

PUBLIC COMMENT:

CINDY JONES, MATH COACH, LAUREL HILL ELEMENTARY, PROVIDENCE, RI

Ms. Jones is a curriculum coordinator for mathematics in an urban community with a large immigrant and Latino population. In her comments, she described some aspects of professional development in which she has engaged that she feels are very effective.

Since the beginning of Ms. Jones' teaching career, she has always had a love for data. This interest started in 1998 when, in her first year of teaching, Ms. Jones' principal informed her that a Rhode Island Department of Education official was coming to observe her class. The official who came to observe did not revoke her teaching certificate. Instead, the official invited Ms. Jones' to join her workshop.

The next three years, working with the Rhode Island Department of Education Office of Assessment Accountability Teacher Committee, Ms. Jones became sold on the idea of using rubrics to assess students' work, and aligning assessments and what they teach with state standards. She became proficient at using standardized test results to help form her instruction.

Ms. Jones stated that the Standards in Practice model (SIP), which is part of her appendices, has become an essential piece of professional development for teachers, administrators and curriculum coordinators. It encourages colleagues to come together and discuss student work in terms of how the work demonstrates proficiency, the math concepts or grade level expectation and the Rhode Island standards targeted.

Colleagues are prohibited from discussing the individual student, but rather they discuss the work itself. They first assess a group of students' work on their own. Then in a small group, colleagues have discussions regarding the grades they have assigned to each piece of work. When discrepancies arise, colleagues are asked to reexamine the student work and the established grading rubric to come to an agreement. The process allows educators to share ideas and perspectives with one another.

Ms. Jones explained that a typical rubric is usually one through four. One is below proficiency, two is partially proficient, three is proficient and four is proficient with distinction. The use of rubrics has permeated every aspect of the school community. She stated that rubrics are a powerful tool for teachers to judge student work based on what the student is actually able to produce.

Ms. Jones is now a math coach, which allows her to integrate standards and assessment in her practice. She and her colleagues review the New England Common Assessment Program's released items, of which twenty-five percent are released annually by the Rhode Island Department of Education. They align the test items to specific grade-level distinctions and Norman Webb's Depth of Knowledge levels. Then they compare what they have to the release test answer page.

Norman Webb's Depth of Knowledge of Mathematics consists of four levels of proficiency. Level four is the most rigorous type of assessment item. It requires higher order thinking skills than the other three. The New England Common Assessment Program, otherwise known as NECAP, does not assess at level four. The first Depth of Knowledge assessment items at level one may consist of simple recall or recognition of facts or math terms, and application of a well-known algorithm. The other levels require higher-level thinking skills, such as comparing/contrasting. Depth of Knowledge level two involves more comparing/contrasting. Depth of Knowledge level three includes justifying and making conjectures. References to these different levels can be found in her appendices.

Ms. Jones feels that integrating Depth of Knowledge into assessment items makes room for rigorous instruction. As a result, teachers have to go beyond just hitting the surface of math concepts. They have to build the kind of understanding that allows students to make conjectures and draw conclusions. As a result, teachers know they have to spend more time on math concepts and have to introduce them in many different contexts. Ms. Jones would like to see more professional development on the issues she described in her comments.

CLOSE OF PUBLIC COMMENT SESSION

Chair Faulkner led the Panel and audience in a moment of silence for the recent victims of the Virginia Tech shootings. He also read from the governor of Illinois' proclamation in remembrance of the lives lost.

TASK GROUP REPORTS:

TASK GROUP ON CONCEPTUAL KNOWLEDGE AND SKILLS

Francis "Skip" Fennell, Chair; Larry Faulkner; Liping Ma; Wilfried Schmid; and Sandra Stotsky; with contributions from Hung-Hsi Wu.

Dr. Fennell began by restating the questions they are approaching, the first one being, what are the major topics of school-based algebra as they know it? Their analysis includes a review of states with standards for Algebra I and Algebra II courses, the recent grade 12 NAEP objectives, the

Achieve and the American Diploma Project benchmarks, and the Singapore Mathematics Curriculum's end of course test in Algebra II for grades seven through ten.

They are also looking at additional international comparisons and major textbook comparisons, as well, to provide a descriptive analysis relative to "what is algebra." That will be fueled by the research that some of the other groups are working on, particularly the Learning Processes Task Group, as they move into algebra itself.

The Task Group has created a list of major topics of school algebra that will be supported with a research-based discussion they hope will be available at the next meeting in Miami. There will be an appendix containing a brief discussion of algebra, as well as a full elaboration of algebra.

