

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

October 24, 2007

SUMMARY

The National Mathematics Advisory Panel met in open session at the Memorial Union Alumni Lounge, Arizona State University, Room 202, Tempe, Arizona, on Wednesday, October 24, 2007, at 8:15 a.m.

PANEL AND EX OFFICIO MEMBERS PRESENT:

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DR. LARRY FAULKNER	Chair
DR. CAMILLA PERSSON BENBOW	Vice Chair
DR. DEBORAH LOEWENBERG BALL	Member
DR. A. WADE BOYKIN	Member
DR. DOUGLAS H. CLEMENTS	Member
DR. SUSAN E. EMBRETSON	Member
DR. FRANCIS (SKIP) FENNELL	Member
DR. BERT FRISTEDT	Member
DR. DAVID C. GEARY	Member
DR. TOM LOVELESS	Member
DR. LIPING MA	Member
DR. VALERIE F. REYNA	Member
DR. WILFRIED SCHMID	Member
DR. ROBERT S. SIEGLER	Member
DR. SANDRA STOTSKY	Member
MR. VERN WILLIAMS	Member
DR. HUNG-HSI WU	Member
DR. IRMA ARISPE	Ex Officio
DR. DANIEL B. BERCH (VIA PHONE)	Ex Officio
DR. JOAN FERRINI-MUNDY	Ex Officio
DR. GROVER J. (RUSS) WHITEHURST	Ex Officio

PANEL AND EX OFFICIO MEMBERS NOT PRESENT:

DR. RUSSELL M. GERSTEN	Member
DR. JAMES H. SIMONS	Member
MR. RAY SIMON	Ex Officio

DEPARTMENT OF EDUCATION STAFF PRESENT:

TYRRELL FLAWN, EXECUTIVE DIRECTOR
MARIAN BANFIELD
HOLLY CLARK
JENNIFER GRABAN
IDA EBLINGER KELLEY
JIM YUN

CALL TO ORDER:

Chair Faulkner called the second day of the Phoenix National Mathematics Advisory Panel meeting to order. He asked if there was a need for signing services, and there was none. He introduced Michael Crow, the 16th president of Arizona State University (ASU). Under President Crow's direction, the university's teaching, research, and creative excellence focus on the major challenges and questions of our times, and those central to this region. Since he took office, ASU has marked a number of important milestones, including the establishment of major interdisciplinary research initiatives, such as the Biodesign Institute, the Global Institute for Sustainability, and the Metrotechnology Works, a program of integrated science and technology for large-scale applications. Under Dr. Crow's direction, ASU has initiated a dramatic research infrastructure expansion to create more than one million square feet of new research space.

MICHAEL CROW, PRESIDENT, ARIZONA STATE UNIVERSITY

President Crow stated that the school, the state, and education are in a period of intensive re-conceptualization. The state has a P-20 Council that will recommend a number of things, such as Algebra II as the minimum math skill for high school graduation and 4 years of high school math for graduation from high school. That will require the school to add or produce 400 new math teachers. The school currently certifies 1,600 teachers a year from their three educational preparation platforms.

In 1925 ASU offered no degrees, they only certified teachers. They offered nothing outside of education until roughly 1960. They had no funded research until 1980. They were Research I in 1994 and they have more than doubled their research enterprise twice since 1994.

The school is driven by three words, and the first two are academic excellence. They are exploring new areas with new schools in Earth and Space Exploration, which merged geology, astrophysics, astrobiology, and astronomy and systems engineering; Human Evolution and Social Change; Family and Social Dynamics; Sustainability. For ASU, excellence means designing what they need, versus what someone else designed in the past.

The third word is access. Because they are a Research I university, people have told them to cut out the bottom level of students. That will be the last thing they do as they will be the one university where they actually can have an outstanding faculty of the first rank engaged in research-orientated programs and curricula, while having egalitarian admission standards.

With their 9,400 freshmen, they guarantee financial access. If a student comes from a family from below \$25,000 a year in income, he or she pays nothing to attend ASU. They do work-study. If he or she comes from a family of under \$80,000 family income, they pay no tuition. ASU and federal grants pay the tuition.

In addition to financial access, they also look at intellectual access. ASU has a Polytechnic Campus where they are building a second engineering program. One school will be a modeling and research-oriented school, and the other school will be completely learning by doing, a studio-focused engineering school. This second program works for

students who came out of K-12 without strong math skills, but who are spatially and tactically intelligent.

They have built three education school platforms: one with a leadership curriculum; one with a teaching, math, and science curriculum; and one with a traditional curriculum. They did the same thing in business, and this is all to broaden access.

ASU did away with all campus infrastructure and leadership, and created one university where the different campuses are only separated by their addresses. There's no provost or chancellor, only deans of the 23 colleges. Each of the 23 colleges has a niche and a mission. They have tried to eliminate the social hierarchy from within the enterprise.

President Crow stated that the work of the Panel is extremely important to ASU, because they look at math preparation and math skill as essential to the evolution of this region. They have highly variable levels of preparation and huge cultural barriers to math in families, in communities, and in entire school districts.

OPEN SESSION:

NATIONAL MATHEMATICS ADVISORY PANEL: SECOND COMMON CONCEPT PAPER DISCUSSION

Chair Faulkner described the goals of the rest of the session and that he hoped to discuss each part of the document. That might mean that they will not be able to take every discussion until it reaches a natural end. They will identify all the major contended points and ideas and then continue the discussion by e-mail and other means. But he states the Panel does need to visit everything.

Chair Faulkner began the discussion with the fractions section, and then sections 4 to 9 in the Learning Processes portion of the report. He asked if there were comments on A through I in Section 4.

Dr. Geary pointed out Section I under fractions, relative to estimation of the magnitude of fractions and so forth. He suggested that it may go under number sense as they reconfigure that.

Dr. Stotsky suggested that Section I begin as a research recommendation and go in another section. Chair Faulkner stated that all the important recommendations would be gathered in one place, at least in the executive summary.

Chair Faulkner then moved to the sections on geometry and measurement, and their three points, A, B, and C.

Dr. Fristedt stated that the section on geometry is there to focus on aspects of geometry that can build towards algebra, but alone, it gives a very unbalanced view of what geometry is. He thinks the Conceptual Knowledge and Skills (CKS) document makes that point a little bit.

Dr. Schmid stated that some of these paragraphs are closely related. For example, A is not consistent with what's in the CKS report. What is said in this report has to be said much more carefully and be in line with what is in the CKS report.

Chair Faulkner stated that the language is going to be brought out of the working papers.

Dr. Clements stated that given that it's not the language, his point might be postponed, but in B, he wouldn't agree that students must eventually make the transition from concrete or visual representations to internal abstract representations. He does not believe this is a valid statement for geometry. Geometry never loses its spatial nature. He thinks that this could be misconstrued as the abstractions leave aside that kind of thing. Dr. Reyna stated that they can just take out the word "abstract" and put "internalized representations," to fix the problem. Chair Faulkner took out "abstract." Dr. Wu stated that it's not a matter of the flow of ideas, but rather what the emphasis is on for learning algebra. Dr. Benbow stated that they would use the most current versions of the documents to create the reports.

Dr. Wu stated that the point he's trying to make is that he is sure at some point they will have to condense the language to create a 30-page document.

Dr. Ball asked whether the report will discuss definitions. She would think part of the point was for students to develop definitions of these shapes, not to be relying purely on visual images, which is one of the historical problems they've had. Dr. Geary stated that they do not. Dr. Wu stated that the most important thing for the learning of algebra is to understand the concept of slope, equation of straight lines, and the correlation between equation and a straight line. For that purpose, there's a great emphasis on how to define slope correctly. The general learning of geometry was considered a little beyond what CKS dealt with. Dr. Schmid stated that the way CKS was written, it was clear that they were talking about the aspects of geometry that are important to algebra.

