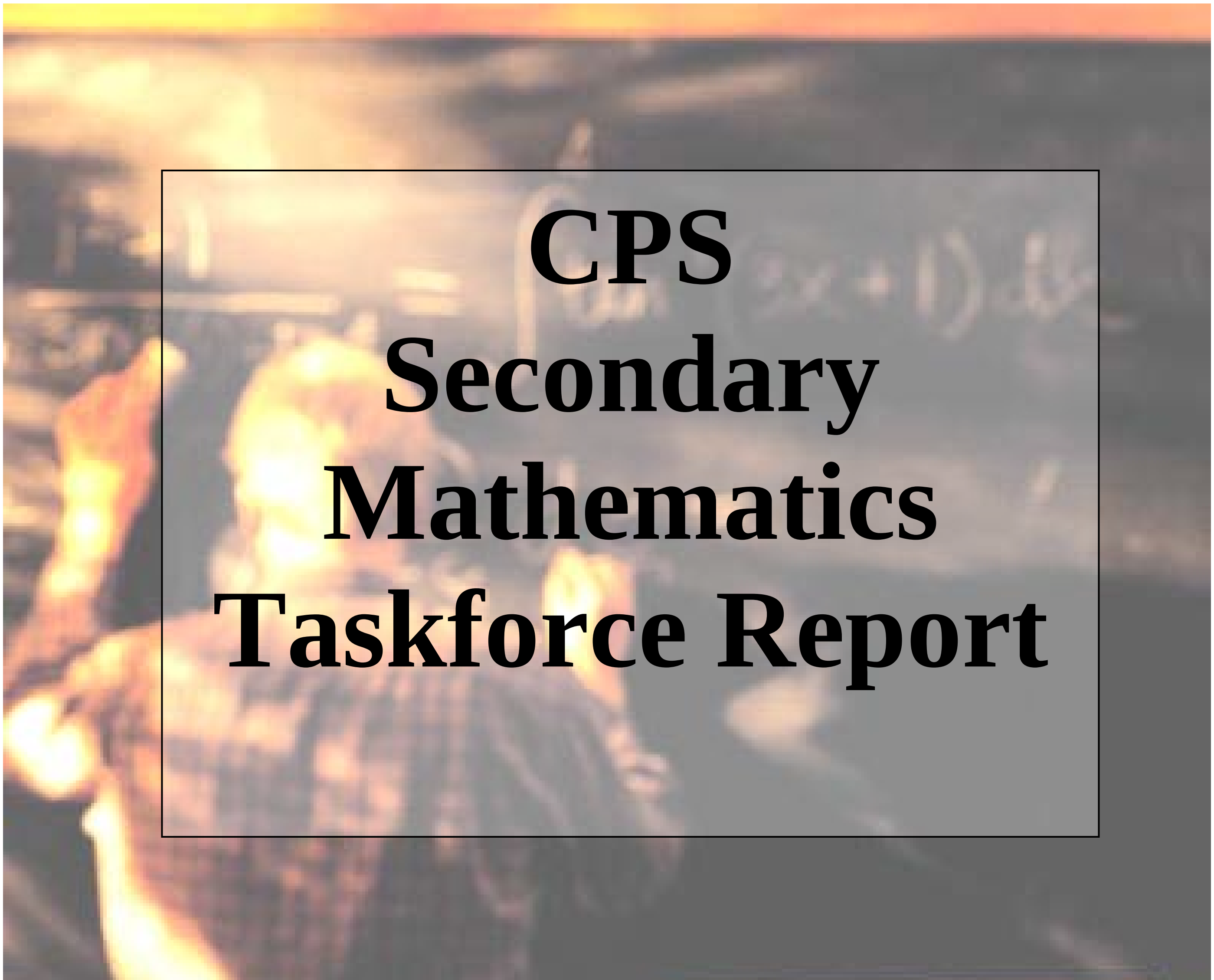

CPS Secondary Mathematics Taskforce Report

Presented to
Dr. Phyllis Chase
and the
CPS Board of Education

May 24, 2007

CPS Secondary Mathematics Taskforce Report
Executive Summary

May 24, 2007

The CPS Secondary Mathematics Taskforce (members listed in Appendix 1), established by Dr. Phyllis Chase, met during the 2006-07 school year to examine the status of CPS 6-12 mathematics education. Specifically, the Taskforce was charged with the following:

- Articulate current status of CPS 6-12 mathematics programs;
- View CPS status in light of what research suggests about learning/teaching mathematics;
- View CPS status in light of Governor Blunt's METS Alliance recommendations; and
- Write a report that addresses CPS programmatic strengths and concerns and includes recommendations for future decision-making.

As the work of the Taskforce comes to an end, we submit this report to document our work. This Taskforce report contains findings in ten (10) areas, as delineated below. Based on these findings, the Taskforce makes five (5) recommendations to Dr. Chase and the CPS Board of Education.

Finding 1: **Students in the U.S. do not perform well on mathematics assessments.**

Findings from the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) indicate that students in the U.S., on average, perform well below their international counterparts on mathematics assessments. Further, findings from the National Assessment of Educational Progress (NAEP), the standardized assessment used in the No Child Left Behind legislation, indicate that overall, students in the U. S. perform poorly in the area of mathematics.

Finding 2: **Explicitly making mathematical connections during mathematics class positively impacts students' opportunities to learn.**

The TIMSS 1999 Video Study found that in the typical U.S. classroom, students are not required to make connections between mathematical concepts, even though problems may be written in a way that encourages students to make mathematical connections.

Finding 3: **Missouri's METS Alliance focuses attention on Mathematics, Engineering, Technology, and Science in Missouri.**

The METS Alliance made the following recommendation, in order to improve the performance of all P-20 students, in its report to Governor Blunt in August 2006 (for the full report, see http://www.missourimets.com):

> *Improve METS curricula and assessments*. Revise Missouri's K-12 GLEs and assessments for mathematics and science to support **focused, inquiry-based instruction modeled on internationally recognized best practices**. Ensure that collegiate-level

METS curricula follow the same focused, inquiry-based instruction. (Executive Summary, p. 1, emphasis added)

Finding 4: **Proficiency in mathematics involves more than procedural competence.**

Adding it up: Helping Children Learn Mathematics (National Research Council, 2001) provides a research-based definition of "mathematical proficiency" that contains five interwoven strands:

1) conceptual understanding,
2) procedural fluency,
3) strategic competence,
4) adaptive reasoning, and
5) productive disposition.

Students' abilities to understand and use the mathematics requires more than knowledge of facts and procedures (procedural fluency). It also requires the ability to formulate, represent and solve problems (conceptual understanding, strategic competence, adaptive reasoning). In addition, teachers should support students in developing logical thought, reflection, and justification in order to generate the habitual inclination to see mathematics as sensible, useful, and worthwhile (productive disposition).

Finding 5: **How we teach mathematics matters.**

In a review of the research literature on mathematics teaching, Hiebert and Grouws (2007) claim that "the nature of classroom mathematics teaching significantly affects the nature and level of students' learning" (p. 371). Further, they report that their review of the research literature indicates that two features are key to success for students:

1) that teachers and students attend explicitly to concepts; and
2) that students struggle with important mathematics.

With regard to feature 2, the authors write,

> We use the word *struggle* to mean that students expend effort to make sense of mathematics, to figure something out that is not immediately apparent. We do *not* use *struggle* to mean needless frustration or extreme levels of challenge created by nonsensical or overly difficult problems….The struggle we have in mind comes from solving problems that are within reach and grappling with key mathematical ideas that are comprehendible but not yet well formed. (p. 387, authors' emphasis)

Finding 6: **Quality professional development for mathematics teachers is important.**

The research on mathematics teaching and learning indicates that limiting students' opportunities to learn has a detrimental effect on their mathematical proficiency. The literature also calls for a shifting view of mathematics classrooms and what it means to 'know' mathematics. Combined, these literatures loudly call for the necessity of mathematics teachers continuing to learn and adapt their classroom practices throughout their careers.