Corollary to the question of "what is algebra" is their second question: What are the essentials, and foundational concepts and skills that lead to algebra? That analysis reviews the mathematics taught in grades K-8 in top-performing Trends in International Math and Science Study (TIMSS) countries.

The Task Group is also looking at the differences in curriculum approaches in those top-performing countries. Using the National Council of Teachers of Mathematics (NCTM) curriculum *Focal Points* as a guide, they are also comparing the mathematics skills and concepts in the six highest-rated state curriculum frameworks. Also to come is a survey of teachers of algebra.

The Task Group at that point will have a draft of the foundations and the essentials students ought to have prior to experiences with algebra. This will not be a full curriculum, but just the elements and critical foundation pieces that lead to algebra. There will be a discussion of those as well and an elaboration on each piece.

The third question is, "Does the sequence of mathematics topics at grade levels prior to algebra affect algebra achievement?" They are reviewing programmatic research on recently developed curricula, benefits of an integrated approach and the role of integrated mathematics in this whole configuration of school mathematics, particularly algebra at the secondary level, and the research on the placement of algebra.

TASK GROUP REPORTS: TASK GROUP ON LEARNING PROCESSES

David Geary, Chair; Dan Berch; Wade Boykin; Susan Embretson; Valerie Reyna; and Robert Siegler.

Dr. Geary recapped that the Task Group last reported a detailed review of what they had done to that point, covering basic principles of learning in cognition, mathematical knowledge children bring to school and math learning in whole number arithmetic. The process at this point on those sections is to take the Panel's comments into consideration, revise the three sections accordingly and bring it to a final draft. As part of those revisions, they will begin to extract policy recommendations.

Between now and June, the Task Group will also be working on a drafted section of the social, motivational, and affective processes. They hope to have a nearly complete section of that to be included with the other three sections for Panel review around the time of the June meeting.

Between the June and September Panel meetings, the Task Group will complete the sections on fractions, estimation, geometry and algebra. The latter two areas may have less work than the other areas, but they will review that and point out areas where there are substantial holes.

For the September meeting, the Task Group hopes to also review differences and similarities across race, ethnicity, socio-economic status and gender in the key areas that are included in their report. They will also have a section on recent work in the brain sciences in math learning and mathematics cognition. During all of these revisions they will be working to integrate the aspects of their report with the aspects of the other three or four task groups.

TASK GROUP REPORTS: TASK GROUP ON INSTRUCTIONAL PRACTICES

Russell Gersten, Chair; Camilla Benbow; Doug Clements; Bert Fristedt; Diane Jones; Tom Loveless; Joan Ferrini-Mundy and Vern Williams.

Dr. Gersten updated the Panel on their approach, including laying out the rules of evidence. Each of the nine questions they are covering will include experimental, high-quality and quasi-experimental studies using criteria very similar to the U.S. Department of Education's *What Works Clearinghouse*.

Other studies the Task Group will review to inform their interpretation of the findings, the framing of the issues and their thoughts about future research will include any other type of quantitative studies, descriptive or correlational studies, qualitative and K studies. They also have a group of tier four studies that are flawed experiments or studies that have some level of problems. They will only mention them with extreme caveats, because the data are not interpretable due to those problems.

Dr. Loveless presented on the first of three topics, which, through a meta-analysis, reviewed the issue of student-centered learning versus teacher-directed learning, considering that as a continuum. The search produced more than 100 studies, and they applied their criteria to screen the literature. The remaining studies were grouped by the common approach or intervention that was tested. The one area that emerged as having a sufficient number of studies to draw some conclusions was cooperative learning and peer-assisted learning.

Dr. Loveless stated that in cooperative learning, one of the techniques studied was team-assisted individualization. This is an intervention that involves putting students into groups of four or five and then giving the students work on particular areas in which they have shown deficiencies. Students then work as a team for a period of time, as opposed to doing individual work. Students are pre- and post-tested.

In these tier one studies that the Task Group is reviewing, students were randomly assigned to both treatment and control groups. In terms of math concepts, the effect was trivial. In math computation, however, there were six studies that produced several pooled effect sizes. The pooled effect size was .340, which is statistically significant, and the p-value was .002. That finding was the most robust finding they found. Dr. Loveless cautioned, though, that the findings do not mean that simply putting students into groups and then giving them math to do necessarily produces results. He stated that these were highly structured interventions. They were not simply testing grouping, but they were testing a particular form of grouping with a specified award structure.

Dr. Loveless reviewed the second area in which the Task Group found sufficient research to perform a meta-analysis, which was student teams achievement division. This is another intervention invented at Johns Hopkins. The Task Group found no significant effect within that area.