Dr. Siegler stated that with regard to Dr. Wu's point about points B and C, he thinks that point C actually should be moved to the General Principles of the Learning Processes section, because it doesn't just apply to geometry, it also applies as the statement already says to algebra and other mathematical skills. With regard to B, he thinks there's a specific reason to include that. It is a very widespread view among educators that these manipulatives somehow inculcate an understanding of geometry, but the evidence just is not there.

Dr. Boykin stated that it is important to take out this issue of distributed practice as superior to open math practice and put that into the General Principles section.

Dr. Fristedt stated that they might create a much better document if at certain places they would go back to the original full reports.

Chair Faulkner stated that the next section, Benchmarks, was covered yesterday and they are moving that up. They also talked about Social, Motivational, and Affective influences. The next section for discussion is the Integrated Curriculum Versus Single Subject approach.

Dr. Schmid stated that there is no discussion of practice in foreign countries, and many of the proponents of integrated curricula point to foreign countries. It is very important that the comparison with foreign integrated curricula be included here. That is done in the CKS report.

Dr. Loveless added that the people who often point to the high achieving nations that have an integrated curriculum often leave out that the lowest scoring countries at the bottom of the distribution also have integrated curriculums.

Dr. Fristedt stated that the word "integrated curriculum" bothers him because publishers have taken that name on and they characterize their own materials with that adjective. But in many cases, that adjective does not fit.

Dr. Stotsky asked, in terms of coherence, whether this whole topic would belong better under discussion of textbooks. She does not know exactly where it fits in terms of what they have been discussing. Dr. Benbow stated that curriculum, integrated versus single subject curriculum, is a bigger decision than just the textbook. One also has to make a decision about which approach one is going to use, and then textbooks are selected.

Dr. Wu emphasized the fact that any time they mention independent curriculum, they have to make sure that it's understood that this term is used in the foreign countries different from the way it in the United States. Chair Faulkner stated that there is language in the CKS document.

Dr. Fennell stated that he agrees with Dr. Schmid, but the issue is broader than textbooks. There are states now that are suggesting that their state frameworks at the high school level are integrated, and so he thinks it stands on its own somewhere.

Dr. Siegler stated that if they have this in the Learning Processes section, all they could possibly say is that there isn't research to say anything, because there is no research on the effects on learning here. The international comparisons, unless they have a correlation between whether there's an integrated or segmented curriculum and students learning, it's impossible to draw a recommendation either way. There are logical arguments on either side of a position. He would either leave it the way it is or move it away from the Learning Processes section because they can't rely on the research.

Chair Faulkner asked whether it was a question of learning and whether they are interested in an integrated curriculum because it facilitates learning. Dr. Siegler stated that it is fine to leave it there, as long as they are not coming out on one side or the other, because the learning research certainly does not entitle them to do that.

Dr. Fennell stated that he sees it as a delivery issue, more than a learning issue. He thinks it's an attempt to take what someone has defined as appropriate mathematics for these levels, and package it differently. Dr. Faulkner asked if the motivation is for students to learn better or to save money. Dr. Schmid stated that the Conceptual Knowledge and Skills group discusses this question and there are no obvious arguments either way and that needs to be said. Then there is the question of where D belongs, augmented by a discussion of practices in foreign countries.

Mr. Williams asked if the very last sentence wasn't a recommendation to change. It states that integrated math does not cover as much material. Chair Faulkner stated that that was a single case study in a single state.

Dr. Stotsky stated that on the basis of some evidence, there needed to be a better qualification than has been in several versions of this document. On the placement issue, she wonders whether this and the next one belong right after the introduction of the Major Topics, because that is thematically what they relate to. The Conceptual Knowledge and Skills report deals with the issues of algebra and above. It's not about development before algebra. This issue may logically follow at this point, for lack of any other place, not as a Learning Process issue, but as a curriculum issue relating to algebra itself.

Dr. Loveless stated that they both have to do with course taking, and how mathematics is packaged into courses. So they may have a section called course taking, and A is point 8 and B is point 9.

Dr. Fristedt suggested removing that item.

Chair Faulkner moved on to the next section, which one of the teams wanted to move out and other teams didn't. He asked the Panel's thoughts on the availability of Algebra I for Grade 9. Dr. Schmid stated that if this is included, there has to be very careful language about what it means to present Algebra I before Grade 9, and that there are very serious issues of preparation. Dr. Loveless stated that he likes this language better than the language of earlier versions because the earlier versions dealt with having states provide incentives for schools and school districts to offer a course.

The problem is that they could just as easily wish that all students take calculus by Grade 2, but what happens with these wishes when they're converted into policy is they create perverse incentives. The District of Columbia had mandated that all students take an algebra course by Grade 8. National Assessment of Educational Progress (NAEP) tests show that the District of Columbia scored at the very bottom of all 50 states and the District on math even though all 8th-graders were taking algebra. They will not necessarily see the results they think they will because there's no one out there to police the authenticity of these courses.

Dr. Benbow stated that there is another danger on the other side, too. People could say that no one should have algebra before 9th grade and that would be a very damaging situation. She thinks they need to have algebra by the 8th grade for some, not all students, and even 7th grade for some, but even fewer students. But the issue has to be that the students have to be ready for it, well prepared, and that the course has to be a rigorous course that we would accept. It shouldn't be a watered down course to have it at 7th grade. That would be self-defeating. Many countries touch on real algebra before 9th grade. If students don't get algebra before 9th grade, they are precluded from getting calculus in high school, and that precludes many career options.

Chair Faulkner stated that the Conceptual Knowledge and Skills language covers all of that.

Mr. Williams stated that he thinks it should be offered at Grades 7 and 8. However, when they start mentioning large numbers of students taking it, it takes on a different meaning, and they end up having teachers pressured to do grade inflation, because they have these students who are not really qualified, but on paper it makes the school system look good. So of course it should be offered in middle school. But to state that large numbers of students should take it, more students are going to be put into a course who shouldn't be, who aren't ready, especially if it's an authentic course.

Dr. Fennell stated that he supports what Mr. Williams said and that there are more and more students in this country doing something called algebra at the grade levels that Mr. Williams teaches every day. So he thinks the words that refer back to those Critical Foundations are essential as prerequisites in here. Dr. Fennell also likes the sort of soft revision that says, "professional judgment supports the value of preparing students to complete," and then deleting the phrase "larger numbers of" so you do not get into a legislative dictum of all students doing Algebra I by Grade 8, whether that's a statewide or a school district decision. It would require course taking without the prerequisites to do so.

Dr. Loveless does not support offering either as an option because many buildings do not have teachers who can teach this course. What they will wind up doing is creating the course first, without a teacher who can teach it. He did a random survey of algebra teachers across the country in middle school, and the percentage of them who had any

kind of degree in mathematics was abysmal. There is already a problem with teachers in middle school who really have not been grounded in teaching algebra. If the Panel instigates a mandate that every school that has a 7th grade needs to offer algebra to 7th-graders, or even to 8th-graders, they are going to exacerbate that problem. He proposed that the language be something more general such as, "We think more students should be prepared for an authentic algebra class at an earlier age as currently happens."

Dr. Stotsky stated that there are not many elementary teachers in Grades 6 and 7 who can properly teach what they are teaching. Would we suggest that therefore we couldn't offer material on slope, ratio and proportions because we don't have teachers who are prepared to teach it properly? No. The point is, we know we have problems with teacher preparation. One of the later suggestions is to try to improve the preparation of teachers so that they are capable of teaching what we think should be offered, and which apparently many other countries also offer. The question is if other countries can offer this course legitimately, why shouldn't we be able to offer the course? There's no mandate, and the wording of the original as Chair Faulkner has suggested is much more carefully worded than this which has a lot of qualifications.