Finding 7: **Communication with stakeholders is important.**

From the very first meeting of the Taskforce, we realized that members who represented different stakeholder groups understood very different things about mathematics education in CPS. Representatives from the parent and community/business stakeholder groups were consistently vocal during Taskforce meetings about the need for CPS to communicate more effectively with the CPS community at large.

Finding 8: **Student, parent, and teacher perceptions provide important indicators of the status of mathematics education in CPS.**

The findings from student, parent, and teacher surveys are twofold:

1) Overall, members of these three stakeholder groups appear consistently satisfied with mathematics education in CPS
2) Some differences exist in the perceptions of CPS mathematics teachers and students/parents with regard to mathematics teaching and learning in CPS.

Finding 9: **CPS students, on average, score higher than the average state scores on the Missouri Assessment Program (MAP). State comparison data indicate that CPS students, on average, score 2 points higher on the ACT than the state average.**

In 2006, 54.1% of 10^{th} grade CPS students, on average, scored at the Proficient or Advanced levels on the MAP. In comparison, the state average for students scoring at the proficient or advanced levels was 42.4. For 2006, the average ACT score for CPS students was 23 and for the state was 21.

Finding 10: **More CPS students are enrolling in more mathematics classes and the percentage of CPS mathematics students "on-level" is increasing. The AP Calculus attrition rate for students who enter "honors" mathematics courses as 8^{th}-graders is concerning.**

Overall, the percentage of students who are enrolled in high school mathematics courses has steadily increased over the past 7 years. Further, the percentage of students in mathematics classes considered "on-level" (e.g., a 10^{th} grader enrolled in Geometry) has also increased. Of particular note is that the number and percentage of African-American students who are enrolled in mathematics is increasing.

For the class of 2006, 285 students enrolled in an honors mathematics course as 8^{th} graders, a choice that positioned them to take AP Calculus in their senior year. However, only 81 of the 285 students were enrolled in AP Calculus as a senior.

CPS Secondary Mathematics Taskforce Recommendations

Based on the findings delineated above, the members of the CPS Secondary Mathematics Taskforce make the following recommendations:

Recommendation 1: **Improve communication with CPS stakeholders.**

CPS needs to improve communication with the parents and the public at large with regard to grades 6-12 mathematics education. Concerted efforts should be made to improve the CPS web site to include information about mathematics education in CPS, the state, and the nation. More effort should be made to utilize Channel 16 as a communication tool for mathematics education. In addition, the Taskforce recommends the creation of a CPS Mathematics Education Community Advisory Board, whose members should be comprised of parents, local business persons, University of Missouri faculty, CPS mathematics teachers, and CPS administrators (both at the school and district levels).

Recommendation 2: **Utilize the five strands of mathematical proficiency as a guiding framework for mathematics education in CPS.**

The Taskforce recommends that the five strands of mathematical proficiency, as described in *Adding it Up: Helping Children Learn Mathematics* (NRC, 2001), be used as a guiding framework when making decisions about curriculum, instruction, and measures for data collection in CPS.

Recommendation 3: **Offer both Algebra and Integrated pathways.**

To provide students with different options for learning mathematics in CPS, the Taskforce recommends that CPS continue to offer enrollment in the Integrated and Algebra pathways. Enrollment in either pathway should be informed by the student, his/her parent(s), and teacher recommendation.

Recommendation 4: **Continue to provide teachers and administrators quality professional development.**

The Taskforce recommends that CPS provide teachers and administrators with quality professional development that is offered during contract hours. This professional development should be school-based and focus on teachers' classroom instruction.

Recommendation 5: **Strategically collect data that will inform CPS with regard to students' achievement across the five strands of mathematical proficiency.**

While ACT and MAP scores inform the district with regard to procedural fluency and conceptual understanding, CPS lacks a mechanism for assessing students' strategic competence, adaptive reasoning, and productive dispositions. Further, CPS should judiciously take into consideration data represented on the DESE and MDHE websites, utilizing the data in combination with locally-collected data.

CPS Secondary Mathematics Taskforce Report
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CPS Secondary Mathematics Taskforce Report

Respectfully Submitted by the Members of the Secondary Mathematics Taskforce
to Dr. Phyllis Chase, Columbia Public Schools Superintendent, and
to members of the Columbia Public Schools Board of Education
May 24, 2007

Introduction

The CPS Secondary Mathematics Taskforce, established by Dr. Phyllis Chase, met during the 2006-07 school year to examine the status of CPS 6-12 mathematics education. Specifically, the Taskforce (comprised of CPS grades 6-12 mathematics teachers, MU faculty, parents of grades 6-12 students, members of the Columbia community, and CPS administrators) was charged with the following:

- Articulate current status of CPS 6-12 mathematics programs;
- View CPS status in light of what research suggests about learning/teaching mathematics;
- View CPS status in light of Governor Blunt's METS Alliance recommendations; and
- Write a report that addresses CPS programmatic strengths and concerns and includes recommendations for future decision-making

As the work of the Taskforce comes to an end, we submit this report to document our work. Appendix 1 contains abbreviated agendas from Taskforce meetings. We pulled from a number of resources to inform our work. We read and discussed research findings from the educational research literature. We used data collected and compiled by the 10-12 Mathematics Evaluation Committee, who did their work the year before we met. A consistent theme that ran through our work, and begun at the first meeting of the Taskforce, was to consistently ask ourselves, "What is important about the topics we discuss that the community at large needs to know?"

Thus, we begin this report much the same way that we began our work as a Taskforce -- with a discussion of what the Taskforce members learned about the need to improve students' opportunities to learn mathematics, from international, national, state, and local perspectives. Following a brief review of research literature on mathematics learning/teaching and teacher professional development, we then report the definition of student success that the Taskforce has adopted in its work. In the following section, we report data collected and analyzed by the CPS 6-12 Program Evaluation Committees, as well as attendance data for professional development over the past five years. We conclude with the Secondary Mathematics Taskforce's recommendations.

Students' Opportunities to Learn Mathematics: International, National, and State Perspectives

International Perspective

Since the early 1980s, the United States has participated in international studies of student achievement in several content areas. U.S students, on average, typically have scored at or just below the international average on the mathematics portion of these assessments. For a large majority of the international assessments, U.S. students' scores are vastly different (lower) than the countries with which we seek to maintain a competitive economic relationship (e.g., Japan, China, France, and Germany). While the race for being first in the world on these assessments should not be our major focus, working to maintain a competitive edge requires continuing to develop both a skilled workforce as well as the ingenuity to invent new technologies and resources.

The Program for International Student Assessment (PISA), sponsored by the Organization for Economic Cooperation and Development (OECD), conducted studies in 32 countries, including the U.S., evaluating 15-year old students' literacy in three areas: reading, mathematics, and science. Students from the U.S. perform at or just below the OECD average. This performance is similar to another international study looking at 4^{th} and 8^{th} grade students' mathematics achievement, the Trends in International Mathematics and Science Study (TIMSS) assessment. These international assessments indicate that low mathematics performance is not merely an issue for students who traditionally struggle with mathematics, but even our top students are being outperformed by the top students from our economic competitors.

On average, most U. S. students are competitive with their international counterparts in the ability to solve simple problems, including those that require a computational skill. The significant difference in performance between U. S. students and students in higher performing countries appears when students are asked to solve problems that require more complex thinking. U.S. students are less likely than their international comparisons to be able to represent underlying mathematical relationships in a problem or relate those concepts to a correct solution. In other words, U. S. students tend to be able to complete skill-level problems effectively, but struggle when applying those skills to more complex problems.