In terms of peer assisted learning, again, the Task Group found an effect on computation. This study had classroom-level data, where classrooms were randomly assigned to treatment and control. Lynn Fuchs was head of the research team. The Task Group found a significant effect of 0.441, which is considered to be modest. The p-value of .021 shows that it is statistically significant.

Dr. Loveless stated that the next group of studies did not fall under the definition of the cooperative learning strategy, but did test cooperative learning. The Mevarech study out of Israel, for example, has an effects size of .230 and is also statistically significant. Dr. Loveless explained that students in this study were assigned in pairs to a computer-assisted learning intervention. He described that in one intervention, students worked individually at the computer and received their math instruction. In the experimental condition, the students worked in pairs at the computer and received their instruction that way.

The last category the Task Group looked at is called the mixed approach, which they interpret with some caution because not only was either peer assisted learning or cooperative learning

part of the intervention, but also there were other characteristics of the intervention. Other things were modified. They were not able to isolate cooperative learning or peer-assisted learning and say that was the intervention that produced the positive effect, but these studies should be noted. Dr. Loveless explained that one of these mixed approach studies was done by Busato in the Netherlands. That study had the largest effect of the studies the Task Group reviewed at .634, and that is statistically significant. Another Fuchs study of peer assisted learning is also in that category.

Dr. Gersten explained the Task Group's work on formative assessment, where they found a set of high-quality studies. The first question addressed by the study was, does formative assessment help students? Is math achievement raised if teachers have some assessment of where kids are, and what they've learned or not learned, with some valid measure?

The second question addresses, is it effective for teachers to just collect the raw data and to try to make sense of it and then develop instructional plans? In addition, are enhancements, or specific tools, strategies or procedures, effective in helping teachers interpret and use the data?

The Task Group found ten high quality studies, which is a high number for the education field, and they are all in the elementary grades. The measures used in the studies are both concepts measures and computation measures. Dr. Gersten explained that the technical characteristics of the measures appear to be acceptable, but experts on the Panel are reviewing the content validity.

The type of formative assessment employed in these studies used a sample of the year's state standards to generate test items. The tests were typically given every other week, on the computer and with a random sample of the items. Dr. Gersten noted that this is very different than the way formative assessment is done in most classrooms in the U.S. or around the world. The idea is that this way one can really track growth by using psychometric and technical qualities that are far superior to the typical weekly unit tests. The tests not only indicate what a student learned during the week, but also what they retained and how they are able to apply that knowledge to later lessons. The studies show that this approach works, and while there may be other approaches, there is not the same level of evidence to support them.

Dr. Gersten stated that the answer to the first question is, yes, there is a consistent, statistically significant effect for teachers using random assignment, high-quality designs. These types of formative assessments raise student achievement by approximately a quarter of a standard deviation or ten percentile points.

The second question in terms of these enhancements is that the effect is more or less doubled, but Dr. Gersten stated that it should be known that the studies of enhancement were almost all, with one exception, done with special education students. Dr. Gersten explained the different types of enhancements, which in one study used a computer, after the performance data was analyzed, to identify areas for practice that became the basis of tutoring sessions. Students received help in the areas they needed. Another enhancement in another study did not involve the creation of materials, but the teacher did have a sense for each child and for where the whole class needed help. So again, it was a way to guide time for differentiated or individualized instruction.

In another study, a group of experts, math coaches and math specialists developed ideas to assist students who were having trouble with place value and hundredths and thousandths, but the Task Group thought this approach was too intense for a small group of kids.

The final study involved students monitoring their own progress, where they were involved in how they were doing and identified where they needed help.

The Task Group feels it has a pretty solid basis for making recommendations and they will continue to incorporate the input they have received from the other task groups.

Dr. Ferrini-Mundy gave an overview of the third category, which covers "real- world problem solving." She noted that the notion of real-world problems is encouraged, and used in mathematics instruction and instructional materials. But the term has a variety of meanings that appear in the research and in the discussions by developers.

For example, the Task Group has seen literature on this issue discuss real-world problems as problems that would be meaningful, appealing and motivating for students from contexts that they know, from imaginary situations or from mathematics. Sometimes the discussion focuses more on

what are called authentic problems, or applicable beyond the school setting. Often there is description of such problems as being complex with multiple steps and involving integration of concepts. And the idea of open-ended problems, problems both with multiple solutions and possibly multiple solution paths, are sometimes included in these descriptions.

Dr. Ferrini-Mundy also stated that in the literature, there are many arguments both for and against the various types of real world-problem emphases she just described. She stated that this complicates a review of the research, and currently they are reviewing only 12 studies. Three are quasi-experimental studies that have examined the impact of what she would call full-blown curricula that feature, in some sense, a real-world emphasis. And these studies all have methodological issues, but they are providing the Task Group with some insights and some ways of framing the discussion.