Dr. Boykin asked what the necessity was for including experience as a form of evidence in this particular claim. The Panel typically haven't talked about experience as a source of evidence. Chair Faulkner stated that the language actually says, "from research results, experience in other leading countries, and professional judgment."

Chair Faulkner then moved the discussion to the Teachers section. Dr. Loveless pointed out that, in section A, those studies actually show 12 to 14 percent of total variability in students learning, not in their gains, because many of them didn't gain. Since in the studies many of the test scores go down, they didn't have any gains. It is the variability in their scores, not in their gains. So why not call it students' learning, students' test scores, mathematics learning, or mathematics achievement. It's about change as opposed to gains.

Dr. Siegler stated that he has concerns about including point A for two different reasons. One is giving a parameter estimate here, which the Panel does not have. It's not based on a huge database, and whether a new study that examined the same thing would get 12 or 13 or 14 percent is highly questionable. The second point is that including the numbers will actually have the opposite effect of what is intended.

Dr. Whitehurst stated that there is a substantial body of research. Larry Hedges has reviewed it and capped it off with an examination using the Tennessee class size experiment data involving randomized trials. The variance accounted for here is a well-founded estimate based on the strong randomization study using the data and then looking at the meta-analysis of weaker studies. It all came to estimates within this same area. One of the comments from reviewers of the Teacher Task Group material was the importance of providing some anchor for what large gains mean. The second sentence here talks about a 10 % difference over the course of the school year. His feeling is that they need something other than just a vague adjective to talk about the importance of this.

Dr. Boykin had a question to those who know this database. These are generic statements about students in general. He asked if these numbers vary as a function of students' ethnic background. Dr. Whitehurst stated there are some racial and ethnic differences there, but they don't change the overall point and they're not particularly large. Dr. Boykin stated that it might relate back to earlier points scattered in the ethnic

and racial differences section, because his suspicion is that these numbers might even be higher for black and Latino children. Dr. Whitehurst stated that they are higher. Dr. Boykin stated that it might be worth pointing out in the report.

Dr. Schmid asked if it would be possible to make the point of the importance of this phenomenon without giving numbers but by saying that it is a larger effect than almost any other variable in schooling curriculum or textbooks, for example. Dr. Whitehurst stated that he was okay with that. However, he does like the second point because it's so specific, that over the course of the school year, there is a 10 % difference in achievement from being in the classroom of a higher-performing versus a lower-performing teacher. Dr. Siegler stated that Dr. Schmid's solution is an excellent one. People do understand what percentages mean.

Dr. Ball stated that they have a section at the beginning of the Teachers Task Group report that was independently reviewed. They need to find a way to write it in a way that might help the common reader understand that this is really an important point to preface what they are doing.

Dr. Fennell stated that on line 403, "More needs to be known," is an opportunity to talk directly and strongly about the need for research about professional development and the impact of professional development. What they need to see in the text is the statement that then merges into a lengthy statement on professional development and then picks up the issue of math coaches. That needs to be separated out.

Dr. Schmid asked if that was the only place marker for comments about professional development and if so, more should be said for the intended audience. Much of the audience really doesn't have a full understanding of how large an industry professional development is and how much money is spent. There is very little or no evidence that this money is being spent efficiently.

Dr. Ball stated that it might help to go back to the Teacher Task Group report where there's more detail about the whole teacher education section. They want to say something about teacher education more generally. This is not only about professional development, but also preliminary preparation of teachers and induction.

Dr. Stotsky asked a question on C, on line 395. It wasn't clear to her whether this was one study or more than one study that was being referred to. This is one of the issues in Standards of Evidence that has been discussed. Dr. Whitehurst stated that they are all cited in the work group paper and they cite three. Dr. Stotsky suggested they should make sure there is indication of the base of studies from which the statements come. She agrees with Dr. Fennell about the professional development issue, and with Dr. Ball about separating that out and having earlier statements on what the research does tell us about teacher preparation. She also agrees about separating out recruitment, which is muddled with retention.

Dr. Siegler stated that the language between 403 and 413 has an implication that he does not feel is justified. There is a presupposition built in that professional development really does work and we just don't quite have the evidence to know exactly how it works. So, for example, when we say more needs to be known about professional development of teachers that equips teachers with the knowledge and skills they need to facilitate student learning, it implies that it's a good thing and we need to know more about it. He's not sure that there's evidence that that's true. Similarly, in 410, although professional development may lead to some positive effects on students learning, there's

not sufficient evidence to clarify which forms or approaches to professional development are most effective. Again, it's saying it probably is a good thing, but they don't know the details.

Dr. Ball replied that it's not a normative statement about anything one might think of as professional development, but the Panel can't conceive a profession or an occupation in which people don't get training to do the work. We need a system in this country that reliably equips an enormous population with the skills to carry out what this report says. Dr. Siegler stated that it is a reasonable idea that leaders need to find out what forms of professional development will allow teachers to achieve their goals more effectively. But at present, he didn't see any evidence in the Teacher's report.

Dr. Schmid stated that there is a hedged statement about the effect of teacher knowledge on student learning. If one examines the language as it is phrased now, there are two components, subject knowledge and professional development, and we do not know much about either. Both are probably okay, and more needs to be known. If one augments what is known from studies with one's own sense of what is going on, there's a huge difference between the two. There is no overwhelming numerical evidence about subject knowledge, but Dr. Schmid is quite certain that subject knowledge is a huge component in successful teaching. In professional development, there is certainly plenty of suggestion that much of the professional development is misguided. The language has to be based on what the Panel actually knows. But beyond that, the way the language is pitched has to convey what the evidence actually means when one applies one's own sense and knowledge of what's going on.

Dr. Stosky directed attention to Table 2 of the Teacher report, which deals with the effects of professional development on student achievement. There are a number of specific studies. Nine out of 42 had reached statistical significance in positive effects on student learning. That does not make a strong case for the value of professional development for proving student learning. That's a weak case. Which then raises the question, what do educational leaders do if they don't find professional development doing much for their teacher core? One obvious implication is that maybe they need to do more in preparing teachers, because evidence does not support training after they are in the profession. They don't have much evidence that trying to correct problems afterwards is doing much.

Dr. Ball stated that we are aware that content knowledge matters and that we need a system of preparing an enormous population of people to know math well enough to teach it and to know the things in the Learning Processes report well enough to pull it off. If we don't say that, we are going to look very foolish. We would not be endorsing something called professional development, as we currently know it. We would in fact be saying just exactly what we are all worrying about. That is, current investments are really not doing the job. Therefore, we have to have a system that will reliably do that.

Dr. Benbow stated that the nation certainly needs very strong pre-service programs, but we also need very strong programs that allow people to update their skills. There has to be a mechanism, and maybe it is not being done in the most effective way. There's no alternative but to have something there.

Dr. Loveless noted that the Panel talks here about recruitment, retention, and professional development, but they don't talk about or take a stand on the evidence of getting rid of demonstratively ineffective math teachers. Perhaps that is linked to the lack

of an effect of professional development. If the community is trying to professionally develop teachers who are unlikely to ever be effective teachers, then that may explain its general ineffectiveness. There actually is some research on that. There's the Cain/Stager study that looks at beginning teachers up through year three and shows through value added, they can identify effective teachers by the end of their third year.

Dr. Whitehurst stated that the Teacher Task Group report has that language, and in fact, a recommendation to that effect was taken out from the synthesis group.

Dr. Clements asked about the sentence that begins, "Teacher's knowledge of mathematics," and whether that could be rephrased. His synthesis group rephrased it to read, "Teacher's knowledge of mathematics (directly measured, not indicated by proxies) does appear to be a positive factor in students achievement." Then the last sentence, "However, solid evidence remains uneven," they took out and replaced with, "Further, there is a dearth of knowledge about how teachers' particular mathematical content knowledge affects instructional quality, students' opportunities to learn, and their gains over time."

