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Office of the Superintendent of Schools
MONTGOMERY COUNTY PUBLIC SCHOOLS
Rockville, Maryland

November 9, 2010

MEMORANDUM

To: Members of the Board of Education

From: Jerry D. Weast, Superintendent of Schools

Subject: Update on the K–12 Mathematics Work Group

The Montgomery County Board of Education and Montgomery County Public Schools (MCPS) have consistently demonstrated a commitment to the relentless pursuit of success for every student and effective instructional programming as articulated in *Our Call to Action: Pursuit of Excellence,* Goals 1 and 2. In order to realize these goals, we have been dedicated to continuous improvement with ongoing examination and refinement of our work. In January 2009, as an outgrowth of this commitment, a K−12 Mathematics Work Group was convened to consider mathematics instruction in MCPS. The work group should be commended for its extremely thorough examination of this important topic and the extraordinary level of outreach undertaken to understand all perspectives. The group's work was rigorous and guided by research as participants developed recommendations for improving the MCPS mathematics program. The attached report provides a detailed review of the work group's findings and recommendations, as well as the basis for both.

Since my earliest days in MCPS, staff and stakeholders have understood the importance of an effective, rigorous mathematics program and have been willing to actively engage in both national and local conversations about what constitutes a superior mathematics program. This ongoing conversation, aided by such efforts as the Phi Delta Kappa International audit of the mathematics curriculum in 2000, and the 2001 development of Board of Education Policy IFA, *Curriculum,* has undoubtedly resulted in improved mathematics instruction in MCPS. Our reform process, grounded in the Baldrige principles of continuous improvement, requires a willingness to engage in ongoing reflection and refinement because systemic change is, by its very nature, evolutionary.

During the past decade MCPS' mathematics program has both evolved and been strengthened. Institutional barriers limiting opportunity for African American and Hispanic students have been dismantled and expectations for all students have been raised. This dual focus on equity and

excellence has been, and remains the foundation for all our reform efforts. As a result, we have seen student success in mathematics increase across the grade levels with more students than ever before achieving at high levels. At the same time, we know that we have not yet completely eliminated the achievement gap among student groups. As staff reviews the recommendations offered by the K−12 Mathematics Work Group, we will examine them carefully through this prism of excellence and equity. It is critically important to note that the adoption of the Common Core State Standards will guide our reforms as we continue our efforts to ensure that every student is well prepared for college and the world of work upon graduation from MCPS. We must acknowledge that fiscal realities will have an impact on our progress. That said, I am eager for staff to begin working to strengthen and improve our mathematics program to meet the needs of all of our children.

There is no question that the K–12 Mathematics Work Group has provided a wealth of material to consider as we move our mathematics agenda forward. I am appreciative of the rigorous and scholarly approach taken by the work group members, as well as the tremendous amount of time each member contributed to this undertaking. The attached report is an excellent springboard for our continued improvement. For your reference, I have attached to this memorandum the executive summary from the K−12 Mathematics Work Group Report.

At the table for today's discussion are: Mr. Erick J. Lang, associate superintendent, Office of Curriculum and Instructional Programs; Mr. Sherwin Collette, chief technology officer, Office of the Chief Technology Officer; Ms. Nicola Diamond, executive assistant, Office of the Chief Operating Officer; Dr. Joanne Smith, principal, Glen Haven Elementary School; and Dr. Kara B. Trenkamp, instructional specialist, Office of the Chief Technology Officer.

JDW:lcw

Attachments

Attachment

K-12 Mathematics Work Group Report Executive Summary

All students in Montgomery County Public Schools (MCPS) must have access to high-quality mathematics instruction in which teachers engage and effectively meet the needs of all students in learning and understanding important mathematical ideas. As students prepare for life and work in the 21st century, there is little doubt that they need to develop strong quantitative literacy skills and be able to think and reason at high levels. Over the years, the mathematics program in MCPS has been the focus of significant attention as the school system worked to provide its students with the necessary foundation in mathematics. The ongoing discussion, which mirrors the national conversation about the complexity of effective mathematics instruction for all students, emphasizes the general consensus that excellence in mathematics curriculum and instruction is a prerequisite for creating and maintaining a premier school system.

Background

For more than a decade, in partnership with key stakeholders, the Montgomery County Board of Education and MCPS continually have reflected on and explored efforts to improve mathematics teaching and learning as part of its ongoing improvement strategies. These improvement efforts have included: a 2000 Phi Delta Kappa International audit of the mathematics curriculum; the 2001 development of Board of Education Policy IFA, *Curriculum*; the 2002 Board of Education approval of the revised mathematics curriculum frameworks; and ongoing administrator professional development that was designed to support their leadership and understanding of high-quality mathematics instruction. These studies and improvement efforts focused on the district's governance, curriculum, instruction, assessment, and teacher preparation and experience, as related to the teaching and learning of mathematics. The action steps stemming from these earlier recommendations resulted in increased student achievement and systemic changes that emphasized communication of multiple pathways for differentiation including acceleration through the K–8 mathematics curriculum.

Over the last several years, MCPS initiated steps to remove institutional barriers that limited African American and Hispanic students, as well as students receiving special education, English for Speakers of Other Languages, and Free and Reduced-price Meals Systems services from accessing challenging mathematics courses. The district's resolve to eliminate barriers and to nurture a culture of high expectations for all students effectively removed sorting and selecting practices based on assumptions about ability. The efforts to increase students' access to higher-level mathematics beginning in the elementary grades meant that not all students were adequately prepared for success in some courses.

These efforts to remedy inequities in mathematics have led to many successes. For example, more students are completing Math 6 in Grade 5 and Algebra 1 by Grade 8, leading to higher SAT scores. In particular, efforts to close the achievement gap between African American and Hispanic students and their White and Asian American peers began to show signs of progress. For instance, the number of African American students receiving a college-ready score on at

least one Advanced Placement (AP) exam has more than tripled over the past 11 years, and for Hispanic students, that number has increased more than four-fold. On the SAT, the average score for African American students in 2010 rose to 1405, up 45 points in just five years. In that time, the gap between the performance of African American and White students has closed by 32 points—11 points on the mathematics portion alone. Hispanic students also have seen dramatic gains on the SAT, showing improvement in all areas, while scores in the state and the nation have dropped during the same time period.

With success also came challenges. The determination to dismantle barriers and change the culture of expectations resulted in over-correction in some instances. The reform effort effectively removed antiquated sorting and selecting mechanisms based on unsubstantiated assumptions about ability, but did not always match the district's efforts to support staff in appropriately meeting the learning needs of all students. As a result, some students were placed in courses for which they did not have adequate preparation. In addition, the achievement gap between African American and Hispanic students and their White and Asian American peers persisted despite some gains. Disturbing trends related to the achievement of special education and English Language Learners (ELLs) in mathematics also persisted. While the reform effort in mathematics has increased student achievement and decreased the disparity among the races, the next phase of improvement requires further refinement of the mathematics program to reflect the dual commitment to equity and excellence.