Dr. Ferrini-Mundy explained that they also have nine other studies that look at the impact of various types of instruction using real-world problems and/or instructional strategies that are meant to help students solve real-world problems. These studies also have methodological issues but they are raising important conceptual issues for the discussion.

TASK GROUP ON INSTRUCTIONAL PRACTICES: QUESTION AND ANSWER PERIOD

Dr. Whitehurst asked whether it would be rationalized in the Task Group's report why at some points effect sizes were pooled across a group of studies, and in other cases a positive effect size for one study was highlighted and smaller effect sizes for other studies were left unmentioned upon. Dr. Loveless responded that they pooled when it was clear the intervention was similar across the studies. And in the ones they did not pool they did do so because the interventions were not similar.

Dr. Whitehurst also suggested as a Panel, that they come to some shared understanding as they talk about small, medium and large effects. They need something to anchor those terms. Dr. Gersten replied that they are working on that issue with Mark Lipsey, and agreed that it is an excellent point and one where guidance from any members of the Panel, Institute for Educational Studies (IES) and others would be appreciated.

Dr. Boykin asked about the 12 methodologically flawed studies mentioned in the presentation, and whether there are any kinds of tentative inferences they can draw from them. Dr. Ferrini-Mundy stated that they are working on that, but they have to decide whether these flaws outweigh the findings. Part of the issue, she explained, has to do with the outcome measures, which vary greatly on these kinds of studies.

Dr. Siegler asked Dr. Gersten to clarify the formative assessment process in the studies he covered where students are not only receiving instruction and the teachers are receiving information, but also the computer program in some or all of the studies is generating problems that are designed to remedy the children's learning difficulties.

Dr. Gersten replied that that is only the case in a few of the enhancement studies. But when looking at the whole set of ten studies, there are conditions where the teachers and students receive the data. The smaller set of enhancement studies with the special education students is where they receive additional information for instruction. Dr. Siegler suggested their Task Group consider the older literature on adaptive computer assisted instruction as another way of thinking about formative assessment, because in that case it is not the teacher who is receiving the formative information, but rather the computer program. Dr. Gersten replied that those studies did not come up in the search, but they could look at them.

Dr. Ma asked if the Task Group has any research available about the relationship between real-world problems and regular word problems. Dr. Ferrini-Mundy responded that they have research studies in both areas, but she does not recall that they have any that actually examine the relationship between the two.

Dr. Reyna asked about tier three evidence and their justification for it. She added that at

that level of evidence, qualitative research is certainly a valid scientific method. Dr. Gersten replied that her question is one that the Task Group has discussed and thought a lot about. They do not exhaustively review tier three studies, but if there is a study that, based on either the Panel's judgment or the author's judgment, helps us frame an issue or interpret findings, they will use them. Dr. Reyna followed up by asking if they were using those studies for theoretical purposes. Dr. Gersten replied that they will use them if they help them understand phenomena, patterns or findings. Dr. Loveless added that it will be marked with its level of quality and will be used to generate future hypotheses that could be tested.

TASK GROUP REPORTS: TASK GROUP ON TEACHERS

Deborah Loewenberg Ball, Chair; Nancy Ichinaga; James H. Simons; Hung-Hsi Wu; Raymond Simon; Grover "Russ" Whitehurst.

Dr. Ball reviewed the four questions the Task Group is considering. The first question relates to the relationship between teachers' mathematical knowledge and their students' achievement. The subsequent question is what is known about programs that help increase teachers' knowledge, both pre-service and in-service, including the relationship of what teachers learn in those programs, evidence about what they learn and the relationship to their students' achievement as a result of their opportunities to learn.

The third question concerns elementary "math specialists." Dr. Ball stated that they have been able to determine that they will not be uncovering studies that link the effectiveness of math specialists programs or math specialist staffing to student achievement. But they will explore the range of models that exists, what the differences are among them and what is known about what kinds of qualifications are used to place people into such roles. They also will be looking internationally to understand the ways in which a "math specialist" may be employed in other countries.

Lastly, Dr. Ball stated, the fourth question will be looking at what is known about strategies for recruiting and retaining highly qualified, skilled teachers in teaching mathematics. In these last two areas they will have to look at data and research beyond mathematics teaching to understand what is known about the recruitment and retention of teachers in general.