Dr. Whitehurst stated that there is a factual misstatement on line 426. The statement says "with respect to salary schemes on differential pay." It says, "They do not appear to attract teachers in the high-need areas." There was nothing in the underlying Task Group report that either made such an assertion or provided evidence with respect to such an assertion. The research reviewed indicated that in some circumstances it might be impractical to do it because of the size of the salary differential that would be necessary. However, there's plenty of evidence around that if one pays enough, people will come. It's not the only factor. To conclude that there's no evidence suggesting that salary differentials affect location choice by teachers is an incorrect statement.

Dr. Stotsky asked why alternative certification is not mentioned as it is a major issue. She would like to see the section broken down. Dr. Ball stated that on the question of alternative pathways, there's a very clear summary of that in their report. Dr. Whitehurst added that there is little evidence of a positive nature on the effectiveness of most of the current industry for preparing and placing teachers. That doesn't come out in this summary, which focuses on particulars, and largely positive instances of conclusions. Yet, when one looks at the body of evidence and finds that the pathway into teaching doesn't seem to make any difference, that examinations of professional development don't seem to make any difference, it suggests an industry for preparing and training teachers that needs to be substantially changed. That point, from the negative evidence is lost in the way that this is described.

Mr. Williams agreed and believes that if an engineer wanted to go into teaching, the first education course they took would make them go back to being an engineer.

Dr. Ball stated that the Teachers report shows that course-taking and content knowledge, as it's typically measured, did not have an effect on K-8 teaching. So, they have to be careful about the logical next step which is that the nation does not have a system that works, so why isn't just anybody let in. Their report shows very clearly in a way that the policy discussions fail to pick up over and over, that the typical measures, course taking and degrees, really don't show effects on student achievement.

Mr. Williams stated that is why districts need alternative certification, because the current certification is abysmal.

Dr. Fristedt stated that he was disappointed that the Teacher's Group didn't take advantage of the expertise they had to make as many professional judgments as, say, Conceptual Knowledge and Skills was willing to do. It was a lost opportunity in some sense.

Chair Faulkner then moved to the sections on textbooks and instructional materials generally.

Dr. Fristedt stated that he is happy with subsection 1. Subsection 2 doesn't have the emphasis he would have liked. While length is important, coherence is more important; and that's not coming through as clearly. There is material that seems to indicate that U.S. books have more topics than foreign books. But he is not sure that that's right. It could be just the way they're broken apart.

Dr. Fennell reminded the panel that Dr. Siegler's group looked at particular instructional materials to do a review of this issue.

Dr. Reyna stated on the topic of coherence versus length, if people skip around and cover different content of a textbook, it's necessary to repeat background knowledge in case students had skipped chapters. So the issue is about being able to refer back and know that students have mastered certain things when they cover subsequent material. Length does in fact create that problem in being able to presume background knowledge. But the language probably needs to be explicit.

Dr. Siegler stated that the Instructional Materials report emphasized length because the general public would be shocked if they knew how long these books are. When asked how long they think the average 8th-grade textbook or 9th-grade textbook in math is, no one was within 500 pages. The Instructional Materials subcommittee went to four different publishers of widely used textbooks and they reported a range in length from 760 to upward of 1,000. In addition to the issues of cost and back strain, there are a lot of very large pages that have grown over the years. It makes it impossible for a textbook writer to have a coherent presentation.

Dr. Siegler stated that coherence is a very hard concept to quantify or to judge. Length, on the other hand, is a very easily understood concept. A superset of all the topics that are in any of the 47 states that don't have state-specific editions adds 200-some pages, according to estimates. It makes a coherent presentation literally impossible. If the textbook writer has absolutely no idea which subset of particular chapters a given student has gone through, it makes it impossible to do anything in a very modular approach for each chapter other than alluding back to concepts that were covered in the previous chapter or two. They have to treat each chapter as a little kernel all by itself. That precludes a coherent presentation.

Dr. Boykin stated on the issue of textbook accuracy that there would be a billion-dollar industry anxious to respond to these concerns here. He asked if errors were found in a few books or was it really widespread across the books in the field. If so, that needs to be stated. Chair Faulkner stated that the Conceptual Knowledge and Skills group chartered a pretty systematic examination of error frequencies in Algebra I books. The top four or five publishers were all examined.

Dr. Ma stated that they heard yesterday that some low-achieving countries also use small textbooks. She wondered what those low achieving countries use and if there is research on that. Dr. Loveless stated that countries have more than one textbook, so that is a tough question. The closed research he knows of is in the book he gave out, and that's

Bill Schmidt's chapter on coherence, but it's really not from textbooks, it's from frameworks. Dr. Schmid stated that the issue is not really whether there can be bad short textbooks. The issue is that there definitely are examples of very well written short textbooks. If coherence and brevity are positive quantities and there is proof of having coherent, short textbooks in high-achieving countries, that is really the issue. Dr. Ma stated that based on her knowledge, she only knows those little textbooks are written very well, but she is very curious about the examples of badly written, small textbooks. Dr. Loveless stated that if they can assume effects of coherence and then they compute correlations with TIMSS scores, they are not as powerful as they might think. This is most likely because low-achieving countries are based on European models, which have small, coherent books. They certainly have frameworks that are coherent. If the textbooks are following the frameworks, then they probably do. But it doesn't examine textbooks.

Dr. Wu asked whether the Conceptual Knowledge and Skills appendix on textbook errors should go into the Instructional Materials report. He has examined about 10 series of elementary textbooks, K to 6. In every single one of them, every five pages, there was a small error. Every 30 pages there was a major error, and these are textbooks tallying up to about 700 pages.

Dr. Fristedt asked to be in the loop when Dr. Siegler recasts that language. He also stated that he is concerned with equity when textbooks are written and designed to get parental involvement on specific subject matter aspects of the course. Dr. Reyna stated that while parental involvement is a wonderful thing, the problem is when one depends on an available parent at home to deliver crucial, fundamental aspects of the curriculum, that there can be an equity issue.

Dr. Ma stated that because textbooks are big and very expensive, children cannot personally own them. Chinese children have very small textbooks, but they own that textbook and they can do whatever they want to do in their book, such as take notes.

Chair Faulkner moved the discussion to formative assessment, explicit instruction, and team approaches.

Dr. Embretson asked if the wording on formative assessments could reflect the review of the studies, which was not quite included in the statement here. The caveat is that they also should be linked to state assessments. That's very important. There's some wording in the working paper from Instructional Practices, lines 358 to 361, about that linkage. There's another statement about when teachers link it to assessment.

Dr. Stotsky stated that these apply to Grades 2 to 6 and that the findings need to be qualified.

Dr. Geary pointed to line 483, the section on students with math difficulties. There are issues regarding the diagnosis of learning disabilities and difficulties in this area. They may add math difficulties in low-achieving, just to make sure they have the full spectrum of students who may benefit from this.

Dr. Loveless stated that that has to be clarified with capital letters. This is one particular approach, and it's T-A-I, Team-Assisted Individualization. Dr. Siegler asked if a person reading this will have an understanding of what this approach is without quite a bit of explanation. Dr. Loveless stated that he doubts that they will.

Dr. Stotsky stated that the other part of the qualification is to what it is being contrasted. She believes that there were a number of other approaches that showed no

effects at all and it is important that this should not be highlighted and erroneously generalized that team approaches are good, when it turns out that other kinds of team approaches did not have significance. Dr. Loveless responded that the finding was based on a meta-analysis of all of the studies and pooled effect sizes for all of the studies of team assisted individualization. So this effect size, which was significant, captures all of the experimental studies of this particular method.