The K-12 Mathematics Work Group

To address our goals of equity and excellence in mathematics, Dr. Frieda K. Lacey, deputy superintendent of schools, convened the K–12 Mathematics Work Group in January 2009, to explore the complex issues surrounding improving mathematics teaching and learning and student achievement in mathematics systemwide. Through a research-based approach, the work group members generated a comprehensive list of issues and concerns that were clustered into meaningful and manageable topics. A research team was formed for each topic, and critical questions were identified that guided each team's research. Through reviewing research literature; meeting with distinguished educators, research analysts, and policy experts in the field of mathematics; and analyzing relevant quantitative and anecdotal data; the work group built its understanding and developed a common knowledge around five research topics. The topics that emerged were the following:

- Curriculum: The Written Curriculum
- Classroom/Instructional Practices: The Implemented Curriculum
- Curriculum: The Assessed Curriculum
- Acceleration Practices: Mathematics Targets and Acceleration
- Teacher Preparation and Development: Teaching for Mathematical Proficiency

The K–12 Mathematics Work Group provided a forum for constructive discourse regarding what the mathematics instructional program should look like in MCPS. Issues were discussed and debated openly in the work group meetings. The work group provided a much needed opportunity for honestly discussing the varying, and sometimes competing perspectives. For

example, some teachers and other instructional staff members voiced frustration over the breadth of the mathematics curriculum and the scarcity of time to ensure students are well grounded in mathematics content and processes, especially in the early years. There were some principals and supervisors who pointed out that performance targets forced them to focus on the number of students enrolled in a level of mathematics and may have had the unintended consequence of students skipping grade-level material that contains critical content or processes. Parent voices told of their need to provide outside tutors for their students to maintain the expected status quo in mathematics achievement. Some students related how their early love for the challenge of mathematics dimmed after years of moving too fast too soon, with the stakes too high.

A significant component of the work group's charge was to gather and consider stakeholder input. The work group used a variety of methods to gather extensive feedback from a broad range of stakeholders including voices that have traditionally not been heard. During the fall of 2009, representatives of the K–12 Mathematics Work Group conducted multiple focus groups. In addition, comments were solicited from all local school Parent Teacher Associations (PTAs) and from each secondary school's Student Government Associations (SGAs). Approximately one-third of the PTAs responded along with seven SGAs. Individual parents and teachers also took the opportunity to share their thoughts and concerns.

During the tenure of the K–12 Mathematics Work Group, the Maryland State Board of Education (MSDE) adopted the Common Core State Standards. Subsequently the Montgomery County Board of Education adopted the standards. The Common Core State Standards initiative is a state-led effort coordinated by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO). The standards were developed in collaboration with teachers, school administrators, and experts to provide a clear and consistent framework to prepare children for college and the workforce. These standards define the knowledge and skills students should have within their K–12 education careers so that they will graduate high school able to succeed in entry-level, credit-bearing academic college courses and in workforce training programs. The standards—

- are aligned with college and work expectations;
- are clear, understandable, and consistent;
- include rigorous content and application of knowledge through high-order skills;
- build upon strengths and lessons of current state standards;
- are informed by other top performing countries, so that all students are prepared to succeed in our global economy and society; and
- are evidence-based.

Members of the work group examined the Common Core State Standards in draft form during their work and considered the impact of the standards on the MCPS mathematics teaching, learning, and assessment program. One notable finding from this examination is that the Common Core State Standards reflect the rigor and world-class standards for quality mathematics achievement for all students that had been the central component of the district's vision and expectations for all MCPS students. Specifically, by outlining a focused, rigorous, and coherent curriculum framework that leads all students to the engagement in and completion of Algebra 1 by Grade 8, the Common Core State Standards provide a pathway to college

readiness for all students and a framework that is aligned with our vision and support equity and excellence.

To aid the task of building consensus on the beliefs and values that should guide the teaching and learning of mathematics, the work group sought out experts in the field of mathematics. The selected speakers were some of the most preeminent scholars in their field. They presented multiple perspectives based on years of research and scholarly publication regarding how to improve the education of students of mathematics. Their specialties ranged from mathematics teaching and learning to educational policy analysis. This expertise provided important insights considered by the members of the work group as they developed their recommendations.

Vision for Mathematics Teaching and Learning

The world of the 21st century is a world in which the roles played by numbers and data are virtually endless. Educated adults need functional literacy in mathematics to live well in the society of the future. Success in the 21st century requires a mathematical knowledge that is greater than formulas and equations. It requires the ability to think quantitatively about everyday issues and to tackle complicated problems with careful reasoning. A deep understanding of mathematics equips people to think critically, to ask intelligent questions of experts, and to challenge assumptions confidently. These are skills required to thrive in the modern world.

As a result, all MCPS students must have access to high-quality mathematics instruction in which educators engage and effectively meet the needs of all students in learning key mathematics concepts and skills. Students must fully participate in classrooms that are challenging and nurturing communities which integrate a wide range of technologies to support 21st century learning. Based on its research findings and stakeholder input, the K–12 Mathematics Work Group members envisioned MCPS mathematics classrooms as communities where—

- students are fluent and resourceful problem solvers working together;
- the curriculum offers students multiple opportunities to learn challenging mathematics;
- there are ambitious expectations for all students, including those who are exceptionally talented in mathematics;
- highly effective teachers have the resources and support to expertly engage students with the mathematics curriculum;
- technology is used to support and engage students as an essential component of the teaching and learning environment;
- the learning needs and diverse backgrounds of all students are supported through differentiated instruction; and
- students confidently engage in complex mathematical tasks chosen carefully by teachers.

Realizing this vision requires a coherent and comprehensive mathematics curriculum; knowledgeable and skillful teachers who use assessment for and of learning; professional development that enhances and supports learning; instruction that meaningfully and purposefully integrates technology; and a commitment to both equity and excellence. Instructional leadership, a climate of high expectations, and frequent monitoring of student progress will combine to produce student success. The standards of proficiency necessary to support learning in

mathematics are clear to students, teachers, parents, and leaders. The challenge is enormous, and meeting it is essential. It is imperative that we provide our students access to these learning environments that enable them to understand and use mathematics in everyday life and in the workplace.

Members of the K-12 Mathematics Work Group expect this vision to provide a foundation upon which the future of mathematics in MCPS is built. They expect this future to be predicated on the belief that all students must achieve mathematical proficiency, which provides strong quantitative literacy skills.

Recommendations

This report presents recommendations that outline a framework that is intended to propel MCPS further down the path of meaningful reform. The recommendations leverage the work that has already been done in mathematics in MCPS and set the stage for the next decade. They are crafted to ensure all students have the opportunity to learn and meet the same high standards allowing them to access the knowledge and skills necessary for post-school success. Consistent with the district's commitment to continuous improvement, the recommendations offer guidance for decision-making about acceleration practices, curriculum and assessment, school structures, classroom instructional practices, and teacher preparation.

The intricate weaving of expert opinion, the realities of implementation, multiple stakeholder perspectives, Maryland's adoption of the Common Core State Standards, and system needs culminated in a shared vision of the ideal MCPS mathematics classroom and resulted in 26 recommendations.

Curriculum: Written Curriculum

For the purposes of this research group, written curriculum was defined as the scope, sequence, and pacing of standards, objectives, and indicators, as well as the resources that are used to teach the outlined indicators and the practices and philosophy that those materials reflect. The written curriculum includes content, processes, and practices that clearly delineate student learning trajectories based on research on teaching and learning. Also included are multiple methods for teaching or reteaching key concepts in mathematics to diverse learners.

Guiding the recommendations below is the belief that the written mathematics curriculum should be rigorous, coherent, and comprehensive. It must provide time, flexibility, and content and pedagogy resources for teachers and other instructional staff. As a result of engaging with this curriculum, all students, regardless of race, gender, or socioeconomic status achieve at high levels and develop a strong working knowledge of mathematics, which includes both the domains and the strands of mathematical proficiency.

Curriculum: Written Curriculum Recommendations

1. Revise and align the MCPS written curriculum to the CCSS, resulting in—
    - a streamlined curriculum with more in-depth study of content at each grade level;

- a focus on mastery of number concepts in elementary school;
- mastery in algebraic concepts by the end of middle school;
- a mathematical proficiency[1] with geometric principles and Algebra 2 concepts; and
- equitable preparation and opportunities for higher level mathematics courses in high school.