Examining the sales figures of textbook materials is one way to investigate which types of curriculum materials are most prevalent in the United States. The mathematics textbooks that hold the largest market shares in the U.S. typically focus most of the instruction on helping students learn to perform particular mathematical procedures. Students who use these textbooks work on structured and prescribed methods for solving sets of mathematical problems, typically presented as 'naked math' problems (problems that have just numbers and no context). This presentation tends to lead students to be able to complete simple skill-based problems, and does not support their ability to use those skills to solve more complex problems. Given this curricular and material design, there seems to be some relationship between what students experience in mathematics classrooms and the results of the international studies – that U.S. students are good at what they have the opportunity to learn (low-level mathematical skills) and not very good at what they do not have access to learning (more complex problem solving).

This information helps us consider the direction that curriculum and instruction should take in the future in the United States. The primary issues to consider in planning for the future mathematics education of our students are: 1) the opportunity to learn (by all students); 2) the availability of instruction that leads to higher order thinking; and 3) the ability to use mathematics to solve complex problems.

National Perspective

The National Assessment of Educational Progress (NAEP) is the standardized assessment that is used in the U. S. to assess K-12 students' mathematical progress. Results from this national assessment support the TIMSS conclusions; U. S. students, on average, have little difficulty with NAEP items that require a computation. However, when asked to complete a multi-step problem, U. S. students have much more difficulty (Kloosterman & Lester, 2004; 2007).

Each state is required to test a portion of its students with the National Assessment of Educational Progress (NAEP) test in both reading and mathematics annually. The U.S. Department of Education then compares NAEP results to the state assessment results, seeking to ensure that the state assessments provide a valid picture of student achievement in Missouri. In other words, NAEP is the "yard stick" to which all U. S. states' individual test results are calibrated. Because each state has defined what "proficient" means, the comparison of state-specific assessment results to State NAEP results ensures a consistency across states with regard to assessing student achievement. So, what is deemed "proficient" in one state should be similar to what is deemed "proficient" in other states.

Analysis of this comparison has shown that many states are over reporting or under reporting the levels of proficiency for their students. This occurs when a state's level of proficiency as measured by their own test is higher or lower than the NAEP results for that state.

For Missouri, the NAEP results were essentially the same as State MAP results showed in mathematics. Thus, MAP *does* give an accurate picture of Missouri student achievement in mathematics from a national perspective; therefore considering MAP scores of CPS students allows us to situate our students in a national landscape.

Missouri Perspective

National and international assessment results have prompted enough concern in Missouri that the current governor, Matt Blunt, recently convened a working group to improve our understanding of student achievement in Math, Engineering, Technology and Science (METS) – the *METS Alliance* (see http://www.missourimets.com). The Alliance's report, submitted to Governor Blunt on August 31, 2006, highlighted several areas of concern that speak to why improving math education at all levels is so critical. First, the report argues, the number of U.S. students earning degrees in METS programs significantly lags behind the number of students earning similar degrees in countries considered to be our economic competitors in Europe, Asia, and other developed nations. Second, other than computer science, the number of bachelor degrees in METS areas has dropped or remained unchanged over the past two decades (even as the need for these areas has increased). Thus, the U.S. is increasingly relying on foreign-born professionals in scientific and engineering fields.

The Alliance report also included data indicating that fewer parents insist that their children to take more math courses, a drop from 48% to 32% since 1994. Recent surveys show that citizens believe that the U.S. will not be the strongest economic power in 20 – 30 years, having been surpassed by China (with significant gains from India as well). Opinion leaders, from both the political and private sector, share the same view forecasting the U.S.'s diminished rank.

These performance trends are particularly concerning when considering the increased need for preparation in mathematics that will be necessary for the jobs of the future. The METS Alliance report reveals that over 50% of all employers, in all occupations, identify a significant need for their employees to have an understanding of mathematics. Jobs in the technology field pay higher than other industries. Creating appropriate opportunities for our children are crucial for their economic futures. The report contains 5 strategies to support METS in the state, the first of which is to "improve the performance of all P-20 [pre-kindergarten through college] students." Further, the report contains the following recommendation:

> *Improve METS curricula and assessments*. Revise Missouri's K-12 GLEs and assessments for mathematics and science to support focused, inquiry-based instruction modeled on internationally recognized best practices. Ensure that collegiate-level METS curricula follow the same focused, inquiry-based instruction. (Executive Summary, p. 1)

What Research Indicates about Mathematics Learning, Mathematics Teaching, and Professional Development for Mathematics Teachers

In this section, we present a brief review of several research studies pertinent to the work of the Taskforce. These findings were reinforced for the Taskforce through presentations given by Ruth Parker (February 20, 2007) and Dr. James Hiebert (March 6, 2007), nationally known experts in the area of mathematics education.

Research on Learning Mathematics

Prompted by trends in student performance, much discussion and work at the national level has taken place over the past two decades with regard to mathematics learning in grades K-

12. Often the conversations narrow, polarizing groups into the declaring the "best" way to learn mathematics in school. Most often, the groups advocate different approaches to mathematics education, and are typically characterized by the descriptors "reform" and "traditional." A reform 6-12 mathematics program can be described as having a structure adheres to a set of content standards, meaning there are certain articulated mathematical concepts and understandings that drive instruction. Typically, students who study mathematics in a program considered to be reform in nature engage in learning several mathematical content strands in one year, and the content spirals and builds over the course of a several-year design. Each year in a reform program, students study in the areas of number and operation, algebra, geometry and measurement, discrete mathematics, and probability and statistics. Students who study mathematics in a program considered to be traditional in nature learn one content strand per year (typically in classes titled Algebra I, Geometry, Algebra II, and Precalculus).

The authors of *Adding It Up: Helping Children Learn Mathematics* (National Research Council, 2001), leaders in the field of mathematics learning, recommend that rather than focusing on an either/or focus for mathematics education, we should focus on supporting our students to develop 'mathematical proficiency.' These authors describe mathematical proficiency as five interwoven and interdependent strands: 1) conceptual understanding, 2) procedural fluency, 3) strategic competence, 4) adaptive reasoning, and 5) productive disposition. Students' abilities to understand and use the mathematics requires more than memorizing facts and procedures (procedural fluency). It also requires the ability to formulate, represent and solve problems (conceptual understanding, strategic competence, adaptive reasoning). In addition, teachers should support students in developing logical thought, reflection, and justification in order to generate the habitual inclination to see mathematics as sensible, useful, and worthwhile (productive disposition).

How People Learn: Bridging Research and Practice (National Research Council, 1999) provides the results of a synthesis of several studies on both learning theory and research of teaching practices. The resulting framework suggests the need to generate optimal learning environments by creating classrooms that value learning, knowledge, assessment, and community. Since learning does not occur in a vacuum, students come to each class, or setting, with prior knowledge upon which teachers must build. A companion to *How People Learn* titled *How Students Learn: Mathematics in the Classroom* (National Research Council, 2005) presents three essential principles of learning mathematics: 1) engaging prior understandings; 2) the essential role of factual knowledge and conceptual frameworks in understanding; 3) the importance of self-monitoring. Taken together, consideration of environment and learning principles creates a classroom where the teacher: 1) acknowledges and builds on students' prior understandings, 2) helps students build conceptual frameworks on which to 'hang' procedural knowledge, 3) assesses student learning throughout instruction and makes instructional decisions based on those assessments; 4) supports students in practices of meta-cognition (thinking about what and how they are thinking mathematically); and 5) builds a classroom community that provides a safe and productive place for students to learn mathematics.

Research on Teaching Mathematics

While each of the frameworks described above seems to use different language and design, it is clear that the instructional model employed in a typical U.S. mathematics classroom (characterized by: teacher demonstrates – students practice) does not include the interacting elements necessary to create the rigor required to increase achievement for all students.