Dr. Ball reported more fully on question one that looks at the relationship between teachers' mathematical knowledge and their students' achievement. The reasons why this question is so important include that there is substantial research and anecdotal evidence that U.S. teachers' levels of mathematical knowledge are often too low for the work they are being asked to do. There also is a growing trend of increased requirements for U.S. students to take more mathematics, which might speak to an increasing need to have qualified teachers who can deliver that content to a wider range of students. In addition, there is a significant need for qualified teachers to be teaching math.

The Task Group will look at the likelihood that a minority student or a student living in poverty will have a teacher who is either certified in mathematics or has a major or minor in the field. A chart taken from the 2003 *Condition of Education* report shows that minority students or students living in poverty have twice the probability of having a teacher who does not hold a major or minor in the field, or who is not certified in mathematics. Looking at high school and middle school teaching, roughly one in four middle school students is being taught by a teacher who is not qualified to teach mathematics, and the number is one in 10 at the high school level.

When thinking about how to inform policy, one of the basic questions the Task Group is facing is, how does teachers' mathematical knowledge relate to students' learning? But going even deeper, they would have to look at how much mathematics teachers need to know to be effective, what mathematics they have to know and in what ways.

The Task Group faces two basic methodological issues as they review the relationship between teachers' mathematical knowledge and their students' achievement. One is how to measure

teachers' mathematical knowledge and the second is definition of students' mathematical achievements.

Their review of the literature shows three different ways of measuring teachers' mathematical knowledge. The first is teacher certification in mathematics, which is indirectly the result of a test. The second is teachers' educational attainment in mathematics measured either by their degree, a degree in mathematics or levels of course taking. The third is through more direct measures, which can be measures of teachers' mathematics knowledge through the curriculum they have to teach. There is not as much research in the third area, and it is less indirect than the first two.

For students' mathematics achievement, they continue to look at high-quality longitudinal data on students' performance using pre-test controls.

Dr. Ball then reported what the Task Group had learned about the three ways of measuring teacher knowledge: teacher certification; course work; and direct measures. For the effect of teacher certification in mathematics on student achievement, she reported that there are three issues that they uncovered in the studies they examined. First, teacher certification is an inexact measure of what teachers actually know. They found some substantial problems of selection bias in these studies, as well as what is actually called certification. These concerns aside, the effect of teacher certification still remains somewhat ambiguous. Of the other studies that met their quality standards, four of those showed a positive effect of teacher certification on students' learning and four others showed no effect. The Task Group will be looking more closely at what the specific certification requirements are, particularly at the middle school level, and the studies that compare teachers with different kinds of certification.

Dr. Ball then reported on what the Task Group has learned about teachers' mathematical study. They are reviewing teachers' college-level mathematics study, keeping in mind that course taking is not a direct measure of what someone knows. The courses taken may not correspond very closely to what teachers actually teach. The content of the courses for a math major, for example, do not align closely with the content of the high school curriculum. But there are more consistent findings on this question than seen in the certification studies. Of the nine studies that met the criteria for high-quality research, seven of those showed a positive impact of teachers' course taking or level of attainment on student achievement. One showed no impact and one showed negative impact. But most of those studies focused on secondary school students, and no evidence was found that related teachers' course taking at the college level positively affecting student achievement at the elementary level.

The third area the Task Group is examining is more direct measures of teacher knowledge using tests of some form. While some of these methods may be closer estimates of what teachers actually know, some of these measures have not been validated and few studies were found that measure them. Of the eight studies that looked at this third area of study, five met their standards. Two of those showed positive effects that were significant. One showed positive effects, although not statistically significant. And two found more ambiguous results. There is support that teachers' mathematical knowledge has a positive impact on students' achievement.

Dr. Ball stated that while they can state that "knowing" mathematics is likely a significant factor in teaching effectively, "knowing" is in quotes because none of the studies come close to the notion of what somebody should know and in what way to teach well. They also do not know from a policy perspective how to increase and improve teachers' knowledge, how teachers' knowledge effects the quality of students' learning or how much course work makes a difference at different levels of schooling.

In conclusion, Dr. Ball summarized where the research gaps exist, including the need for better and more reliable proximal measures of teachers' actual mathematical knowledge, better ways to understand how the teaching of mathematics demands mathematical knowledge so that they can target the research they are doing in a more focused way on the actual mathematical demands of the work. They also would like to see studies with better designs that would permit stronger causal inferences.

The next step for the Task Group is to gather better details about certification requirements

including not only what is required to get certification, but also what are the assessments, the cut scores and the nature of the mathematics asked on some of those tests. They also are going to look more closely at teacher qualifications at the middle school level, who is teaching middle school, and what the requirements are. They hope to report on questions three and four at the June meeting and question two by the following meeting.