2. Investigate the adoption of the integrated secondary school mathematics pathway as articulated in the CCSS.

3. Provide curriculum resources that are aligned with the CCSS and support equitable access to learning by—
    - addressing content, pedagogy, assessment, and instructional practices;
    - offering tasks that allow for multiple places to begin a problem, multiple solution strategies or multiple solutions; and
    - presenting mathematics in contexts that include the use of culturally responsive practices and universal design principles.

4. Integrate a variety of technologies into the written curriculum to affect how mathematics is taught—to encourage critical thinking skills, to increase student motivation, and to facilitate access to mathematics content for all students, including those with disabilities and English Language Learners.

5. Create an online forum that allows instructional staff members to contribute to an evolving curriculum.

[1] Mathematical proficiency is the ability to think and reason mathematically and use mathematics to solve problems in authentic contexts. It consists of five strands: understanding, computing, applying, reasoning, and engaging.

Classroom Instructional Practices: Implemented Curriculum

The implemented curriculum is what is taught in the classroom and the strategies used to teach it. Instructional strategies, technology, and school structures are all important components in effectively implementing mathematics curriculum and student learning; however, the core message in all the research is that the competency of the teacher is the key to successful implementation of curriculum. Teachers and other instructional staff members make multiple decisions and should have multiple supports to determine the instructional strategies that are most appropriate for both the concept and the student.

Guiding the recommendations below is the belief that, in order to effectively implement the written curriculum, a highly-skilled teacher should be in each classroom and be supported by effective structures. A highly-skilled teacher should use effective pedagogical strategies, flexibly group students to meet the needs of all learners, and develop and utilize assessments embedded in instruction. School structures and schedules should support effective teachers by enabling collaboration, common planning time, and job-embedded professional development opportunities. The implemented curriculum should be aligned with the written curriculum and result in all students achieving mathematical proficiency by developing both conceptual understanding and procedural fluency.

Classroom Instructional Practices: Implemented Curriculum Recommendations

1. Support the improvement of mathematics teaching through the development and use of an instructional practices rubric that includes but is not limited to fidelity of curriculum implementation, equitable practices, inquiry-based instruction, mathematics discourse, metacognitive strategies, and differentiation.

2. Develop and implement a self-assessment, incorporating the instructional practices rubric, for instructional staff members to identify content and pedagogical strengths and needs so that instructional staff members have data to guide their professional development.

3. Identify school structures and strategies that promote success for all students and work to support their replication in multiple locations.
    - Implement school schedules that promote effective instruction and provide all students, including students receiving special education services and ELLs, with the mathematics instruction and support they need to succeed; and
    - Support instructional staff members as they work in collaborative teams to review curriculum, plan instruction, discuss student progress, review student data, and make adjustments in teaching.

4. Monitor implementation of MCPS Regulation IHB-RA, *School Academic Grouping Practices*, which establishes standards for ongoing and flexible grouping and regrouping of students to provide instruction differentiated to meet the needs of all learners.

5. Provide research-based guidance on the appropriate use of calculators.

Curriculum: Assessed Curriculum

Assessment refers to activities teachers and other instructional staff use to help students learn and to determine student progress; and can be informal or formal in design. Two general categories of assessment are used in education: assessment for learning, or formative; and assessment of learning, or summative. Formative assessment occurs during the instructional process and is intended to provide accurate and timely data on student progress. Summative assessment is intended to measure learning outcomes at the end of a unit or course and report those outcomes to students, parents, and administrators. Both formative and summative assessments are used nationally in K–12 mathematics, and are an integral part of teaching and learning in MCPS.

Guiding the recommendations below is the belief that assessment is not an event but an ongoing component of effective teaching and learning that prepares students for college and career success. Assessments are an important and intrinsic component of the instructional program. Mathematics assessment in MCPS makes students' thinking about mathematical content, concepts, and processes visible to the teacher, and indicates progress toward meeting standards. Teachers and other instructional staff use assessment data to make daily instructional decisions and to provide meaningful feedback to students that empowers them to own their learning. Local, state, national and international summative assessments ensure that students are receiving a standards-based education that prepares them for the 21st century global economy.

Assessed Curriculum Recommendations

1. Revise the MCPS mathematics assessment program to ensure it is aligned with the CCSS and measures a student's growth and achievement over time in all content standards, across all strands of mathematical proficiency (understanding, computing, applying, reasoning, and engaging), and at all levels of mathematical thinking (reproductions, connections, and analysis).

2. Provide formative and summative assessments at each grade level/course that make students' thinking visible to the teacher and inform teaching and learning.

3. Build time into the school schedule for mathematics teachers to collaboratively plan ongoing formative assessment, examine assessment data, reteach, reassess, and provide effective individual student feedback.

4. Provide professional development on formative assessment practices including item development, data analysis, and individual student feedback.

5. Create an online forum that will enable teachers to share their formative assessment items and practices.

6. Ensure the overall assessment program includes appropriate national and international norm-referenced assessments that provide useful national and international comparison data.

Acceleration Practices: Mathematics Targets and Acceleration

Acceleration is a term used to describe many instructional practices and is interpreted in different ways by different users. Acceleration can mean compacting curriculum, skipping units, grade levels or courses to reach an adequate level of instructional challenge for the student, and helping underperforming students master foundational knowledge to quickly reach grade-level or above grade-level standards. Currently the most common practice in MCPS is reflected in the second definition above—skipping units, grade levels or courses as students have demonstrated mastery. Consequently research focused on the impact and benefit of accelerating students into above grade-level courses.

Guiding the recommendations below is the belief that the MCPS mathematics program should be challenging and rigorous for all students and should be taught to mastery. Any acceleration should be based on the needs of the learner, supported by data, and flexible as the student moves through the course or content. Targets should be aligned with mastery of mathematical content.

Acceleration Practices: Mathematics Targets and Acceleration Recommendations

1. Eliminate the practice of having large numbers of students skipping grade levels in mathematics. Ensure that all students have access to in-depth content knowledge at each grade level or course as reflected in the CCSS.

2. Continue programs and acceleration for students who demonstrate exceptionally strong and consistent proficiency in all mathematical strands (understanding, computing, applying, reasoning, and engaging) as represented in the CCSS.

3. Monitor, at the school and district levels, secondary course placement decisions to ensure equitable preparation and opportunities for advancement for all students, including those groups who have been underserved in the past: African American, Hispanic, special education, and ELLs.

4. Assess the impact of the implemented CCSS on the instructional program, including acceleration and targets.

5. Refocus the elementary mathematics target and Key Three of the Seven Keys to College Readiness (Complete Advanced Math in Grade 5) to reflect the implementation of the CCSS.

Teacher Preparation and Development: Teaching for Mathematical Proficiency

High quality mathematics professional development is job-embedded, data-driven, research-based, differentiated, sustained over time, and balanced between content and pedagogy. It is the vehicle by which educators acquire or enhance the knowledge, skills, and beliefs necessary to produce high levels of learning for all students. Professional development designed to improve the teaching and learning of mathematics helps instructional staff

understand mathematics content and how students learn that content. The impact and effectiveness of professional development is increased when groups of instructional staff collaboratively reflect on and refine their instructional practice.

Guiding the recommendations is the belief that intensive and sustained high-quality professional development for all teachers and leaders of mathematics is essential to improve student achievement. High quality mathematics professional development is collaborative, job-embedded, data-driven, research-based, differentiated, and balanced between content and pedagogy. Professional development should be generative, and applied in a cycle of continuous improvement which results in mathematically proficient students and educators. The parents and students of MCPS should be confident that the teacher of mathematics in every classroom possesses the knowledge and skills necessary to enable every student to understand and use mathematics in a 21st century global society.

Teacher Preparation and Development Recommendations

1. Provide time and structures for instructional staff members to engage in collaborative, job-embedded professional development; apply what they learn; and reflect, reinforce, or revise instructional practices. Develop a plan to evaluate the impact of professional development on student learning.