Dr. Boykin stated that the section title for this should not be Team Approach; it should be Cooperative Learning or Group Learning. They could contextualize the fact that overall, they wouldn't find any of the effects, but there was one strategy that was successful, and that it had the brand name of TAI. Dr. Loveless agreed that the caution has to be there.

Dr. Benbow stated that there is one very important conclusion of the analysis between explicit instruction and child-centered, discovery learning. There is no data to support the ideology that is out there. Dr. Loveless agreed and stated that the reason why they looked at that in the first place was from anecdotal evidence from teachers, that they are often urged to be more student-centered in their instruction. Those kinds of sweeping recommendations are simply not warranted by research.

Chair Faulkner asked about the title of the section and the group agreed on Cooperative Learning. He then moved the discussion to technology and applications of technology, line 489 down to 526.

Dr. Clements stated that there will be a replacement section and it's questionable whether they want to make anything but a few general statements, because this doesn't represent what the present reviews say. For their new software review, they will do a meta-analysis.

Dr. Geary had a statement about calculator use not inhibiting proficiency with computational algorithms. The outcome measures are accuracy, and not speed and accuracy. It didn't address fluency. Dr. Clements stated that based on his comments and other people's comments, it's been changed.

Dr. Schmid also asked about the sentence, "calculator use does not inhibit proficiency," because the basis for the sentence is that if one looks at the literature, there was no overall negative effect, but this is a very sweeping statement. It could be read as, no matter how much calculator use we permit in the classroom, this will not inhibit proficiency with computation algorithms, and this is surely nonsense. Many of these studies are dated, and calculator use is moving far more rapidly than anything else that they are talking about.

Dr. Wu stated the Panel must be very careful about how they talk about the existing uncertainty of the literature, in view of the amount of anecdotal evidence.

Dr. Reyna stated that a possible resolution for this would be saying that calculator use supplants the opportunity to practice the retrieval of arithmetic facts, and we know that the retrieval of arithmetic facts has a demonstrated influence on mathematics achievement and performance.

Dr. Berch stated that there is some language in Instructional Materials about that.

Dr. Loveless stated that he is concerned that these studies are predominantly done with students. It is good, solid experimental research with students after Grade 3. So they have very little evidence of what happens.

Chair Faulkner directed the discussion back to real-world problems and gifted students.

Dr. Benbow stated that the description under real-world problems doesn't reflect very well the conclusions from the report.

Dr. Fristedt stated that this is one of the places where he is most concerned about terminology. Word problems mean everything that involves words, and there have to be at least some nonmathematical words. There's a floating definition of "real world." On the survey of algebra teachers, one thing that was listed as even more critical than fractions were word problems.

Dr. Loveless stated that Dr. Ferrini-Mundy conducted a meta-analysis of the research on real-world problems, and that's the basis of the statement and of the section of the report. So one key question there is how that meshes with this notion of word problems. Dr. Ferrini-Mundy stated that all of those studies were based around a particular kind of intervention involving a particular definition of real-world problems, so that can be added. It's real world problems used as the main carrier of the mathematics, in a sense, in the instruction; so they could be clearer about that too. It's not use of real-world problems to test how well students can apply something, but it's rather to teach the mathematics through the real-world problems. For testing, more subtlety needs to be included. Kendall raises the right point about what the outcome measures are, and where there's an effect and where there isn't.

Dr. Reyna was surprised that there wasn't more material that passed their standards. The work of Walter and Kinch and colleagues on what was called word problems, but in many situations could be viewed as real-world problems, and work on transfer might have tapped some of this work. Dr. Ferrini-Mundy will go back to Abt to look at their original searches. They used word problems as a search term, but they may have excluded those for different reasons.

Dr. Fennell asked whether it is worthwhile to draw the distinction about the importance of children solving problems as they learn mathematics and the use of words as context to get to that place, whether it's an assessment or instruction.

Mr. Williams agreed that there is a need because one leads to focused learning, and the other leads to confusion.

Dr. Schmid stated that the sentence about real-world problems research seems to say that the use of "a" in instruction appears to have a significant impact on student's ability to do "a."

Dr. Benbow, now in the chair, moved the discussion to the section on gifted students.

Dr. Fristedt stated that a general theme should appear somewhere that math teachers are confronted with a problem that is deeper in mathematics than in other areas. At the top end, the students can do so much more than would be done in a typical class. And at the bottom end, they can struggle forever to get a certain prerequisite nailed down so they can move on. And the breadth between them is very large.

Dr. Reyna stated that she has been concerned about a theme that cross cuts this issue and others about at-risk kids needing more help. This also ties into the issue about students having the opportunity to take courses so that they can ultimately take calculus, and so that they can ultimately have certain careers. The theme that cuts across all of this is tradeoffs that are not inherent, but that seem to pop up regardless. So I would avoid

making these tradeoffs. It's important to help the gifted, those with learning disabilities, and the broad swath of students that are underperforming. We need not make these choices among which group of students we're going to help.

Dr. Benbow then moved the discussion to the Assessment section.

Dr. Embretson stated that this does not have enough material in it and more material should be taken from the working paper. Her particular concern is with the "how to measure" aspect that is not really elaborated at all here in this concept paper. It gets into one of the major findings they had, which is the NAEP Validity Study, and the rather large proportion of marginal and flawed items. But then it goes to the guidelines needed for assessing mathematics.

Test developers and item writers have guidelines, but they're not going to get at the features that they have been concerned about. What they need is knowledge to generate better guidelines. And that is what they do not have. Now that should be based sometimes on logical analysis, but other times on scientific evidence.

One review that was undertaken that should be mentioned in the Panel report was with respect to a popular design feature, namely, whether the item was constructed response or multiple choice. It's commonly believed that the constructed response items measure different kinds of mathematical processes, different kinds of knowledge skills and abilities than do the multiple choice. Literature does not support that.

The literature shows that when there are tight comparisons available between constructed response and multiple choice, that is, they have the same stem, in one case students have to select an answer, and the other case they have to provide it. The studies are from different perspectives, but they don't find much difference. They measure the same common dimension.

When it's done experimentally, looking at problem solving strategies, students apply the same problem solving strategies to the constructed response that they do to the multiple choice. One strategy that is associated specifically with multiple choice is taking the answers and plugging them in the problem, rather than actually working out the problem and finding the answer. Students can do that too with constructed response items. They can generate candidates for the right answer and plug them in. And that is a rather interesting thing.

Now one might say, maybe we don't want the short answer constructed response; we're more interested in the long ones where they have to show work or provide explanations and so forth. Well, there's very little literature available to compare the processes involved, on any basis, to what's involved in the multiple choice items.

The two item types can't be compared tightly. One has to look at the best of multiple choice and the best of constructed response, and then compare them to outside knowledge, abilities, and skills such as verbal abilities and so on. There are very few studies like that.

So in other words, to say that guidelines are needed for assessing mathematics isn't going to make much sense, unless it is also said that there needs to be some more solid knowledge to provide the basis for those guidelines. That language is in the working paper, numbered responses 1 through 6.

Dr. Loveless stated that the first paragraph should be moved down so the discussion of fractions is not first. It's a discussion of NAEP and state frameworks, and fractions represent one topic discussed in regard to NAEP and state frameworks. There's

a slight technical problem in the first paragraph where it says, “descriptive studies of the framework have revealed.” Those were not studies of framework; those were studies of item pools that revealed the lack of fraction items among items.

Dr. Whitehurst pointed out a statement that begins on line 550 that he would prefer to have deleted, because he thinks it's not well founded. It calls for better communication essentially between NAGB, the National Assessment Governing Board, and National Center for Educational Statistics (NCES). He does not know what empirical work has demonstrated poor communication. There's a lot of communication back and forth between those two staffs. He thinks unrecognized here is that the Governing Board approves every cognitive item, item by item. So not only do they specify the design characteristics of those items, but they approve the actual items that appear in the test.