Based on their review of research on teaching and learning mathematics, presented as a chapter in the *Second Handbook of Research on Mathematics Teaching and Learning* (Lester (Ed.), 2007) titled "The Effects of Classroom Mathematics Teaching on Students' Learning," Hiebert and Grouws claim that "the nature of classroom mathematics teaching significantly affects the nature and level of students' learning" (p. 371). Further, they report that two features are key to success for students: 1) that teachers and students attend explicitly to concepts; and 2) that students struggle with important mathematics.

With regard to the first feature (that teachers and students attend explicitly to concepts), Hiebert and Grouws write:

> By *attending to concepts* we mean treating mathematical connections in an explicit and public way…. This could include discussing the mathematical meaning underlying procedures, asking questions about how different solution strategies are similar to and different from each other, considering the ways in which mathematical problems build on each other or are special (or general) cases of each other, attending to the relationships among mathematical ideas, and reminding students about the main point of the lesson and how this point fits within the current sequence of lessons and ideas. (p. 383, authors' emphasis)

With regard to the second feature (that students struggle with important mathematics), Hiebert and Grouws write:

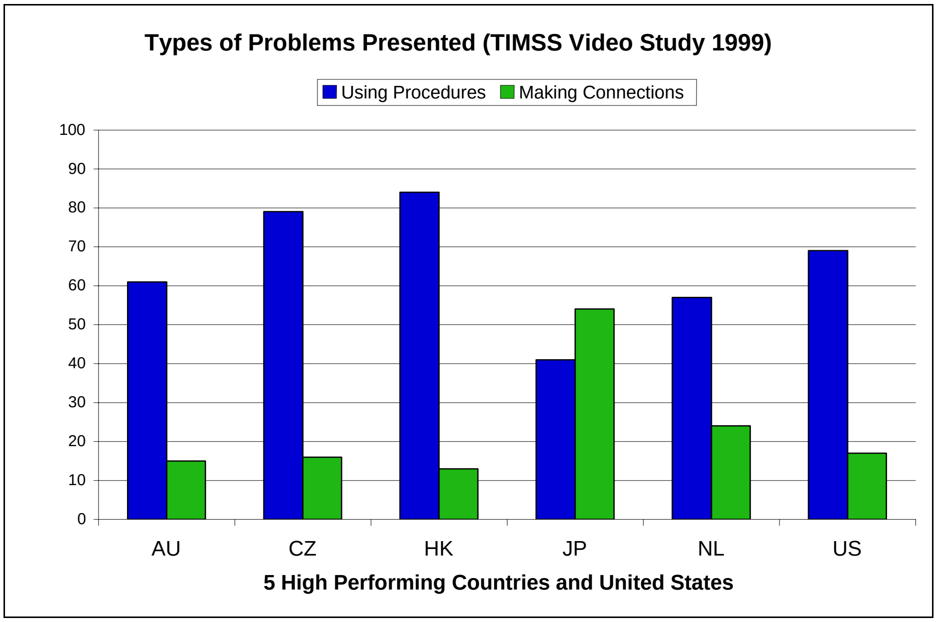
> We use the word *struggle* to mean that students expend effort to make sense of mathematics, to figure something out that is not immediately apparent. We do *not* use *struggle* to mean needless frustration or extreme levels of challenge created by nonsensical or overly difficult problems….The struggle we have in mind comes from

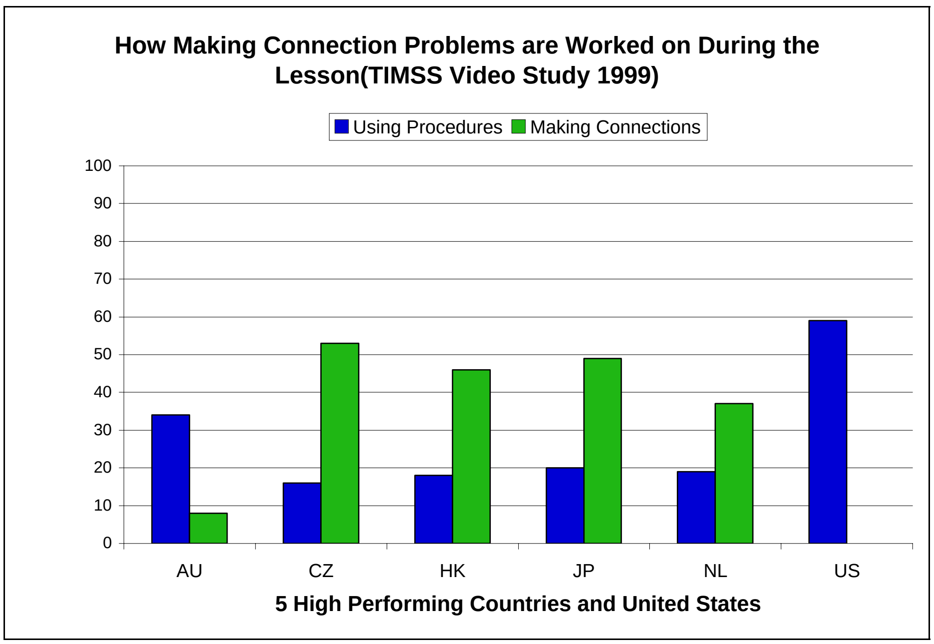
> solving problems that are within reach and grappling with key mathematical ideas that are comprehendible but not yet well formed. (p. 387, authors' emphasis)

Research indicates that student learning gains where highest for students whose teachers maintained a high level of cognitive demand throughout the learning process. When teachers chose problems that require a high level of cognitive demand, allowed their students an appropriate amount of time for grappling with mathematical concepts, supported their learning through scaffolding, did not take over the thinking for their students, and maintained a measure of classroom discipline, then their students met with a level of success not found in classrooms where teachers allowed the level of cognitive demand to decline during instruction (Henningsen & Stein, 1997; Stein & Lane, 1996).

Results from the TIMSS 1999 Video Study found similar results. In this study, researchers sought to understand instructional practices of mathematics teachers in the U. S. as well as in seven countries whose students scored higher (sometimes significantly higher) than U.S. students on the TIMSS mathematics assessment. One of the aspects of teaching that researchers investigated was the extent to which the mathematical problems are chosen and implemented in a way that helps students make mathematical connections (in other words, that help students understand how the mathematics "works"). As indicated in Figure 1, the U. S. results look similar to the higher-achieving countries regarding the types of mathematics problems that teachers choose for their students (1st graph). However, when researchers then analyzed how teachers and students implemented those problems (2nd graph), the U. S. results look very different from results of the higher-achieving countries. (For the entire TIMSS 1999 Video Report, see http://nces.ed.gov/pubs2003/timssvideo/Index)

Figure 1. *Results from the TIMSS 1999 Video Study*.





"Opportunity to learn is widely considered the single most important predictor of student achievement" (National Research Council, 2001, p. 334) and creating classrooms where students have the opportunity to learn meaningful mathematics should be the focus of mathematics classrooms at all levels.

> Opportunity to learn is not entirely a function of teaching or entirely under control of the teacher. The curriculum [mathematics textbook] the teacher is required to use, for example, surely influences students' opportunity to learn…But teaching, as we have defined it, plays a major role in shaping students' learning opportunities. The emphasis teachers place on different learning goals and different topics, the expectations for learning that they set, the time they allocate for particular topics, the kinds of tasks they pose, the kinds of questions they ask and responses they accept, the nature of the discussions they lead – all are a part of teaching and all influence the opportunities students have to learn. (Heibert & Grouws, 2007, p. 379).