2. Offer online, face-to-face, and hybrid (combination of online and face-to-face) professional development opportunities that align with the written curriculum and balance content knowledge and pedagogy.

3. Designate a school-based mathematics specialist in every elementary, middle, and high school with allocated release time whose primary role is to support the professional growth of mathematics instructional staff.

4. Expand and strengthen university program partnerships to—
    - provide teacher preparation aligned with MCPS goals for the teaching and learning of mathematics; and
    - place student teachers and interns in classrooms that provide models of effective mathematics teaching.

5. Continue to recruit and hire mathematics teachers with content expertise from a variety of professional backgrounds, including those who have pursued alternate routes to teacher certification. Involve content experts in the hiring process.

Next Steps

The work group is aware that implementation of the recommendations will require further decisions and work. The next phase of this work includes creation of an action plan and timeline for implementation. The revision of the Maryland State Curriculum as a result of the Maryland State Department of Education's adoption of the Common Core State Standards will be needed before some recommendations can be started. After implementation of curricula based on the

Common Core State Standards, exhaustive study will be required to determine the impact on teaching and student learning.

Undoubtedly, given the limitations and constraints of the current budget outlook, each recommendation's fiscal impact must be evaluated and decisions also will be required about current programs and practices that may need to be altered to implement new recommendations. A timeline for preliminary action plan related to the recommendations is expected by spring, 2011.

Conclusion

The K–12 Mathematics Work Group, representing a wide array of stakeholders, worked diligently and respectfully to wrestle with the complex issues inherent in mathematics education reform. The work group created recommendations to effectively meet the diverse needs of all students in a rigorous and challenging mathematics program and improve teaching and learning to prepare students for success in college and the world of work. These recommendations are predicated upon extensive research, exhaustive debates, and sound analytical methods. Just as the 2000 mathematics audit was one measure that guided our work in raising the bar and closing the achievement gap for all students during the past decade, these recommendations set the stage for mathematics education in MCPS for the next decade. They are crafted to ensure all students have the opportunity to learn and meet the same high standards so that they can access the knowledge and skills necessary in their post-secondary lives. The recommendations will guide our future decisions about curriculum and assessment, school structures, classroom/instructional strategies, acceleration practices, and teacher preparation to prepare all students for success as productive citizens in the 21st century.

K–12 Mathematics Work Group Report

In an effort to address the variety of complex questions surrounding mathematics instruction in Montgomery County Public Schools, a work group representing a broad array of stakeholders was convened to grapple with developing recommendations for the direction of teaching and learning in mathematics. Detailed below are the findings and recommendations of the work group; based on extensive research, analysis, and stakeholder input. The recommendations span the essential elements of a mathematics program including the curriculum, instruction, assessment, acceleration and expectations, and staff development.

Background

Mathematics literacy is a minimal requirement for success in the 21st century. Literacy in mathematics is not limited to formulas and equations; rather it speaks to an ability to think quantitatively about everyday issues and to tackle complicated problems with careful reasoning. These skills are imperative for individuals to be successful, and it is essential for a thriving equitable society to have a citizenry equipped to tackle tomorrow's challenges. It is upon this shared belief that the K–12 Mathematics Work Group predicated its work.

Vision

The world of the 21st century is a world in which the roles played by numbers and data are virtually endless. Educated adults need functional literacy in mathematics to live well in the society of the future. Success in the 21st century requires a mathematical knowledge that is greater than formulas and equations. It requires the ability to think quantitatively about everyday issues and to tackle complicated problems with careful reasoning. A deep understanding of mathematics equips people to think critically, to ask intelligent questions of experts, and to challenge assumptions confidently. These are skills required to thrive in the modern world.

As a result, all MCPS students must have access to high-quality mathematics instruction in which educators engage and effectively meet the needs of all students in learning key mathematics concepts and skills. Students must fully participate in classrooms that are challenging and nurturing communities which integrate a wide range of technologies to support 21st century learning. Based on its research findings and stakeholder input, the K–12 Mathematics Work Group members envisioned MCPS mathematics classrooms as communities where—

- students are fluent and resourceful problem solvers working together;
- the curriculum offers students multiple opportunities to learn challenging mathematics;
- there are ambitious expectations for all students, including those who are exceptionally talented in mathematics;
- highly effective teachers have the resources and support to expertly engage students with the mathematics curriculum;

- technology is used to support and engage students as an essential component of the environment;
- the learning needs and diverse backgrounds of all students are supported through differentiated instruction; and
- students confidently engage in complex mathematical tasks chosen carefully by teachers.

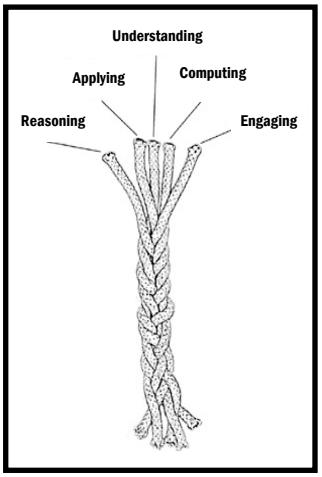
There is a shared understanding that this vision will require a coherent and comprehensive mathematics curriculum; knowledgeable and skillful teachers and other instructional staff members who use assessment to enhance learning; professional development aligned with the written curriculum and assessment that promotes and supports learning; instruction that meaningfully and purposefully integrates technology; and a commitment to both equity and excellence. To assemble these various components into a new paradigm will require steadfast instructional leadership, a climate of high expectations, and frequent monitoring of student progress.

Members of the K–12 Mathematics Work Group hope this vision will provide a foundation upon which the future of mathematics in MCPS is built. They expect this future to be predicated on the belief that all students must achieve mathematical proficiency, including quantitative literacy skills.

Mathematics Proficiency

Mathematical proficiency is the ability to think and reason mathematically and use mathematics to solve problems in authentic contexts. According to the National Research Council (NRC) (2001), students with mathematical proficiency understand basic concepts, are fluent in performing basic operations, reason clearly, formulate, represent, and solve mathematical problems, and maintain a positive outlook toward mathematics. The NRC succinctly explains mathematical proficiency as consisting of five interwoven and interdependent strands. These five strands serve as a framework for curriculum, teaching, assessing student knowledge, and professional development to build the capacity of instructional staff and leaders as follows:

- Understanding: comprehension of mathematical concepts, operations, and relations— knowing what mathematical symbols, diagrams, and procedures mean.
- Computing: carrying out mathematical procedures such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately.
- Applying: being able to formulate, represent, and devise strategies for solving mathematical problems using concepts and procedures appropriately.
- Reasoning: using logic able to explain and justify a solution to a problem or to extend from something known to something not yet known.
- Engaging: seeing mathematics as sensible, useful, doable, and worthwhile, coupled with a belief in effective effort and self efficacy.



Mathematical proficiency is not a one-dimensional trait, and it cannot be achieved by focusing on just one or two of the strands. Some views of mathematics learning have tended to emphasize only one aspect of proficiency, with the expectation that others will develop as a consequence. For example, some people who have emphasized the need for students to master computations have assumed that understanding would follow. That is not the case and proficiency in all strands is both needed and possible.

Just as all students can become proficient readers, all can become mathematically proficient. Students who are mathematically proficient believe that they can solve problems, develop understanding, and learn procedures through effective effort, and that becoming mathematically proficient is worthwhile for them. The goal of mathematical proficiency for all students has implications for how we think about and design curriculum, how teachers and other instructional staff members develop that proficiency in their students, how we assess students' mathematical proficiency, and how we design professional development experiences that cultivate instructional staff members' understanding of what it means to be and teach for mathematical proficiency. Proficiency for all students demands the alignment of curriculum, instruction, assessment, and professional development.