Dr. Embretson thinks that it's a problem not only of communication, but also of a mismatch in the expertise of people who have the statistical results on items, versus those who look at the item content. This is especially true with state assessments where the psychometricians are all PhDs and have a very sophisticated statistical language, which the people who are involved in item- writing and development can't understand and basically tune out. The statistics are handed to someone else, which are then handed to item writers and developers who mostly have a bachelor's degree at most, maybe not even subject matter experts, and they decide which items should stay on the test or not. Now this is a problem. The first statement is the more important one, that is, the one about having a range of experts representing the item content analysis and better communication. She does not know enough about NAGB and NCES to be able to include that.

Dr. Benbow stated that they would take out those specific references to NAGB and NCES.

Dr. Reyna asked whether Dr. Embretson was saying that it was preferable to have better ongoing communication between those people who are experts, and could they add that, and have those people involved in the policy. Dr. Benbow stated that they actually have much better language about this issue in their revised paper.

Dr. Loveless added that if there were any empirical evidence to support the general assertion of the lack of communication, even among state people, it would be good to cite that.

Dr. Whitehurst asked about the final statement on line 554, which seems to be redundant with what's already been covered under the heading of formative assessment. Dr. Fristedt stated that they have noticed that on at least the released items from NAEP and the six states that there's a real lack of actual problems asking for calculational facility at Grade 4 with whole numbers and at Grade 8 with fractions. That's one of the things that they have noticed. Thus, the calculator issue has been somewhat moot because those are the problems where it makes a big difference.

Dr. Siegler reiterated Dr. Whitehurst's point and suggested that the language be struck on the point about better communication. There's an implicit criticism there, and there's no data to support it. By their very nature, policy makers aren't going to have the statistical expertise to communicate with the people who are designing the items. Unless there's evidence to say that communication, per se, is inadequate, he felt it should be deleted.

Dr. Embretson stated that common knowledge is the basis here. Anyone who has been involved with test development outfits, whether they're commercial, large or small, or even the military, they all know that the psychometricians and the item developers do not fit together. She is not sure how they are going to put that in, but she thinks it's an important point. She thinks there are statistics that are not necessarily reported, which will help the item writers to revise their items in such a way that they can be better.

Dr. Benbow stated that they didn't have much of a discussion about communication in their report that was sent out for review, and this was the very comment that came back from the person who was a test developer, that this is a well-known problem about the lack of communication. So she thinks they can couch it in the sense of not making it scientific evidence, but fairly common knowledge.

Dr. Schmid reiterated that it is not a statement about NAGB and NCES. It is really a statement about the degree of cooperation among various groups in test development. He agrees that there is common knowledge and agreement among people who have been involved in the review of various tests that there are these separate worlds -- the psychometric world and the world of those who construct test items -- and the separation between them has absurd consequences.

Dr. Loveless stated that it would be nice to say that there needs to be more communication or better communication, but he asked if they know that better communication is going to lead to any positive outcomes. Maybe they don't want better communication. Maybe to preserve, for instance, the technical integrity of the test, the people who don't know much about testing shouldn't be directing the show.

Dr. Embretson stated that rather than communication, the more important point has to do with the basis of the review and analysis. One thing they suggest is they need to hire a level of expertise including people who know the mathematical content, but also cognitive scientists. How do people approach this kind of problem? In a practical sense, all those people can't look at every item because that's very expensive. So what is also needed is better research on design features, which will lead to certain opinions by this higher level of expertise.

Dr. Reyna stated that for example, that a layperson could look at an item and think it is obvious what that item measures. And this is an issue of validity, which is a fundamental psychometric property. One can say that's clearly a computational fluency item, but it's not mathematically, and it's known that it's not. So the person has to bring that, and they can't maximize psychometric properties that they are unaware of and don't understand.

Dr. Schmid stated that he was involved in the NAEP validity study review of mathematical accuracy. One of the outcomes was that when the same group of mathematicians was asked to look at the next new collection of items that were constructed afterwards, there was an obvious difference. Their concerns had been taken into account. The other is the statement that there has to be better communication between policy makers who specify item content and those who construct the actual test items. This also speaks to the gap between frameworks and actual tests. There's a huge gap. Looking at various frameworks and at the state tests, those are separate worlds as well. Better communication, better integration of these two sides of policy and implementation would be hard to argue against.

Chair Faulkner moved the conversation to the recommendations section.

Dr. Whitehurst asked about question 2, the last line, line 563, if they could strike the word "reliable." He does not know that any research has been done on the reliability of teachers.

Dr. Fennell asked for clarification on the phrase, "at risk for later failure." Dr. Geary responded that students who enter kindergarten behind tend to stay behind throughout their entire career, and the gap may well increase. They're certainly at risk for staying well below where we want them to be throughout their entire school career. Dr. Whitehurst suggested changing the phrase to "at risk for low achievement."

Dr. Fristedt stated that he was looking for ways of combining the list, because 19 is a rather long list. He thinks that 1 and 2 could be combined, and that 4 and 5 could be combined. But in the combining of 4 and 5, he'd like the word calculational facility or computational facility. Chair Faulkner asked the group and the agreement was to combine 1 and 2.

Dr. Schmid stated that what is glaringly missing in 4 is the automaticity with number facts, and also algorithms. And when they are included, then probably 4 and 5 become unwieldy. Items 4 and 5 can be repackaged. But the Panel absolutely needs to include both a strong recommendation that number facts need to be automatic and a strong statement about the importance of algorithms.

Chair Faulkner stated that there is language from Conceptual Knowledge and Skills that deals with this. Dr. Siegler stated that it is critically important to keep fractions as its own item. It's so fundamental to learning algebra, it's so clear that kids are terrible at it. It's one of the biggest findings of the whole Panel process. Item 4 can be rewritten so that it's primarily about whole numbers, and Item 5 rewritten so that it incorporates the material from Item 4 about fractions that isn't there now.

Dr. Fennell asked that they take the original language relative to whole numbers, which includes statements with regard to facts and algorithms, and patch that in. This would also be done with the similar original language with regard to fractions.

Dr. Schmid stated that the Siegler group had two such recommendations, one focusing on whole number arithmetic and the other on fractions. They addressed the concerns that have been mentioned here now. So maybe the way they should address this is to look again at the two corresponding recommendations by the Siegler group.

Dr. Fennell stated that they packaged that under number sense.

Dr. Fristedt commented on automaticity, and that they don't want to give the impression that it's only basic number facts. For instance, when they go to fractions, often one of the denominators might be 54 and the other one 36, and you'd want them to see the factor of six sitting there. So there are more than just the basic facts.

Dr. Geary stated that the effect of practice on automaticity is there in all areas that have been studied. He agrees that they should have automaticity in all basic skills that students need to carry forward to be successful in algebra. That includes arithmetical facts, algorithms, fractions, prime numbers, and factoring.

Dr. Reyna noticed that the Panel is missing something that it has in the other common concept about the pervasive difficulty with fractions. The difficulty with fractions presents an obstacle to further progress in mathematics and other academic domains and it has been linked to negative outcomes in adulthood. Chair Faulkner said that it does not belong in the recommendation.

Dr. Whitehurst asked about item 8 and what it was trying to say: "Research base supported application and local evaluation of certain practices can be recommended." What he would suggest is that they just list the interventions out of the Instructional Practices and other reports where there is sufficient evidence to demonstrate effectiveness. He added that 9 and 10 could be combined. The middle sentence in 9 seems to be out of place. The rest of 9 and 10 are about the accuracy, focus, and coherence of textbooks, and then there's a statement there "that a large amount of research has been conducted on instructional materials," but it doesn't meet methodological standards. He would like to strike the sentence or combine 9 and 10 and create a new sentence that talks about how little research exists on the effectiveness of instructional materials.