TASK GROUP ON TEACHERS: QUESTION AND ANSWER PERIOD

Dr. Benbow asked whether there is no evidence assessing the importance of mathematics for elementary teachers' effectiveness, or was it that there is evidence but that it is showing no effect. Dr. Ball clarified that the course work studies do not show an effect of course work on teachers. But in the third grouping of direct measures, one of the high-quality studies showed a significant effect at the first grade and third grade level of teacher's mathematical knowledge.

Dr. Clements asked about the third question on math specialists, which speak to instructional effects rather than pure math knowledge. He wondered whether there had been any discussions similar to Shulman's seminal pedagogical content knowledge versus content knowledge work and whether the Task Group will look at the former. Dr. Ball stated that they have not yet found studies that examine the effects of math specialists. If they were to design a study, they would want to know what effect there is on instructional practice or student learning from having math specialists. Dr. Clements added that he wanted to know if the Task Group will look at instructional issues, in addition to the mathematics content knowledge issues in their presentation. Dr. Ball stated that they are open to looking broadly at what is defined as mathematical knowledge, but most of the studies are looking at content knowledge measured rather narrowly. It will have to be one of the recommendations of the Panel for future research to look more broadly. They will attempt to do some of this through the intersection with the Learning Processes Task Group, to understand how knowledge of students' learning of math might affect teachers' effectiveness.

Mr. Williams asked whether the Task Group had compared the number and types of K-12 math courses taken by teachers in some of the high scoring countries with teachers in the United States. Dr. Ball stated that they should do that.

Dr. Schmid asked if the Task Group will look at the effects of professional development or if this will be done indirectly through assessing content knowledge of teachers. Dr. Ball stated that their second question, which they have not yet reported on, will examine programs at the pre-service level and professional development intended to increase teachers' mathematical knowledge. And they will be looking to see whether and how they affect increases in teachers' knowledge and their effectiveness. Dr. Schmid followed up by asking whether in their review of retention of teachers if they will look at the question of differential pay for mathematics teachers. Dr. Ball stated that, yes, they will look at differential teacher pay.

Dr. Loveless asked if the Task Group had done anything with these studies to pool their effects, or applied any analytic techniques to understand the size of the effects overall, and whether or not they are statistically significant. Dr. Ball responded that they are still trying to find a way to do that. Dr. Loveless also asked whether the literature addressing the question about college-level courses differentiates between courses taken in math education as opposed to mathematics departments. It was mentioned earlier in a presentation on TIMSS that the United States is an outlier in terms of eighth grade algebra teachers, showing that most U.S. algebra teachers in eighth grade received their math education in a school of education. Around the world, most eighth grade algebra teachers received their education in math departments. Dr. Ball stated that there are several questions there, including where the math courses are housed, what the effects are of course taking and math methods, and what the middle school requirements are. The Task Group will try to address the "where" question by asking these other questions.

Dr. Stotsky asked if when they look at pre-service programs, will they look at student teacher issues, such as placement, and evaluations and what those look at in relation to mathematics

knowledge as opposed to mathematics teaching. Dr. Ball stated that they will be looking into what programs actually are, as opposed to simply looking at programs and whether they have effects, as this will likely offer clues about preparation.

Dr. Wu stated that one of the main issues within the Task Group's question one is to pin down the nature of the knowledge teachers need to teach. Dr. Ball agreed and said that their Task Group may form hypotheses based on their judgment.

TASK GROUP REPORTS: TASK GROUP ON ASSESSMENT

Camilla Benbow, Chair; Douglas Clements; Susan Embretson; Francis "Skip" Fennell; Bert Fristedt; Tom Loveless and Sandra Stotsky.

Dr. Embretson reported that the Task Group recently had its first meeting, and their main charge will be to determine the correspondence of National Assessment of Educational Progress (NAEP) fourth and eighth grade tests to selected state accountability tests for validity in assessing mathematics proficiency. Looking at validity, four aspects are particularly relevant for comparing NAEP to state accountability tests, and these are content validity, substantive validity, consequential validity and generalizability.

Tests are constructed with blueprints that outline topic areas, which create the content validity of the test. The substantive aspect has to do with the underlying processes and theory about what is going into solving the test items, which will be informed by the Learning Processes Task Group and will help define the nature of what is tested by particular items. Test items can be formed on the same content topic in many different ways and can involve different processes required by the students. Consequential validity is the impact of the test on defined categories of groups of people such as gender, racial ethnicity, English as a second language or disabilities. Generalizability looks at the impact of some features of testing that may impact score levels, such as whether or not the test was presented by computer or paper and pencil, and whether or not the questions are given in multiple choice format or through a constructive format.