It is critical that all students develop strong quantitative literacy skills and be able to think and reason at high levels in an increasingly technological society. Just as the 2000 mathematics audit represented one step on the path to an exemplary mathematics program, the work of the K–12 Mathematics Work Group is intended to propel MCPS further down the path of meaningful reform. The recommendations leverage the work that already has been done in mathematics in MCPS and set the stage for the next decade. They are crafted to ensure all students have the opportunity to learn and meet the same high standards, allowing them to access the knowledge and skills necessary for post-school success. The recommendations offer guidance for decision making about acceleration practices, curriculum and assessment, school structures, classroom/ instructional practices, and teacher preparation. Equally as important, this effort continues MCPS' commitment to continual improvement.

Early Reform Efforts

In 2001, three studies were completed to support the development of a framework for improving the mathematics curriculum and the instructional practices. These three studies focused on the district's infrastructure; including governance, curriculum, instruction and assessment, and teacher preparation and experience as related to the teaching and learning of mathematics.

- The study, *The Role of Teacher Background and Preparation in Students' Algebra Success,* found that, when controlling for student ability based on eighth grade achievement, what teachers do with instruction in the classroom was more important to student learning than the teachers' credentials.

- The study, *An Analysis of Middle School Mathematics, Classroom Observation, and Teacher Interview Data*, found great variability in the use of instructional strategies by

teacher in their approach to classroom instruction. Students had diverse learning needs that many teachers said they felt unprepared to address; specifically they said they lacked a repertoire of instructional strategies to respond to the diverse needs of students.

- The study, *The Curriculum Management Audit of Mathematics Education*, described the curriculum as adequate in scope but lacking appropriate guides for teacher in terms of sequence and quality. The external audit concluded that "tracking by ability" (which, in essence, was tracking by "achievement") negatively impacted African American and Hispanic students.

As a result of these three studies, extensive curriculum, staff development, and leadership decisions were made. These included the following:

- Development of a new K–12 mathematics curriculum, with a grade-to-grade scope and sequence with clear goals, objectives, and performance indicators that are aligned with the Common Core State Standards (CCSS).
- Implementation of comprehensive staff development that provided principals and teachers with resources and assistance focused on providing the highest level of advanced mathematics instruction and expectations possible for all students, especially for African American and Hispanic students.
- Review and selection of mathematics instructional materials and resources that are aligned with the scope and sequence of the new curriculum.

The actions stemming from the findings and recommendations of the FY 2001 studies resulted in increased student achievement as well as systemic changes such as an emphasis on, and communication of, multiple pathways for differentiation including acceleration through the K–8 mathematics curriculum. The increases in student achievement stemming from the early reform efforts in mathematics are evidenced in the *Annual Report on Our Call to Action: Pursuit of Excellence,* the MCPS strategic plan. Specifically, Goal 1, *Ensure Success for Every Student,* establishes the expectation that every student achieves or exceeds the performance standards set by the district and includes algebra and geometry completion data points. Goal 2, *Provide an Effective Instructional Program,* promotes a consistent, congruent continuum of curriculum and instruction which is essential to student achievement and includes advanced mathematics in Grade 5 proficiency data points. The data points contained in the annual report reflect both the tremendous success of, and frustrating gaps in, the early mathematics reform efforts.

- The proficiency of Grade 5 students in Mathematics 6 or higher-level mathematics was recognized as a data point in 2006. Since the baseline year of 2001, proficiency rates for students have risen 17.1 percentage points from 31.9 percent in 2006 to 49.0 percent in 2010. African American and Hispanic students have steadily increased achievement, rising 16.6 and 13.7 percentage points, respectively.

Grade 5 Students Proficient in Mathematics 6 or Higher by Racial/Ethnic Group

Grade 5 Student Racial/Ethnic Group	% Successfully Completed			
	2001	2008	2009	2010
All Students	31.9	43.1	48.8	49.0
Asian American Students	52.1	64.0	70.0	70.1
African American Students	15.2	25.1	29.0	31.8
White Students	43.3	56.8	64.1	63.3
Hispanic Students	13.4	22.8	27.3	27.1

- Since the baseline year of 2001, Grade 8 algebra or higher-level mathematics completion by all students has increased by 24.7 percentage points from 43.1 percent in 2001 to 67.8 percent in 2010. The rate of increase was 4.6 percentage points greater for African American (29.3 percent) and 7.7 percentage points greater for Hispanic students (32.4 percent).

Grade 8 Algebra or Higher-Level Mathematics Completion by Racial/Ethnic Group

Grade 8 Student Racial/Ethnic Group	% Successfully Completed			
	2001	2008	2009	2010
All Students	43.1	59.6	65.5	67.8
Asian American Students	60.6	78.8	84.6	85.3
African American Students	21.2	38.4	46.6	50.5
White Students	55.5	74.7	80.1	82.0
Hispanic Students	16.4	38.8	45.8	48.8

- Since the baseline year of 2001, Grade 9 algebra or higher-level mathematics completion rates have climbed 10 percentage points from 71.5 to 81.5 percentage points. The achievement gap is narrowing, with gains of 23.5 percentage points for both African American and Hispanic students.

Grade 9 Algebra or Higher-Level Mathematics Completion by Racial/Ethnic Group

Grade 9 Student Racial/Ethnic Group	% Successfully Completed			
	2001	2008	2009	2010
All Students	71.5	77.0	78.0	81.5
Asian American Students	89.0	88.8	89.5	91.2
African American Students	49.4	65.3	66.6	72.9
White Students	84.3	88.2	89.2	91.8
Hispanic Students	44.2	62.1	63.5	67.7

- Since the baseline year of 2004, Grade 10 geometry completion rates have risen 9.3 percentage points since then, from 70.2 percent in 2004 to 79.5 percent in 2010. African American and Hispanic students' completion rates increased 20.2 and 18.5 percentage points, respectively, doubling the rate of increase for all students.

Grade 10 Geometry Completion by Racial/Ethnic Group

Grade 10 Student Racial/Ethnic Group	% Successfully Completed			
	2004	2008	2009	2010
All Students	70.2	73.8	77.4	79.5
Asian American Students	85.1	87.9	88.2	92.1
African American Students	47.8	55.4	63.2	68.0
White Students	84.8	88.9	91.1	90.8
Hispanic Students	44.0	52.0	59.6	62.5

Despite this strong record of achievement, a disheartening trend continues with African American and Hispanic students consistently less likely to successfully complete the desired course than their White or Asian American peers. This trend—in conjunction with the growing understanding of the numbers of variables such as acceleration practices, curriculum and assessment, beliefs and expectations, school structures, classroom/instructional practices, and teacher preparation that impact student success in mathematics—laid the groundwork for the convening of a multistakeholder mathematics work group. As these factors were coming together, stakeholder concerns were emerging about the scope of the curriculum, pacing of instruction, and the emphasis on acceleration, particularly at the elementary level. It was this perfect storm of convergent interests that lead to the recommendations contained in this report.

The K–12 Mathematics Work Group

In response to the concerns raised, and with a commitment to continuous improvement and transparency, in January 2009, Dr. Frieda K. Lacey, deputy superintendent of schools, convened the K–12 Mathematics Work Group to explore the complex issues surrounding mathematics teaching and learning and to develop recommendations to improve student achievement in mathematics in MCPS systemwide. The work group brought together parents, elementary and secondary teachers, elementary and secondary administrators, representatives from the employee unions, and staff members from various central service offices and divisions (Attachment A).

Using a research-based approach and soliciting input from a wide range of stakeholders, the work group used the following steps to conduct its work over the course of 16 months:

- Discuss issues and concerns.
- Cluster the interests into meaningful and manageable topics.
- Form research groups and identify critical questions to guide the inquiry.
- Conduct research participate in meetings with national experts in the field of mathematics.
- Analyze relevant data, both quantitative and qualitative.
- Develop recommendations to strengthen the district's mathematics program.