As the vision of what it means to be mathematically literate in our society has moved from basic-skills to a more demanding standard, the limits of past pedagogical practice have become increasingly apparent (Struchens, Johnson, & Tate, 2000). For example, Newmann, Marks, and Gamoran (1996) found much higher levels of achievement on complex performance tasks for students of all backgrounds who experienced what researchers termed as "authentic pedagogy" or instruction focused on active learning in real-world contexts. Authentic pedagogy calls for higher-ordered thinking, consideration of alternatives, use of core subject ideas and modes of inquiry, extended writing, and an audience beyond the school for the work. Lee, Smith, and Croninger (1997) found that where such authentic instruction was widespread, an average student would learn a significant amount more math between 8th and 10th grade than a comparable student in a school with a low level of authentic instruction.

One of the most pervasive dichotomies that currently exists in mathematics education is the procedures-first/conceptual understanding second OR conceptual understanding first/procedures second. As described above, the second essential principle for learning articulated by *How Students Learn: Mathematics in the Classroom* (NRC, 2005) suggests that procedural knowledge is lasting when built upon conceptual frameworks. Other research also indicates that this sequencing is more effective for mathematical learning. Pesek and Kirshner (2000) found that students who focused first on conceptual understanding and then on associated mathematical procedures scored higher and had greater retention than students who first learned the procedures and then worked to understand the associated underlying mathematical concepts. This finding does not mean that engaging in a conceptual focus is easier for students; these researchers also found that this learning sequence generated some student discomfort due to the high levels of cognitive demand required. This study supports the need to provide appropriate rigor as a part of the instructional opportunities for students.

Many studies, notably by Oakes (1990) and Powell (1994) as well as one conducted by the Education Trust (1998), highlight the tendency for schools to place minority students in courses that have a greater emphasis on drilling the “basics” rather than on engaging students in higher level thinking necessary to be successful in math. Powell (1994) indicates that minority students were 7 times more likely than whites to be placed in lower academic track courses. Further, Powell reported that even when lower-SES minority boys scored the same as middle-class white girls on standardized tests, the minority boys tended to be placed in special education programs. Minority students often are relegated to low level options where the curriculum tends to be oversimplified, repetitive, and fragmented (Oakes, 1990).

Providing students with the opportunity to take higher-level courses results in an increase in performance on national tests, regardless of the ethnic group. Providing a rigorous mathematics curriculum also improves student achievement (Education Trust, 2001).

Professional Development for All Mathematics Teachers

Few would deny the many challenges presented in the teaching profession. The difficulties are not eased when one considers how our teachers are products of our system of education in the U. S – the very system, experts argue, that has not been challenging students sufficiently. Deborah Ball (1987) described this phenomenon as 'teachers teach as they have been taught.' As a result, teachers' views of what a classroom looks like, and how the teacher and students interact in that classroom, has typically limited students' opportunities to learn. Given the research cited in prior sections of this paper, we know that limiting students' opportunities to learn has a detrimental effect on their mathematical proficiency. The literature also calls for a shifting view of mathematics classrooms and what it means to 'know' mathematics. This creates the necessity of mathematics teachers to continue to learn and adapt their classroom practices throughout their careers. The research literature provides much information about 'best' practices of professional development.

Teachers with relatively weak conceptual knowledge tend to employ an instructional style in which they demonstrate a procedure and then give students opportunities to practice the procedure (demonstrate/practice). These teachers provide students with little assistance in developing understanding of what they are doing, focusing instead on students' abilities to mimic the completion of a procedure (Leinhardt & Smith, 1985). (As has already been discussed in this paper, a lack of conceptual understanding negatively impacts student achievement.) In examining the relationships between teacher content knowledge and student performance, Brown and Borko (1992) found that teaching mathematics from a conceptual perspective is very unlikely to occur unless a teacher has a deep conceptual understanding of the subject matter.

Thus, professional development should have as one of its focal points work to insure that teachers' content knowledge is supported and deepened.

Sanders and Rivers (1996) found that students whose teachers were rated "highly ineffective" averaged gains of 29%, and students whose teachers were rated "highly effective" averaged a gain of 83%. In addition, residual effects were present; students of the 'ineffective' teachers continued to struggle with subsequent mathematical learning, while the students of the 'effective' teachers experienced continued benefits even two years later. Research further indicates that students who have 'ineffective' teachers two years in a row may never recover. Districts cannot afford to look the other way in terms of developing stronger teachers.

Wenglinsky (2000) correlated over 7000 students' NAEP scores to surveys completed by both students and teachers and found that students whose teachers received professional development in working with special populations outperformed their peers by more than a full grade level. In addition, students whose teachers received professional development in higher-ordered thinking skills outperformed their peers by 40% of a grade level. The need to provide continuous relevant professional development is crucial for all of our students.

Classroom practices have been shown to have the greatest impact on student achievement (Wenglinsky, 2000) over other factors (i.e., years teaching, degree held, major or minor). Wenglinsky found that students whose teachers regularly taught lessons containing hands-on learning activities outperformed their peers by 72% of a grade level in math. Regular use of "ditto sheets," which most often focus on rote performance of mathematical procedures, correlates negatively with student test scores. Students whose teachers regularly used point-in-time assessments outperformed peers by 46% in math; and students whose teachers emphasized higher-order thinking skills in math scored about 40% of a grade level higher than their peers whose teachers regularly emphasized lower order thinking skills.

Research by Lichenstien, McLaughlin, and Knudsen (1992) indicates that teachers' knowledge of subject matter is strengthened when they engage in networks with other teachers. These authors argue that participating in a professional learning community helps teachers to recognize their own expertise and expand their knowledge about instruction.

Districts must be focused on increasing student achievement, and given the significant impact teachers have within the classroom, plans must also be made to support the growth of teachers on a continuing basis. A few years of work to implement a program is not enough to support the new learning necessary for teachers to be effective in the mathematics classroom. Teacher turnover, changes in technology, and changes in the needs of particular groups of students all point to the need for continuous development of our teacher workforce. Learning, be it student or teacher, should be something we commit to do for a lifetime. Providing structures to promote growth through professional development will be the most direct method for impacting student achievement.

Many structures for supporting teacher learning exist. For example, extended summer workshops support teachers who are learning to implement a new textbook series. However, summer workshops are limited in supporting teachers in changing their classroom instructional practices in a significant manner. Professional learning communities (or professional learning teams) have emerged as an effective model of teacher professional development in recent years. Research on professional learning communities indicates that allowing teachers to work together on content grounded in their everyday classroom practices has a positive impact on their teaching (see, for example, Dufour & Eaker, 1998). Another structure for supporting teacher learning is the use of mathematics coaches. Coaches, typically experienced mathematics teachers, work one-on-one or with a small group of teachers over an extended time period. Much of the work of this type of professional development happens in the classroom, where the coach and teacher focus on improving instructional practices.

A Guiding Framework for CPS Mathematics Education

Following our review of the research literature, the members of the Taskforce adopted the definition of "mathematical proficiency" as provided by the authors of *Adding it Up* (NRC, 2001). This definition of mathematical proficiency includes five interwoven strands:

> *Conceptual understanding* – comprehension of mathematical concepts, operations, and relations
> *Procedural fluency* – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
> *Strategic competence* – ability to formulate, represent, and solve mathematical problems
> *Adaptive reasoning* – capacity for logical thought, reflection, explanation, and justification
> *Productive disposition* – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy. (Executive Summary, p. 5)

The authors of *Adding it Up* explain:

> The most important observation we make about these five strands is that they are interwoven and interdependent. This observation has implications for how students acquire mathematical proficiency, how teachers develop that proficiency in their students, and how teachers are educated to achieve that goal. (Executive Summary, p. 5)

Members of the Taskforce believe that this definition allows CPS to collect different kinds of data as evidence of CPS students' depths of mathematical proficiency (see Appendix X for more information).