Dr. Siegler stated that he would favor striking the last clause in number 8, because his synthesis group talked a lot about this, and there doesn't seem to be any evidence for it. Dr. Reyna asked in that connection, if they are adding things and trying to integrate them across task groups, there were a number of things that they identified in the Learning Processes group that fell out as effective practices, including the board game intervention and demarcating names for fractions as parts of wholes. They may want to enumerate those here as well, in number 8.

Mr. Williams stated that in 8, "explicit instruction for students with mathematical difficulties," is effective. He asked if they would consider explicit instruction to be more teacher centered, and if so, if in 8, they would not be able to say that teacher-centered instruction is actually better for students with mathematical difficulties. Chair Faulkner stated that they did say earlier in this document that explicit instruction was better for low achievers. Mr. Williams asked if explicit instruction was more teacher-centered or more student-centered. Chair Faulkner stated that they would deal with those terms.

Dr. Ferrini-Mundy stated that their synthesis group talked about how explicit instruction is used here as a kind of truncated description of the actual intervention that worked. They need to go back and look at what the research actually said and what explicit instruction was in those particular cases where it was supportive of well-achieving students. She also flagged number 7, and the Instructional Practices report may bring some adjustments in that one.

Dr. Fristedt stated that 9 and 10 seemed weaker than the earlier statement on the length of textbooks. Length and coherency of textbooks can be in a clear statement there. And one other thing that should be added is that choosing textbooks is a major task for schools and teachers. He added that formative assessment seems to be a plus for learning. He can't help but wonder if teachers in the schools don't use it because they're required to keep records of everything. He wonders what school policies are around this.

Mr. Williams stated that in the school system where he teaches, he does need to keep records of the benchmarks that are passed by each student and what he's done to remedy the hindrance of any progress. Teachers do complain vehemently about the paperwork involved.

Dr. Fennell suggested on number 11, that they take the language used earlier, which was something along the lines of "evidence from research supports the value of preparing larger number of students to complete an Algebra I course or its equivalent," rather than this. Dr. Whitehurst pointed out that it's not a recommendation. Chair Faulkner stated that they would turn it into one. Dr. Fennell also stated that the particular

recommendation from the Teacher group on mathematics teacher specialists should be clear about the definition.

Dr. Whitehurst commented on number 14 and Dr. Siegler's synthesis group's rewording.

Dr. Ferrini-Mundy stated that 13 and 15 aren't yet really phrased as recommendations. Chair Faulkner said that they are going to have to decide what a recommendation is and what a finding is.

Dr. Whitehurst noted that on 15, it should be made clear that they are talking about the salary differential between teachers with training in mathematics and other technical fields.

Dr. Fennell stated that on 18, the recommendation that was made relative to the NAEP content frameworks was more extensive than what's here about the areas, and they can provide that.

Dr. Embretson stated that 19 as stated isn't going to do anything at all, because there is already quality control in oversight procedures. So they need to add a phrase after "oversight procedures" like this, "that are based on scientific evidence and logical analysis at high levels of expertise." Chair Faulkner asked Dr. Embretson to send that language to him.

Dr. Reyna added a friendly amendment to that. She stated that high levels of expertise also could be construed in very loose ways. How about "doctoral level of expertise"? Dr. Embretson said she was not sure about that. She added that because Assessment's report is not yet done, they didn't get a recommendation in there. The one she has is related to quality control, oversight procedures, and their basis. "Research is needed on the ideal design features that impact the knowledge, skills, and abilities that students apply to solving items." Chair Faulkner asked her to send that to him.

Dr. Siegler added about number 19 that they need to specify the kinds of expertise that they thought were critical for better item design and selection.

Chair Faulkner moved the conversation to recommendations related to research capabilities and the research agenda. He stated that he believes that this Panel does need to consider whether the shape of the federal research establishment is conducting the research that is needed. The Panel have in effect gone through reviews of something like 18,000 studies. They have found that a relatively small proportion actually reaches the stage of generalizability, which is what they are being asked to address with respect to practice and policy. His impression is that the shape of the funding structure isn't quite adequate to generating the kinds of studies that they have found useful. It's certainly reasonable for this group to consider whether to make recommendations that bear on that question. It is within the scope of what the President asked them to do.

Dr. Siegler stated that there is a need for greater overall funding in education, and it's related to point number 21, because they don't want this to be something that yanks away all the other education funding. A statistic was cited in the discussion yesterday that was really pretty shocking, that in a comparison, in education funding, less than one-half of one percent of discretionary spending is spent on research. In health spending, 42 % of discretionary spending is spent on research. It could be viewed as feathering their nest to recommend greater funding of research, but not to do so would be irresponsible. The total amount of money is a very large problem.

Dr. Reyna directed the group's attention to tab 16 in their binders for more details on item 16. She emphasized the importance of large trials. She also mentions experiments that get at causal mechanisms. They really don't even have basic knowledge about what the problems are with fractions. They don't know about learning disabilities.

Dr. Whitehurst appreciates the motive behind point 21, but he doesn't think it's sufficiently informed by what the federal government has already done. His office was established in late 2002 to do this work. They are beginning to get yield from it. Grants take 4 or 5 years. Reviewing the list, "distinct federal funding program that can support a small number of rigorously designed and executed trials," is something they have through their National Center for Education and Evaluation. There are 22 such trials in the field, some of which have already generated results like the technology study that has been reported to the Panel.

Within their research center that funds individually initiated projects at the university level, they also have the goal to take projects that have been shown effective at smaller scale and move them to larger scale. They have about 40 projects under way there. With regard to point C, they have established 10 interdisciplinary pre-doctoral training programs that are scattered across America, and have currently 190 doctoral students in training who have produced to date about 200 publications all directed to the pipeline issue. So he thinks this work is under way. Certainly the National Science Foundation (NSF) has similar work. He is leery about a recommendation from this Panel to create some kind of new bureaucracy that is intended to address matters that are already being addressed, but have a delayed yield curve because of the necessary time it takes to fund research and get products.

Chair Faulkner stated that these comments were made on the basis of what their experience has been on the basis of research that has been available to them. And that's a relatively new initiative.

Dr. Whitehurst applauds the motive behind it, but wanted to indicate that there is a lot of this already under way. New entities and new boards might interfere.

Dr. Ferrini-Mundy underscored what Dr. Whitehurst said. From the NSF angle, part of what they are not seeing enough of are the efficacy studies that get things set up and ready to a point where the large scale studies then happen. So there would be more subtlety perhaps if something like this still goes forward about the particular kinds of places where there is a continuing need for more investment. Chair Faulkner asked if a group could work on that language. Dr. Ferrini-Mundy added that the discussion of capacity around federal funding is interesting and good. Another place where they might choose to make some recommendations and push the capacity issue is toward higher education. The federal agencies have programs, but will only be able to fund what is strong.

Dr. Reyna added that without a prospect of funding, it's hard to encourage people to dedicate their careers to something. But there's a supply issue as well.

Dr. Berch added that he is also concerned about creating yet another layer of bureaucracy and coming up with a recommendation about this program. It's interesting that at this moment the National Institute for Child Health and Human Development has a request for research out about mathematical learning difficulties with disabilities. He stated that he would be uncomfortable being a part of this group because it would be almost as though they are making recommendations to themselves. There is certainly a

model for this sort of thing that comes out of some of the National Academy reports, and he concurs that it would be important to make this kind of recommendation.

Dr. Fennell stated that it seems to him that however this is crafted, these are general avenues for research. Underneath that they have a lot of very specific things that they might want to delve into deeper.