Dr. Embretson outlined the possible differences between NAEP and the state tests: 1) the weighting of content between and within sections of each test; 2) the cognitive complexity of items between NAEP and state tests; 3) the empirical difficulty of items that measure the same content; 4) the use of tools, including calculators and manipulatives; 5) the test delivery mode (e.g. the differences between computer-based versus paper and pencil tests; 6) the representation of items on NAEP versus the state tests (i.e. formats ranging from true/false, multiple choice, constructed response, work problems).

These possible differences represent their comparison variables, and the Task Group will examine proportional representations of content from test blueprints where they hope to find more information about cognitive complexity and conceptual skill level of actual items. They will select a subset of states for this review.

Within the six questions that will help determine differences between state tests and NAEP, the Task Group will first determine what will go into the measures of cognitive complexity and empirical item difficulty. Within tool inclusion and test delivery mode, they will work to understand what their impact is.

TASK GROUP ON ASSESSMENT: QUESTION AND ANSWER PERIOD

Dr. Schmid asked from the questions they have outlined, what kind of policy recommendations do they think they might be able to make, depending on what they find. Dr. Embretson stated that it would be hard to say at this point, as they do not know the status of this relationship. Dr. Schmid added that the U.S. Department of Education has commissioned a study of the validity of NAEP, and that he has been involved with that effort. He stated that questions about validity are very difficult questions to answer about NAEP alone. Dr. Embretson stated that the Task Group is doing something different in that it is looking at the bigger picture, in the content validity area and the proportional representation of items. The Group is not going to check the reliability of the categorization of items in the various areas, as in the larger NAEP study, nor check validity from the perspective of mathematical principles. Dr. Schmid asked whether creating policy recommendations would require them to determine whether NAEP was a reliable measure, and then determine how well the state tests track that measure. Dr. Embretson agreed with that, and said the Task Group will look at other features of NAEP, as available in the literature.

Dr. Whitehurst asked about the overall purpose of the exercise in which the Task Group is engaged and how it will inform matters before the Panel. He also encouraged the Task Group to become familiar with the NAEP studies that exist or are underway at the U.S. Department of Education to avoid duplication. He added that another area of interest would be the relationship between what is being assessed in this country, whether it through NAEP or state tests, versus international assessments. Dr. Embretson responded that early in the stages of this new Task Group, the belief is that the state tests are closer to teaching than NAEP, because there are more consequences attached to the state tests. They will examine the content of state tests to determine the factors that might be changed.

Dr. Loveless stated that the Task Group is looking at NAEP because it is considered the national report card and the most important test that represents U.S. student performance. They included state tests because those are the tests in all 50 states as required by No Child Left Behind. Those test results have consequences for schools.

Dr. Whitehurst responded that he agrees that the Panel should address what is being assessed with NAEP and what is being assessed at the state level. But he does not understand the framing of the Task Group's question and how it will generate answers that are relevant to policy concerns. Specifically, he would like to see the relative difficulty of state tests versus NAEP tests in defining proficiency. Dr. Embretson said the Task Group will look at that available data.

Dr. Wu stated that it would be important to look at whether NAEP is measuring the right thing, particularly since the Panel's charge talks about student achievement in mathematics lagging behind international standards. Dr. Loveless responded that the U.S. Department of Education has conducted one study comparing NAEP and TIMMS, but what would be good to look at is a comparison of NAEP to other nation's national assessments

Dr. Whitehurst responded that there are studies that, for example, draw conclusions about how many students in Singapore would be judged to be proficient on NAEP by cross walking results on international assessments, and he asks the Task Group to look at those findings.

Dr. Boykin stated that the Executive Order explicitly says this particular Task Group should address the role of assessment in promoting math proficiency. He asked if that is something that will be directly addressed. Dr. Embretson stated that by their nature, tests are involved in math proficiency and its promotion. But their concern is with validity in terms of what is being assessed.

Dr. Siegler asked if the Task Group could predict what the state versus state and state versus NAEP comparisons will yield and whether there will be overlap. He feels they will find a set of descriptive results where it will be extremely difficult to make recommendations regardless of the findings. International comparisons strike him as a more potentially promising way to go. Dr. Embretson stated that the Task Group feels that a good outcome would be to see how the results interface with the other concerns from the other task groups. They hope to draw some conclusion

about the definition of proficiency.

Dr. Reyna stated that the notion of computation skill versus conceptual understanding is a theme that is beginning to emerge across the different subgroups, particularly in Learning Processes and Teachers. Dr. Reyna asked whether the Assessment Task Group will look at whether tests assess computational skills, conceptual understanding or both. Dr. Embretson stated that they will look at that question in relation to complexity level. They are not sure yet whether that can be reliably assessed. They will start with a review of NAEP, which would be a smaller set.