The Status of CPS Secondary Mathematics Education

During Taskforce meetings, we examined three types of CPS data: 1) enrollment figures; 2) standardized test data; and 3) student, parent, teacher, administrator/school personnel perceptual data. In addition the Taskforce members requested that a section of this report be dedicated to the current status of professional development for CPS 6-12 mathematics teachers. In this section, we report status of CPS grades 6-12 mathematics education.

Enrollment Figures

CPS enrollment data indicate that the percentage of grades 10-12 students who take mathematics has increased over the past 5 years (see Table 1 below). In fact, the percentage of students enrolled in mathematics classes has increased at a faster rate than the percentage of students enrolled overall. It is important to note that these numbers reflect students who ended the year in these courses rather than those who began the year, so the percentages are reflective of students who completed a mathematics course. In addition, these numbers reflect student course-taking trends prior to changes in state requirements for mathematics (an increase from 2 credits to 3 beginning with the class of 2010). While we currently have students taking multiple courses, such as lab courses to support their primary course, these percentages **do not** include the lab courses.

Table 1. *Enrollment in CPS Mathematics Courses, Grades 10-12*

Year	Percentage of grades 10-12 students enrolled in mathematics courses
2000-01	78.2
2001-02	73.8
2002-03	75.3
2003-04	75.3
2004-05	80.5
2005-06	82.3

Table 2 (below) presents enrollment data with regard to the percentage of students who are in “appropriate” levels of mathematics courses. The phrase “on-level” is used to characterize those students who are taking the appropriate course (or a more advanced course) for their grade level. For example, a 12th grader in geometry would not be considered “on-level” because geometry is considered to be a 10th grade-level course. CPS students have shown an increase in the percentage of students who are “on-level” or above over the past 3 school years. This growth is present in all our ethnic groups, but is especially noteworthy in our African-American population, which has shown the largest percent gains over this period. While differences remain between on-level enrollments of the white and black populations, there has been a narrowing of the “on-level” enrollment gap. The data indicate no appreciable differences between male and female students with regards to “on-level” enrollment.

Table 2. *Percentage (Number) of Students On- or Above-level in Grades 9-12*

	White	African-American	Hispanic	Asian	American-Indian	Total
2003-04	77 (n=2551)	38 (n=209)	29 (n=44)	79 (n=158)	45 (n=5)	71 (n=2967)
2004-05	81 (n=2710)	50 (n=328)	59 (n=61)	84 (n=183)	71 (n=10)	76 (n=3292)
2005-06	83 (n=3093)	56 (n=499)	64 (n=95)	87 (n=215)	65 (n=13)	78 (n=3910)

The data presented in Table 2 do not represent enrollment patterns in honors courses. The data presented in Tables 3 and 4 represent honors course enrollment data for the classes of 2007 and 2008. Enrollment levels in CPS-designated “honors” mathematics courses are concerning. For example, when considering the students in the class of 2007 who were placed into an honors mathematics course in 8th grade and were still in CPS schools as 11th graders, only 72% (sum of total percentages for Integrated 4, Integrated 4H, Pre-calculus, or Pre-calculus H in Table 3) of those students were enrolled in a mathematics course in grade 11 that is above-level. A closer look into the data shows that less than ½ of those students are still enrolled in a course designated as "honors," with 26% of students in the Algebra pathway enrolled in a Pre-calculus honors course and 52% of students in the Integrated pathway enrolled in an Integrated Math 4 honors course.

Table 3. *Percentage of students (who began Honors Mathematics in grade 8) in 11th grade math class (graduating class of 2007)*

	Alg. 2	Coll. Alg.	Int. Math 2	Int. Math 3	Int. Math 3H	Int. Math 4	Int. Math 4H	Pre-Calc.	Pre-Calc. H	Stat.
Alg 1 H (n=43)	2	16	2	7	5	0	0	40	26	2
Int 1 H (n=48)	6	2	0	10	0	27	52	0	0	2
Total (n=91)	4	9	1	9	2	14	27	19	12	2

For the class of 2007, both options were only available for 8th-graders at Jefferson Junior High School, thus explaining the difference in enrollment numbers for the two sets of data presented in Tables 3 and 4.

For the class of 2008, the trends appear much the same (see Table 4). This is the first class in which students, across the district, could opt into either the Algebra pathway or the Integrated pathway as 8th-graders. As 10th-graders, 70% (sum of percentages of Algebra 2, Algebra 2 honors, Integrated Math 3, Integrated Math 3 honors in Table 4) of the students who began in honors classes as 8th-graders were still in classes that are above-level. Again, a closer look at the data indicates that the attrition from honors courses is concerning, with 46% of students in the Algebra pathway enrolled in an Algebra 2 honors course and 68% of students in the Integrated pathway enrolled in Integrated Math 3 honors.

Table 4. *Percentage of students (who began Honors Mathematics in grade 8) in 10th grade math class (graduating class of 2008)*

	Alg. 2	Alg. 2H	Appl. Math	Geom.	Int. Math 2	Int. Math 2A	Int. Math 3	Int. Math 3H
Alg 1 H (n=155)	29	46	1	6	18	0	0	0
Int 1 H (n=176)	0	1	0	1	14	1	15	68
Total (n=331)	14	22	0	3	16	1	8	36

As a historical example, data for the class of 2003 present a similar situation. Enrollment data for that class indicate that 22.7% (62/273) of those students who started in an Algebra 1 Honors course in the 8th grade were enrolled in AP calculus as seniors. As the data for the classes of 2007 and 2008 regarding AP Calculus course enrollment become available, it will be important to document the percentages of students who are enrolled in AP calculus in order to be able to study these trends.

Standardized Tests

Most college-intending students in CPS take the ACT (formerly known as the American College Testing Program) during their junior and/or senior years. The mathematics assessment on the ACT is one of four areas for which students receive a score. Data from recent administrations of the test provide a snapshot of our students' abilities at the end of their mathematics coursework in CPS. As shown in Table 5, the scores of CPS students, on average, have not changed appreciably over time. The district average of just over 23 for the time period is higher than average scores at both the state and national levels. In fact, the consistency of ACT scores over this time period is particularly impressive when considering increase in the percent, from 1999, of CPS students who took the test. Often, an increase in the number or percent of students who take the ACT correlates with a decrease in the ACT average. This negatively correlated relationship was not the case for our district during this time period.

Table 5. *Number, Percentage, and Average ACT Scores, 1998-2006*

	Number (Percentage) of CPS Seniors Taking the ACT*	Average ACT Mathematics Sub-score for CPS students
1998-99	565 (59%)	23.2
2003-04	811 (72%)	23.3
2004-05	802 (73%)	23.3
2005-06	786 (73%)	23.2

*These data include any student that took the ACT as a senior **plus** any student who took the ACT as a junior but *not* as a senior

Data available on the Missouri Department of Elementary and Secondary Education (DESE) website indicate that CPS students' ACT scores, on average, are consistently at least two points higher than the state and national averages.

Table 6 contains data with regard to ACT scores of students who have been enrolled in the Algebra pathway and the Integrated Math pathway. From these data, it appears that students enrolled in the non-honors Algebra pathway, on average, out-score those students enrolled the non-honors Integrated pathway on the ACT. The ACT scores of those students enrolled in the honors versions of both pathways are comparable.

Table 6. *Class of 2006 Average ACT and 8th-grade Terra Nova Scores*

	Average ACT Score (Grade 12)	Median Terra Nova Percentile (Grade 8)
Algebra Pathway (non-honors) n=98	25.2	86
Integrated Math Pathway (non-honors) n=68	20.2	56
Algebra Pathway (honors) n=6	25.2	94
Integrated Math Pathway (honors) n=6	24.9	90

The difference in ACT scores for non-honors students is concerning, until other data are also considered. Also presented in this table are the scores from the Terra Nova assessment (part of the Missouri Assessment Program or MAP) for these same students when they were in 8th grade.