The work group identified issues and concerns. The issues and concerns were translated into interests and clustered into meaningful and manageable topics. The topics that emerged included the following:

- Curriculum: The Written Curriculum
- Classroom/Instructional Practices: The Implemented Curriculum

- Curriculum: The Assessed Curriculum
- Acceleration Practices: Mathematics Targets and Acceleration
- Teacher Preparation and Development: Teaching for Mathematical Proficiency

A research group was formed for each topic and critical questions were identified that guided the research group's inquiry. Through reviewing research; meeting with distinguished educators, research analysts, and policy experts in the field of mathematics; and analyzing relevant quantitative and anecdotal data, the work group built its capacity and developed common knowledge around the five topics.

Stakeholder Input

A significant component of the work group's charge was to gather and consider stakeholder input. The work group used a variety of methods to gather extensive feedback from a broad range of stakeholders, including voices that traditionally have not been heard. During the fall of 2009, representatives of the K–12 Mathematics Work Group conducted multiple focus groups. In addition, comments were solicited from all local school Parent Teacher Associations (PTAs) and from each secondary school's Student Government Associations (SGAs). Approximately one-third of the PTAs responded along with seven SGAs. Some individual parents and teachers also provided comments. The stakeholder groups, PTAs, and SGAs that shared their points of view are listed in Attachment B.

A total of 2,458 comments were received in response to the five questions.

K–12 Mathematics Work Group Survey/Focus Group Questions	**Comments**	
	Number	**% of Total**
Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?	380	15.5%
Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?	644	26.2%
Question 3: Do you feel that your child/your students is/are prepared with the mathematical knowledge he or she/they needs for his/her/their next steps? Next course? Why or why not? Explain.	456	18.6%
Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?	398	16.2%
Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?	523	21.3%
General Comments	57	2.3%

K–12 Mathematics Work Group Survey/Focus Group Questions	Comments	
	Number	% of Total
Total	2,458	100%

After reviewing all responses, the comments were sorted by the five research topics. Noted below are the percentages of the total comments, by topic. A summary of the feedback, and sample comments by research topic, is attached to this report (Attachments C–H).

Research Topic	% of Total Comments
Curriculum: Written Curriculum	27.6%
Classroom/Instructional Practices: Implemented Curriculum	28.8%
Curriculum: Assessed Curriculum	6.9%
Acceleration Practices: Mathematics Targets and Acceleration	16.4%
Teacher Preparation and Development: Teaching for Mathematical Proficiency	10.8%
Other Comments	9.5%

This considerable outreach allowed the work group to have access to the perspectives of a wide array of stakeholders. The work group honored the stakeholders' contributions by carefully considering, weighing and, where appropriate, incorporating the input.

Adoption of the Common Core State Standards

During the tenure of the K-12 Mathematics Work Group, the Maryland State Department of Education (MSDE) adopted the CCSS. Subsequently the Montgomery County Board of Education preliminarily adopted the standards. Members of the K-12 Mathematics Work Group examined the standards in draft form during their work and considered the changes for the teaching of mathematics in the future that will result from the standards as part of their work.

The Common Core State Standards Initiative is a state-led effort coordinated by the National Governors Association Center for Best Practices and the Council of Chief State School Officers. The standards were developed in collaboration with teachers, school administrators, and experts to provide a clear and consistent framework to prepare our children for college and the workforce.

One of the factors driving recent interest in standards is the worry over the United States' mediocre performance on international tests. The results from country-by-country exams such as Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) vary, but generally show students in the United States scoring in the middle of the pack in mathematics and science, well behind top performers such as Finland, Singapore, and South Korea. Several major national-standards documents, produced by organizations of educators and subject-matter experts, emerged during the late 1980s and 1990s. The organizations included the National Council of Teachers of Mathematics (NCTM), the

American Association for the Advancement of Science, the National Research Council (NRC), and the National Council of Teachers of English.

While some of the documents drew strong opposition from those who questioned their content, they also influenced states' development of academic standards in the years that followed. During the mid-1990s, many states were only beginning to create and refine their own standards; today all 50 states and the District of Columbia have their own standards across subjects. Yet those documents vary enormously in content and structure—and in quality, according to analysts who have reviewed them. The hope was that national standards developed in the 1990s would bring more consistency to state documents, but that did not happen, in part because the national documents were politically unsustainable and did not take hold.

The CCSS in mathematics seek to bring coherence, rigor and focus to instruction. They address the common complaint that many states' mathematics standards are "a mile wide and an inch deep," in contrast to standards in countries that have outpaced the United States in achievement in recent years. The CCSS provide a consistent, clear understanding of what students are expected to learn so teachers, other instructional staff members, and parents know what they need to do to help. The standards are designed to be challenging and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy.

The standards are informed by the most effective models from states across the country and countries around the world. Consistent standards provide appropriate benchmarks for all students, regardless of where they live. These standards define the knowledge and skills students should have within their K–12 education careers so that they will graduate high school able to succeed in entry-level, credit-bearing academic college courses and in workforce training programs. The standards—

- are aligned with college and work expectations;
- are clear, understandable and consistent;
- include rigorous content and application of knowledge through high-order skills;
- build upon strengths and lessons of current state standards;
- are informed by other top performing countries, so that all students are prepared to succeed in our global economy and society; and
- are evidence-based.

The standards are research and evidence-based, aligned with college and workforce training program expectations, reflective of rigorous content and skills, and internationally benchmarked. Ms. Dixie L. Stack and Ms. Donna M. Watts of MSDE spoke to the K–12 Mathematics Work Group and described the activities currently under way to revise the state curriculum to align with the CCSS. Hundreds of classroom educators, instructional leaders, administrators, and higher education representatives will help state officials refine and align the current Maryland State Curriculum. The new state curriculum is expected to be ready for Maryland State Board of Education adoption in June 2011.

Comments by Experts in the Field of Mathematics

To aid the task of building consensus on the beliefs and values that should guide the teaching and learning of mathematics, the work group sought out experts in the field of mathematics. The selected speakers were some of the most preeminent scholars in their field. They presented multiple perspectives based on years of research and scholarly publication regarding how to improve the education of students of mathematics. Their specialties ranged from mathematics teaching and learning to educational policy analysis. This expertise provided important insights considered by the members of the work group as they developed their recommendations. A brief biography of each speaker can be found in Attachment I.

Dr. Francis (Skip) Fennell, professor of education at McDaniel College, identified national issues in mathematics education for the work group members. Among the priorities, he listed a common curriculum, equity, linking research and practice, professional development, and advocacy of mathematics for all students. He spoke of the importance of coherence and alignment of curriculum and a need to allocate funds for early childhood and primary grades mathematics programs, as well as the need for elementary mathematics specialists.

Dr. Steven Leinwand, of the American Institutes for Research, spoke to the group about "mathematics instruction that makes a difference." He stated that because we are planning high quality, rigorous mathematics programs for all students—something that is unprecedented—the time has come for us to focus attention on what specifically we want students to learn, identify how to best teach those concepts, understand how to best measure student learning, and then plan quality support for teachers learning how to teach in these ways. He identified core knowledge that students should have by the end of Grade 5.

Dr. James Hiebert, professor at the University of Delaware, stressed that we may change many things—curriculum, textbooks, structure of class periods, performance targets, and assessments—but if we fail to address teaching, none of these changes make their way into the classroom and impact students in meaningful ways. The focus of his talk centered on the importance of creating structures where teachers are able to study their teaching and the teaching of others. By studying teaching, conversations about shared learning goals, student learning, best teaching practices, and professional development around content knowledge can all be fostered.