Dr. Siegler stated that on number 25, they should strike the four or five words on the last line and just say, "research is needed to identify key features of teacher education that have effects on students achievement." Otherwise, it opens the door to saying well we taught them Finn's theory of pedagogy and now they know Finn's theory of pedagogy, and that doesn't do anyone any particular good. They really should keep the emphasis on student achievement and the effects of teacher training on that.

Dr. Fristedt went back to 21, and the one thing he noticed in reviewing the few research articles is that in some studies a particular person has an idea and carries it through and compares it with a more conventional idea. But of course that person has a vested interest in how it comes out. And no one seems to pick up on that idea and replicate it.

Dr. Whitehurst stated that on 24 they cite the Cognitive Tutor as an example, and it is probably inappropriate to cite a commercial product as an example of what they are about. He would like that struck. On 23, it seems to him that they are talking about a particular program, cognition and student learning, where they require grantees, who are in every case cognitive scientists, to spend a majority of their grants doing work in authentic education settings. The recommendation here is not to impose that requirement on the research community. He thinks that would be ill advised for a couple of reasons.

One is that there are many sources of funding for cognitive science. One can go to the National Science Foundation (NSF), for example, in the divisions having to do with learning, and obtain research funding to do laboratory type work that exposes the basic mechanisms of learning and memory. All of that work is important, and much of it is important as a foundation for what happens in education. What they don't have is translational work that takes the findings from cognitive science and moves them into classrooms and other learning situations. This would be under conditions of extended learning, with the complexity of what's going on in a classroom, and generates yields that have a relatively small gap between the findings and what educators might use. That's what the particular program at Institute for Educational Studies (IES) tries to do. It's done it with a great deal of success.

Dr. Geary mentioned that a lot of cognitive scientists do work that is potentially relevant and usable, and if they go to National Science Foundation or to the National Institutes for Health (NIH), they're really not thinking about educational types of issues. If there were additional funding with IES or some focus on educational issues, then they could think about the studies they're doing with respect to learning of A, B, and C in a school setting. That basic kind of mechanism type of research could be done in a more lab-like setting. Work like it is being done in lab settings, but without really any thought about classrooms. If one goes to NSF or NIH, in many cases the researcher does not have to think about that. What they're thinking is reduction. They think about how they can understand this process a little more, in a little more refined way, rather than the other direction.

Chair Faulkner recommended that 21, 23, and 24 all be taken into this group that they are talking about here, Drs. Reyna, Siegler, Ferrini-Mundy, and Whitehurst, and they all can think about the overall recommendation text.

Dr. Fennell stated on number 28, he would suggest that the item be amended to something like, "longitudinal research is needed to specify the skills and knowledge and their sequence and level of emphasis, which lead to algebra." In other words, it's not just the identification of the skills, but how they might be ordered and the amount of time that should be spent at various levels.

Dr. Siegler expanded on that for 28 because there should be emphasis here. There are skills that kids attain several years before they enter algebra courses that are important. And then there are skills that they obtain right at the beginning of the algebra courses. Those are somewhat different issues. Whether one needs to remedy things years in advance, or whether one just needs to do it at the beginning of the algebra course, is a very important instructional issue, and one where the data today don't exist. Chair Faulkner asked Drs. Siegler and Fennell to work on that language.

Dr. Fristedt stated that it seems to him that in general, they have not discussed much in the Panel about what are the most important prerequisites for learning fractions. He feels that whole number arithmetic fluency is very important. Dr. Siegler stated that empirically, this problem is somewhat understood. While whole number fluency is predictive, it's not the most predictive factor. The most predictive factor is conceptual understanding of fractions. There are a huge numbers of students who just don't understand what a fraction is. That turns out to be easily the most predictive factor. Steve Hecht used a variety of measures of conceptual understanding, one being number line. Dr. Reyna stated that this is reviewed in detail in the Learning Processes Task Group report. There were a variety of operational definitions. Hecht looked at word problems, computational facility, and a variety of other kinds of things like relative magnitude judgments of fractions and so on.

Dr. Fristedt stated that it seems that some recommendations for publishers are in order here. When they talk about addition and subtraction of fractions in textbooks, they don't mention the number line and moving to the right or the left on the number line.

Dr. Whitehurst noted that 30, 31, and 32 are not research recommendations at all, and so they either need to be struck or put in a different place. What's missing is, "Research to identify and inculcate the characteristics of persistently effective teachers."

Dr. Ferrini-Mundy stated that on 28 they want to be a little careful for consistency sake when they call for longitudinal research needed to specify the skills and knowledge leading to success in algebra. Earlier they have quite clearly stated what the critical foundations for algebra are.

Dr. Schmid amplified what Dr. Fristedt said. He was not aware either that there was such detailed understanding of the predictive value of conceptual understanding of fractions. If the evidence is really that strong, then we have to say more as a recommendation to textbook writers. Chair Faulkner asked Drs. Schmid, Fristedt, Reyna, and Siegler to develop a recommendation.

Dr. Ma asked if there is any research available talking about whole number division as the prerequisite. Dr. Reyna will give that to her.

Dr. Fennell stated that the item on teacher salary issues is not a recommendation.

Dr. Reyna stated that in regard to 33 and the rest of the items, they had a number of recommendations on learning principles and content areas in learning for teachers. They include links between intuitive knowledge and formal knowledge as an area for focused research. Because in domain after domain, fractions and geometry, in particular, that link was not well understood and is the foundation for progress and formal mathematics. These ideas are in the Clements synthesis paper as recommendations.

Dr. Siegler stated that on number 33, points A and B are almost identical, and identical with point number 25.

Dr. Benbow stated that might be true, but didn't they want something on professional development? Did they have a question on research on professional development? This is a big issue that they don't think their current practices are effective.

Dr. Fristedt stated that should go instead of A through C.

Dr. Whitehurst asked if question 25 would be inserted after teacher education and professional development, as all of the questions there are relevant both to the pre-service and to professional development of teachers.

Dr. Fennell stated that the phrase "teacher education" would pick up varied levels of certification, be that alternative or not.

Dr. Ferrini-Mundy stated that the working paper from the Instructional Practices group didn't really consolidate any recommendations for research. She suggested adding a placeholder for that group.

Dr. Embretson stated on 32, with "raising student achievement," she worries how that is going to be measured. Measurement of change depends on the match of the test to the student. If students are already at a pretty high level, they can't get much higher. They will need some language about persistently high achieving students or something like that.

Dr. Schmid asked if Chair Faulkner would go back to the working papers or the reports to write this paper.

Dr. Siegler stated that with this large number of recommendations, he worries that the ones that are especially high priority will get lost.

Chair Faulkner explained that while there will be a need for further discussion, they will gradually try to get the best language from the best sources. The next public meeting will be in Baltimore, Maryland on November 28th.

The meeting was adjourned at 12:19 p.m.

I certify the accuracy of these minutes.

Chair Signature _____ Date _____

Vice Chair Signature _____ Date _____

ADDENDUM: PUBLIC PARTICIPANTS

Last Name	First Name	Organization
Brown	Judy Ann	Words and Numbers, Inc.
Eyre	Gary	Advance Associations
Gutierrez	Rodrigo	University of Arizona
Hertzog	Kim	Phoenix Elementary School District
Knuck	Mary	Arizona Department of Education
Prado	Sharon	ASU
Rickhoff	Rick	SRA McGraw-Hill
Saxberg	Bror	K12
Stiles	Jan	Paradise Valley School District
Varley	Maura	Dept. of Language, Reading and Culture Center for the Mathematics Education of Latinas/ University of Arizona
Whitehead	Sharon	Mesa Public Schools
Whiting	David	McGraw- Hill
Winchester Marshall	Lori	McGraw-Hill School Solutions Group