These data represent the median percentile for the group of students. When considering the Terra Nova data, one can see that the achievement of the students who entered the two pathways was different from the onset. Thus, to simply compare ACT scores of these two populations of students as an indicator of curricular impact is ill advised.

CPS 10th-grade students participate in the mathematics portion of the Missouri Assessment Program (MAP). The percentage of CPS students who score at the “proficient” or “advanced” levels on the 10th-grade mathematics assessment is higher than in many districts across Missouri. CPS students consistently out-perform their counterparts in the state. Additionally, the percentages of CPS students scoring at these two levels has been increasing at a faster pace than the same percentages in districts across the state. Columbia also has a smaller percentage of students who score in the bottom two categories and these averages are decreasing at a faster rate than those of many districts across the state. Although these data are encouraging, the MAP data also indicate a persistent gap in average scores between different demographic groups of students, most notably between White and African-American students.

Perceptual Data

The Secondary Program Evaluation Committee surveyed CPS 10-12 students, their parents, 10-12 teachers and administrators/counselors in order to gather data about the different stakeholder groups’ perceptions of secondary mathematics. The data indicated that, overall, the four groups felt that high school mathematics courses were challenging, required reasoning and justification, and were preparing students for their future. (The results of the entire survey are available upon request to the Secondary Mathematics Coordinator and will be posted on the CPS website during summer 2007.)

We present an abbreviated list of questions and responses from students, teachers, and parents in Table 7. Each survey contained about 27 questions; many of the questions and responses shown below were on all three surveys. As shown in this table, interesting differences exist between students' and teachers' responses. Also of interest is that only 45% of students agreed with the statement "In general I enjoy math class."

Table 7. *Selected Questions from the CPS Perceptual Survey Data*

		Students			Teachers			Parents		
Item	Question	Sum of SA & A	N	Sum of SD & D	Sum of SA & A	N	Sum of SD & D	Sum of SA & A	N	Sum of SD & D
A	Math courses are academically challenging.	74.87	17.38	7.75	92.59	7.41	0	85.61	9.36	5.03
B	Math courses help to develop my reasoning skills to solve problems.	70.32	21.21	8.47	96.29	3.7	0	84.02	11.64	4.34
C	Classroom experiences show me how to apply math to real-world situations	42.78	35.03	22.19	77.78	18.52	3.7	58.22	31.96	9.82
E	In general I enjoy math class (for teachers and parents, the question asked about their students' enjoyment of math class)	45.1	27.09	27.81	59.26	25.93	14.81	66.44	19.63	13.93
F	Group work supports my learning in mathematics class	62.75	24.96	12.29	81.48	7.41	11.11	59.14	32.88	7.98
G	A variety of teaching strategies are used in my math class to help me understand concepts	54.82	29.06	16.12	92.59	7.41	0	58.91	31.05	10.04
H	Activities performed in math classes actively engage me	46.97	33.24	19.79	85.18	14.81	0	60.05	30.82	9.13
I	The amount of knowledge and skills learned in math is preparing me well for my future education and/or employment	56.59	26.11	17.3	81.48	3.7	14.82	73.28	17.81	8.91
J	Math classes encourage me to use multiple approaches (e.g. graphical, numerical, algebraic) to solve a problem	67.83	21.66	10.51	100	0	0	77.17	16.44	6.39
K	Explanations to justify answers are often required in my mathematics class	71.48	19.34	9.18						

SA - Strongly Agree; A - Agree; N - Neutral; D - Disagree; SD - Strongly Disagree
Number of Students completing survey: 1122; Number of Parents: 432; Number of Teachers: 27

CPS Mathematics Teacher Professional Development

Over the past five years, CPS 6-12 mathematics teachers have had the opportunity to participate in mathematics-specific professional development (PD) on a consistent basis. These opportunities have included: (a) PD designed to support teachers implementing Connected Mathematics at grades 6-8; (b) PD designed to support teachers implementing Core-Plus at grades 8-12; (c) Professional Learning Team meetings at some district schools (RBHS, JJHS, OJHS, GMS); (d) 2-3 days of PD during early release time at all district schools; and (e) academic-year, district-wide PD meetings led by Chip Sharp.

A very high percentage of CPS mathematics teachers participate in PD that occurs during their contract hours (e.g., c-e above). Smaller percentages of 6-12 mathematics teachers participate in PD that occurs outside of contract hours (e.g., after-school, on Saturdays, or in the summer months). To value the PD that teachers participated in outside of contract hours, they received either in-service credit (which teachers apply to movement on the salary schedule), or a monetary stipend.

Attendance records for CPS-sponsored PD held outside of contract hours indicates that only about ½ of the mathematics teachers in grades 6-12 take full advantage of this type of PD. For example, over the past 4 years, CPS has offered over 130 hours of PD (outside of contract time) for grades 6-8 teachers that focused on implementing Connected Mathematics. During this time period, the district employed approximately 35 mathematics teachers at grades 6-8. Of those teachers, attendance records indicate that approximately 45% attended the available PD on a regular basis, approximately 20% attended on a sporadic basis, and approximately 35% either attended rarely or did not attend at all. During 2002-2005, CPS offered over 200 hours of PD for teachers in grades 8-12, which focused on implementing Core-Plus. Approximately 50 teachers taught at a junior high school or high school during this period. Of those teachers, about 40 taught at least one Integrated Math course. Attendance records indicate that about 26 of those teachers attended over 75% of the available PD. The other 14 teachers' attendance could be characterized as sporadic or non-existent.

The attendance records from these types of PD indicate that while a number of CPS 6-12 mathematics teachers attend PD on a regular basis, this type of PD is not reaching all teachers on a consistent basis. In addition, results from the teacher survey indicate that teachers are not satisfied with the opportunities for collaboration with other mathematics teachers within the timeframe of their workday, with 52% of the teachers marking 'disagree' or 'strongly disagree' when asked to respond to the prompt, "There is adequate time during the day to support collaboration among faculty."

CPS Secondary Mathematics Taskforce Recommendations

Based on the findings of our work delineated in this report, the members of the CPS Secondary Mathematics Taskforce make the following recommendations:

Recommendation 1: **Improve communication with CPS stakeholders.**

CPS needs to improve communication with the parents and the public at large with regard to grades 6-12 mathematics education. We recommend three avenues for improved communication:

1) Concerted efforts should be made to improve the CPS web site to include information about mathematics education in CPS, the state, and the nation. Among other helpful information about mathematics education specific to CPS, this website should include links to important documents discussed in this report (e.g., *Adding it Up: Helping Children Learn Mathematics*; *How Students Learn: Mathematics in the Classroom*; The METS Alliance Report; The Nation's Report Card (NAEP results); and the TIMSS 1999 Video Study).

2) CPS should create and maintain a Mathematics Education Community Advisory Board, whose members should be comprised of parents, local business persons, University of Missouri faculty, CPS mathematics teachers, and CPS administrators (both at the school and district levels).

3) CPS should make concerted efforts to use local media to communicate with the public about mathematics education. For example, more content about mathematics education, as well as video from mathematics classes, could be shared through Channel 16.

Recommendation 2: **Utilize the five strands of mathematical proficiency as a guiding framework for mathematics education in CPS.**

The Taskforce recommends that the five strands of mathematical proficiency, as described in *Adding it Up: Helping Children Learn Mathematics* (NRC, 2001), be used as a guiding framework when making decisions about curriculum, instruction, and measures for data collection in CPS.

Recommendation 3: **Offer both Algebra and Integrated pathways.**

To provide students with different options for learning mathematics in CPS, the Taskforce recommends that CPS continue to offer enrollment in the Integrated and Algebra pathways. Enrollment in either pathway should be informed by the student, his/her parent(s), and teacher recommendation.