Dr. William H. Schmidt, of Michigan State University, proposed that fundamentals are the key to mathematical proficiency. Without the fundamentals, it is difficult to move to the next level. Dr. Schmidt recommended attention to three principles—coherence, rigor, and focus. He recommended decreasing the number of variations (from remedial to accelerated) because the sorting of children creates different opportunities. He proposed that standards for every child (e.g. "In third grade you should be doing X.") should be true for all students. The basic argument to move toward standards for all is, to Dr. Schmidt, a moral argument.

Dr. Daniel Chazan, Dr. Lawrence Clark, and Dr. Whitney Johnson, all of the University of Maryland, noted the changing importance of algebra to today's students with a belief that algebra

is the literacy test for citizenship in a technological society. They emphasized the need to change teacher preparation programs to impact mathematics teaching and learning systems. Drs. Chazan, Clark, and Johnson also noted that, if ambition goals are set, one must work on building teacher capacity to manage a wide range of prior knowledge—not teaching a homogenous group of children.

Findings and Recommendations

The K–12 Mathematics Work Group developed recommendations for each of the five topics based on findings culled from the research, stakeholder feedback, data analysis, and information presented by the mathematics experts. A brief summary of the research findings, along with relevant stakeholder and expert comments, is included below to provide the context for the recommendations. The full findings from each research group, along with a citation of annotated sources related to each research question, are included with this report (Attachment J). The research findings provide indispensable insight into the rationale behind the recommendations. A listing of the work group recommendations can be found in Attachment K.

Curriculum: Written Curriculum

Definitions of curriculum range from a simple list of the standards, indicators, and objectives for a particular grade level to encompassing the supporting guides, lessons, textbooks, instructional materials, practices, and processes that reflect a given philosophy and view about student learning. For the purposes of this research group, written curriculum was defined as the scope, sequence, and pacing of standards, objectives, and indicators, as well as the resources that are used to teach the outlined indicators and the practices and philosophy that those materials reflect. The written curriculum includes content, processes, and practices that clearly delineate student learning trajectories based on research on teaching and learning. Also included are multiple methods for teaching or reteaching key concepts in mathematics to diverse learners.

MCPS has historically recognized the importance of excellence in its mathematics curriculum. After research in 2001 that concentrated on the infrastructure and personnel issues related to student achievement, extensive actions were taken to improve the teaching and learning of mathematics. At that time MCPS implemented changes in staff development, instructional leadership, policy, and evaluation and assessment that resulted in increased student achievement and an emphasis on multiple pathways for differentiation, including acceleration through the K–8 mathematics curriculum. Since then, with the recognized importance and emphasis on successfully completing Algebra 1 by Grade 8, there is a need to align the MCPS curriculum to meet these outcomes for all students.

In addition to the needs for improvement identified by experts and various stakeholder groups, with the state of Maryland adoption of the CCSS, there is a need to align the current MCPS curriculum to the CCSS, which provides a pathway for all students to complete Algebra 1 by Grade 8. Currently, with the writing of the Elementary Integrated Curriculum, the kindergarten and Grade 1 curricula are aligned with the CCSS.

Stakeholder Feedback

Stakeholders commented on the broad range of content topics as being a strength of the current written MCPS mathematics program. The way in which units are designed to connect with upcoming units or parts of the unit also was an identified strength. Other strengths mentioned were the multiple enrichment programs/courses and the available resources (lessons, guides) and textbooks. Areas of the current curriculum that stakeholders commented on as needing improvement included the alignment (or lack thereof) of units, the writing quality in questions, the order of indicators, and the logical flow of the curriculum.

Expert Guest Speakers

The expert guest speakers shared findings from their research, which members of the K–12 Mathematics Work Group considered in developing the recommendations. The experts did not specifically address mathematics in MCPS, nor were they asked to comment on the recommendations. Shared below, and in similar sections for each research work group, is the K–12 Mathematics Work Groups' understanding of the relevant information shared by the experts.

Several of the experts who spoke to the K–12 Mathematics Work Group focused on understanding and implementing a coherent K–12 mathematics curriculum. Dr. Fennell spoke of the importance of coherence and alignment of curriculum, and referenced the NCTM Curriculum Focal Points as a guiding document. Dr. Fennell also highlighted the need for proficiency with the critical foundations in K–8, including whole numbers, fractions, particular aspects of geometry, and measurement.

Dr. Schmidt echoed Dr. Fennell's comments by recommending attention to three principles—coherence, rigor, and focus. He stressed that standards for every child (e.g. "In third grade you should be doing XYZ.") should be true for all students, and that all students should have a solid foundation in algebraic reasoning by the end of Grade 8.

Identified Issue: Curriculum: The Written Curriculum

The work group's written curriculum committee was charged with examining research about national, state, and local standards, the Voluntary State Curriculum, and the MCPS curriculum. With the CCSS serving as an anchor for the new scope and sequence of a revised curriculum, this research group focused on four questions related to important milestones in mathematics, national and international comparisons of curricula, the role of equity in curricula as it specifically relates to special populations, and the processes and practices that are represented in high quality and effective mathematics curricula.

Research Findings

Curriculum: Written Curriculum Research Question 1: What is the ultimate outcome of the written curriculum for all students? What are important milestones throughout Grades K–12? What does it mean to be mathematically literate and proficient?

By the end of high school, students must be prepared to think critically, compute, reason, communicate, and solve problems to ensure success in life. In addition, greater numbers of students need to be prepared to pursue careers in science, technology, engineering, and mathematics (STEM) to help support the competitiveness and economic viability of their state and nation. As college students and employees, high school graduates will need to use mathematics in contexts quite different from those found in the high school classroom. They will need to make judgments about what problem needs to be solved and, therefore, about which operations and procedures to apply. Beyond acquiring procedural mathematical skills and rote knowledge, students need to become proficient in skills of reading, conceptualizing, interpreting, representing and "mathematizing" a problem.

According to the National Research Council (2001), mathematical proficiency has the following five strands (see illustration on page 2):

- Understanding: Comprehending mathematical concepts, operations, and relations—knowing what mathematical symbols, diagrams, and procedures mean.
- Computing: Carrying out mathematical procedures, such as adding, subtracting, multiplying, and dividing numbers flexibly, accurately, efficiently, and appropriately.
- Applying: Being able to formulate problems mathematically and to devise strategies for solving them using concepts and procedures appropriately.
- Reasoning: Using logic to explain and justify a solution to a problem or to extend from something known to something not yet known.
- Engaging: Seeing mathematics as sensible, useful, and doable—if you work at it—and being willing to do the work.

The most important feature of mathematical proficiency is that these five strands are interwoven and interdependent. The milestones critical for each level of mathematics in K–12 monitor progress toward proficiency expected at each level in number, concepts, and operations, with a goal of proficiency in Algebra 2 by graduation.

Curriculum: Written Curriculum Research Question 2: What does the research say about international, national, and state curricula?

A focused, coherent progression of mathematics learning, with an emphasis on proficiency with key topics, should become the norm in elementary and middle school mathematics curricula. Any approach that continually revisits topics year after year without closure is to be avoided. Two major differences between our curriculum and the curricula of top-performing countries include the number of topics presented at each grade level and the expectations for learning.

The United States includes many topics at each grade level, with limited development of each, while top-performing countries present fewer topics in greater depth. Other countries are more

likely to expect closure after exposure, development, and refinement of a particular topic, while the United States reviews and extends topics at successive grade levels.

The formal study of algebra is both the gateway into advanced mathematics and a stumbling block for many students. The basic ideas of algebra as generalized arithmetic should be anticipated by activities in the early elementary grades and learned by the end of middle school. Instructional strategies that help students move from arithmetic to algebraic ways of thinking in Grades Pre-K–8 provide a foundation for later successes.

Curriculum: Written Curriculum Research Question 3: What does research say about aspects of curricula that support equity in student learning for all students, including English Language Learner and special education students?