Dr. Stotsky stated that some of the questions the Task Group will try to make a little clearer will be how state assessments drive instruction, how they change instruction, and if there's any research or literature available, how they drive teacher training and professional development. She feels there is a lot more that can be put into this study beyond what its relationship is to NAEP.

Dr. Ball asked whether the Task Group will take up anything about teacher assessment. Dr. Embretson stated that the Task Group had discussed that, but at the moment it is not on the list. Dr. Ball replied that it would be good for the Teacher Task Group and the Assessment Task Group to talk because the Teachers Task Group is looking at the psychometric quality of the measures being used to assess teachers' knowledge. Dr. Embretson stated that the student level may consume most of their time.

Ms. Jones asked, in relation to the definition of algebra, if it would be useful to compare current eighth grade data with post-Sputnik generation (e.g. Iowa, Stanford) data to test algebra competency then versus now. This may satisfy some of the questions about changes in perception about what constitutes algebra and algebra standards. Dr. Embretson agreed that it was a good question and they can look at long-term NAEP to see some of that. Dr. Fennell replied that the Conceptual Knowledge and Skills Task Group is addressing that question as they review curriculum frameworks and textbooks, but not assessments, at least in the United States.

Dr. Embretson stated that the Assessment Task Group is open for suggestions. They in particular will look at patterns and estimation in algebra and their representation on tests.

Dr. Ferrini-Mundy asked, in reference to looking at computational skill versus conceptual understanding, whether real-world problems might be included within the complexity level discussion. She recommended that Instructional Practices and Assessments work together on what they have seen and some definitions.

Dr. Schmid stated that looking at various tests, meaning the tests themselves and not just the outcomes, might be too broad a charge for the Task Group. He suggested that they take a hard look at data that exist or are being generated about NAEP, including comparisons of NAEP to TIMMS, and to other international tests. Dr. Embretson agreed that may be the case.

Vice Chair Benbow stated that this is a very important question and that they will make sure they prioritize the right parts of it.

Vice Chair Benbow thanked the public for attending and listening to the Panel. She announced that the next National Math Panel meeting will be hosted by Miami-Dade College in Miami, Florida on June 6th 2007.

The session adjourned at 12:11 p.m.

I certify the accuracy of these minutes.

Chair Signature _____ Date _____

Vice Chair Signature _____ Date _____

ADDENDUM: PUBLIC PARTICIPANTS

First Name	Last Name	Organization
Anna	Belluomini	McGraw-Hill/Wright Group
Judy Ann	Brown	Words & Numbers
Alison	Castro	Fermilab
Cathie	Dillender	Pearson Scott Foresman
Dawn	Dolby	Learning Point Associates
Dr. Becky	Gill	Hough Street Elementary
Melissa	Kalinowski	PLATO Learning
Michael	Lach	Chicago Public Schools Medill Professional Development Center
Elizabeth	Lehnertz	Pearson Prentice Hall
Kathleen	Pitvorec	University of Illinois at Chicago
Bror	Saxberg	K12, Inc.
Timothy C.	Schell	Waunakee Community School District
Mark	Schmit	ETA Cuisenaire
Mary Jo	Tavormina	Chicago Public Schools Medill Technical and Professional Development Center
Mary A.	Thomas	Hoffman Estates High School
Anna	Vilcheck	Pearson Education
Jennie	Winters	Lake County Regional
Barb	Youngren	Great Lakes East Comprehensive Assistance Center
Wendy	Zachrisen	Learning Resources
Rima	Binder, Ph.D.	Hands-on Equations/Borenson & Assoc
Cindy	Jones	Laurel Hill Elementary
Patrick W	Thompson	Dept. of Mathematics and Statistics/Center for Research on Education in Science, Mathematics, Engineering, and Technology
Kevin	Killion	The Illinois Loop
Jack	Rotman	Department of Mathematical Skills
Ken	Indeck	IAGC (Illinois Association for Gifted Children)
Sara Delano	Moore, PhD	ETA/Cuisenaire
Barbara	Wilmot, Ph.D.	
Janie	Zimmer	National Council of Supervisors of Mathematics (NCSM)
Ken	Mullen	ACT
Spencer	Pasero	Fermilab
David	Whiting	McGraw-Hill
Ruth	Lubawy	Pearson Scott Foresman
Ruby	Hogan-Chin	Pearson AGS Globe
Karen	Usistein	Pearson Scott Foresman
Rosi	Marshall	Pearson Scott Foresman
Tom	Super	Pearson Scott Foresman
Susan	Dahl	Fermilab