Recommendation 4: **Provide teachers and administrators quality professional development.**

The Taskforce recommends that CPS make a concerted effort to provide teachers and administrators with quality professional development that is offered during contract hours. This professional development should be school-based and focus on teachers’ classroom instruction.

Recommendation 5: **Strategically collect data that would inform CPS with regard to students' achievement across the five strands of mathematical proficiency.**

While ACT and MAP scores inform the district with regard to procedural fluency and conceptual understanding, CPS lacks a mechanism for assessing students' strategic competence, adaptive reasoning, and productive dispositions. Further, CPS should judiciously take into consideration data represented on the DESE and MDHE websites, utilizing the data in combination with locally-collected data.

Concluding Remarks

K-12 mathematics education in the U. S. is undergoing a transformation, begun two decades ago and continuing through today. Advances in our understanding of how students learn mathematics, coupled with the non-stop growth of a global community that depends upon technological advances, has created a world in which the mathematics education designed for the agrarian culture of the early 1900s, and has been prevalent in our schools ever since, no longer suffices for our students. Thomas Friedman, author of *The World is Flat*, states,

> The sky is not falling today, but it might be in fifteen or twenty years if we don't change our ways, and all signs are that we are not changing, especially in our public schools. Help is not on the way. The American education system from kindergarten through twelfth grade just is not stimulating enough young people to go into science, math, and engineering. (Friedman, 2005, p. 270)

The situation is indeed worthy of serious reflection, and CPS is positioned well to take its students into the next century by providing opportunities for all students to become mathematically proficient.

References

Ball, D. L. (1987). Unlearning to teach mathematics. *For the Learning of Mathematics*, *8*(1), 40-48.

Brown, C. A., & Borko, H. (1992). Becoming a mathematics teacher. In D. A. Grouws (Ed.) *Handbook of research on mathematics teaching and learning* (pp. 209-239). New York: MacMillan Publishing Company.

Dufour, R., & Eaker, R. E. (1998). Professional learning communities at work: Best practices for enhancing student achievement. Bloomington, IN: Solution Tree Publishing.

The Education Trust. (1998). *Achievement in America 1998*. Retrieved May, 2004, from http://www.vcss.k12.ca.us/region8/Presentations/Downloadpresentations/achievementinamerica.ppt

The Education Trust. (2001). *Achievement in America 2001*. Retrieved February, 2004, from http://www2.edtrust.org/NR/rdonlyres/033F3F28-4CF8-449B-80D9-322159E43E6E/0/achievement2001.ppt

Friedman, T. J. (2006). *The world is flat: A brief history of the 21st century*. New York: Farrar, Straus and Giroux Publishing.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371-404). Charlotte, NC: Information Age Publishing.

Henningsen, M., & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level thinking and reasoning. *Journal for Research in Mathematics Education*, *28*, 524-49.

Leinhardt, G., & Smith, D. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology*, 77(3), 247-271.

Lee, V. E., Smith, J. B., & Croninger, R. J. (1997). How high school organization influences the equitable distribution of learning in mathematics and science. *Sociology of Education, 70*(2), 128-50.

Lichenstein, G., McLaughlin, M.W., & Knudsen, J. (1992). *Teacher empowerment and professional knowledge*. Palo Alto, CA: Stanford University.

Kloosterman, P., & Lester, F. K. (Eds.), (2004) *The 1990 though 2000 mathematics assessments of the National Assessment of Educational Progress: Results and interpretations.* Reston, VA: National Council of Teachers of Mathematics.

METS Alliance Report. Found at http://www.gov.mo.gov/mets/

Nation's Report Card (NAEP). Found at http://nces.ed.gov/nationsreportcard/

National Research Council. (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academy Press.

National Research Council. (1999). *How people learn: Bridging research and practice.* Washington, DC: National Academy Press.

National Research Council. (2005). *How students learn: Mathematics in the classroom.* Washington, DC: National Academy Press.

Newmann, F. M., Marks, H. M., & Gamoran, A. (1996). Authentic pedagogy and student performance. *American Journal of Education, 104,* 280-312.

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science*. Santa Monica, CA: RAND Corporation.

Pesek, D. D., & Kirshner, D. (2000). Interference of instrumental instruction in subsequent relational learning. *Journal for Research in Mathematics Education, 31*, 524-540.

Program for International Student Assessment (PISA). Found at http://www.oecd.org/pages/0,2966,en_32252351_32235731_1_1_1_1_1,00.html

Powell, M. J. (1994). *Equity in the reform of mathematics and science education (executive summery)*. Austin, TX: Southwest Educational Development Laboratory.

Sanders, W.L. & Rivers, J. C. (1996). *Cumulative and residual effects of teachers on future student academic achievement*. Knoxville, TN: University of Tennessee Value-Added Research and Assessment Center.

Stein, M. S., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation*, 2, 50-80.

Struchens, M., Johnson, M. L., & Tate, W. F. (2000). *Changing the faces of mathematics: Perspectives on African Americans.* Reston, VA: National Council of Teachers of Mathematics.

Trends in International Mathematics and Science Study (TIMSS). Found at http://nces.ed.gov/timss/.

Wenglinsky, H. (2000). *How teaching matters: bringing the classroom back into discussions of teacher quality*. Princeton, NJ: Milken Family Foundation, Educational Testing Service.

Appendix 1

Secondary Mathematics Taskforce Members

Name	Role/Affiliation
Dr. Sandra Abell	Community Member – Parent
Ms. Sheila Adams	Teacher – chair, Lange Middle School
Dr. Fran Arbaugh	Community Member – MU (Taskforce Facilitator)
Mrs. Teresa Barry	Teacher – chair, Oakland Junior High School
Mrs. Katie Bihr	Teacher – chair, West Junior High School
Dr. Wanda Brown	Assistant Superintendent for Secondary Schools, CPS
Dr. Kathryn Chval	Community Member - MU
Mrs. Linda Coutts	Elementary Mathematics Coordinator, CPS
Dr. Cheryl Cozette	Assistant Superintendent for Curriculum and Instruction, CPS
Mrs. Dana Ferguson	Teacher – chair, Gentry Middle School
Mrs. Lisa Holt	Teacher – chair, Rock Bridge High School
Ms. Julie Kammerich	Teacher – chair, Smithton Middle School
Mrs. Lori Kilfoil	Teacher – chair, Jefferson Junior High School
Mr. Guy Lanphere	Community Member, 3M
Mrs. Cheryl Lightner	Teacher – chair, Hickman High School
Dr. Sally Beth Lyon	Director of Research and Assessment, CPS
Mr. Gordon McCune	Community Member – Parent
Mr. Randy Morrow	Community Member – Boone Hospital
Mr. Charles Neville	Community Member – Harry S Truman VA Hospital
Mr. Judi Privitt	Community Member – Parent
Dr. Robert Reys	Community Member – MU
Mr. Chip Sharp	Secondary Mathematics Coordinator, CPS

Secondary Mathematics Taskforce Meeting Schedule and Topics

Date	Topic
October 25, 2006	Review of International, National, and State Data
November 16, 2006	Review of CPS data, part 1
January 31, 2007	Review of CPS data, part 1
February 20, 2007	Presentation by Dr. Ruth Parker
February 21, 2007	Meeting with Dr. Parker – community building
March 6, 2007	Presentation by Dr. James Hiebert
March 14, 2007	Presentation debriefing and implications for CPS
April 2, 2007	Work on taskforce report
April 23, 2008	Work on taskforce report

Taskforce Report External Reviewers

Name	Affiliation
Dr. Lex Akers	Associate Dean for Academic Programs, MU College of Engineering
Dr. Monica Beglau	Director, eMINTS National Center
Dr. Melvin D. George	Professor Emeritus, MU Department of Mathematics President Emeritus of the University of Missouri
Dr. Paul Pitchford	Director, Central Regional Professional Development Center