Learning, as it normally occurs, is a function of the activity, context, and culture in which it occurs (i.e., it is situated). This contrasts with most classroom learning activities which involve knowledge that is abstract and out of context. Social interaction is a critical component of situated learning—learners become involved in a "community of practice" which embodies certain beliefs and behaviors to be acquired. Cobb and Hodge (2002) propose to conceptualize equity in terms of students' participation in communities. Equity, as they view it, is concerned with how continuities and discontinuities between out-of-school and classroom practices play out in terms of access.

Research has shown that this kind of equity can be achieved in classrooms where, among other things, teachers have solid mathematical knowledge, all instructional staff members believe in their students, students are adequately supported to understand rigorous mathematics, real-world contexts are provided for their learning, and (on many occasions) students are encouraged to work in noncompetitive ways with their peers. Further, research has shown that students with diverse backgrounds and learning needs thrive in mathematics classrooms where the curriculum is accessible to them. Specifically, the mathematics content is made accessible through problems that are specifically and strategically structured to include multiple points of entry, multiple paths to solutions, and multiple solutions. In this way, not only are the practices and processes reflective of equitable instruction, but the mathematics content is as well.

Equity, however, can be threatened by the underlying belief that not all students can learn mathematics. That is, whereas other countries believe that differences in student achievement are due to effort (Stevenson & Stigler, 1992), U.S. citizens tend to believe that mathematics achievement is more directly related to ability at birth. Therefore, the belief goes, no amount of effort will compensate for those students who lack innate ability or talent. When this belief is present, equity can be difficult to achieve.

Curriculum: Written Curriculum Research Question 4: What key elements need to be embedded in the written curriculum? Problem solving? Technology? Communication?

Key instructional practices in mathematics classrooms, including but not limited to differentiation, use of technology, inquiry-based instruction, problem solving, communication,

embedded assessment, and multiple instructional approaches for the teaching of mathematics, should be embedded within the written curriculum. Problem solving is central to school mathematics. The ability to formulate and solve problems coming from daily life or other domains, including mathematics itself, is not being developed well in Pre-K–8 classrooms. Problem solving should be the site at which all of the strands of mathematics proficiency converge. It should provide opportunities for students to weave together the strands of proficiency and for teachers and other instructional staff members to assess students' performance on all of the strands.

Also, technology is essential to teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. Technology is not just calculators and computers. Technology, which includes nonelectronic media and tools, assists instructional staff members and students to compare, count, classify, explain, illustrate, and measure various concepts of mathematics. Successful technology-rich schools generate impressive results for students, including improved achievement; higher test scores; improved student attitude, enthusiasm, and engagement; richer classroom content; and improved student retention and job placement rates.

Finally, how instructional staff members and students talk with one another in the social context of the classroom is critical to what students learn about mathematics and about themselves as doers of mathematics. Knowing about students' mathematical thinking supports opportunities for asking questions linked to students' ideas, eliciting multiple strategies, and drawing connections across strategies. Structures for high quality discussions about important mathematics should be built into the written curriculum and supported through the development of instructional materials that outline questions, processes, and practices that help foster the kinds of mathematics classroom communities where rich discussions are occurring.

Curriculum: Written Curriculum Recommendations

Guiding the recommendations below is the belief that the written mathematics curriculum should be rigorous, coherent, and comprehensive. It must provide time, flexibility, and content and pedagogy resources for teachers and other instructional staff members. As a result of engaging with this curriculum, all students, regardless of race, gender, or socioeconomic status achieve at high levels and develop a strong working knowledge of mathematics, which includes both the domains and the strands of mathematical proficiency.

1. Revise and align the MCPS written curriculum to the rigorous CCSS, resulting in—
   - a streamlined curriculum with more in-depth study of content at each grade level,
   - focus on mastery of number concepts in elementary school,
   - mastery in algebraic concepts by the end of middle school,
   - mathematical proficiency with geometric principles and Algebra 2 concepts, and
   - equitable preparation and opportunities for higher level mathematic courses in high school.

2. Investigate the adoption of the integrated secondary school mathematics pathway as articulated in the CCSS.

3. Provide curriculum resources that are aligned with the CCSS and support equitable access to learning by—
    - addressing content, pedagogy, assessment, and instructional practices;
    - offering tasks that allow for multiple places to begin a problem, multiple solution strategies or multiple solutions; and
    - presenting mathematics in contexts that include the use of culturally responsive practices and universal design principles.

4. Integrate a variety of technologies into the written curriculum to affect how mathematics is taught—to encourage critical thinking skills, to increase student motivation, and to facilitate access to mathematics content for all students, including those with disabilities and English Language Learners.

5. Create an online forum that allows instructional staff members to contribute to an evolving curriculum.

Classroom/Instructional Practices: Implemented Curriculum

The implemented curriculum is what is taught in the classroom and the strategies used to teach it. Instructional strategies, technology, and school structures are all important components in effectively implementing mathematics curriculum and student learning; however, the core message in all the research is that the competency of the teacher is the key to successful implementation of curriculum. The taught, written, and assessed curricula are three parts of the same whole which, when aligned, support student academic success and maintain consistency within and among schools. The best-case scenario is when what is taught, how it is taught, and how it is assessed remain in balance. Teachers and other instructional staff members make multiple decisions and should have multiple supports to determine the instructional strategies that are most appropriate for both the concept and the student.

The implemented curriculum starts with the written curriculum, but it also requires a skilled teacher to implement classroom practices to maximize student learning. Since the introduction of the newest written curriculum in 2002, thoughtful planning and hard work on many levels has occurred. Teachers and other instructional staff have had professional development to implement the new curriculum. Administrators and other instructional leaders have received training and use varying tools to monitor the effective implementation of the curriculum. In many schools, how students are grouped for mathematics and even how the school is structured for mathematics instruction is significantly changed from what it was in 2002.

Adopting the CCSS will require that teachers have the ability to explore content in greater depth. The CCSS list the following eight standards for mathematical practice:

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.

- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

Teachers will need to be skilled in both content and pedagogy to instill this expertise in their students. The emphasis on problem solving and conceptual understanding encourages teachers and other instructional staff members to explore concepts in detail and achieve deep mastery in their students.

The targets developed for and monitored as part of the MCPS strategic plan, *Our Call to Action: Pursuit of Excellence*, have had an impact on how mathematics is being taught. The accountability measures put in place to monitor student success and the positions allocated to support implementation of mathematics have had some success toward decreasing the inconsistency of implementation that was identified as a concern in prior mathematics audits. School-based and central services administrators and instructional leaders continue the effort to minimize the inconsistency. Continued development of curriculum resources in *my*MCPS and the online curriculum make the curriculum digital, portable, and overall more accessible. These supports provide greatly improved opportunities for teachers and other instructional staff members to collaborate as they implement the curriculum.

Stakeholder Feedback

Feedback from the numerous stakeholder groups indicated that implemented curriculum has many strengths. The most commonly identified strength was the flexible grouping practices implemented in many schools and classrooms. Another theme that emerged was support for the varied instructional practices implemented in many classrooms, especially those practices that related the mathematics to real world situations. An identified concern focused on the perceived need for greater emphasis on basic concepts and more time for in-depth study. It is very important to many of the stakeholders that students have mastered mathematical concepts before moving to the next level. The written curriculum and teaching practices should ensure that each student receives high quality mathematics instruction.

Expert Guest Speakers

The work group called on numerous experts who reinforced the idea that a skilled teacher is the critical component for quality mathematics instruction. The experts advocated for linking teaching practices to research, identifying best practices, and sharing those best practices among teachers. Dr. Leinwand talked about the importance of quality instruction. He noted that, in order to provide high-quality instruction for all students, we need to identify how best to teach, understand how best to measure learning, and then plan quality support for teachers to learn how to teach in these ways. Dr. Schmidt recommended decreasing the number of variations of mathematics courses, from remedial to accelerated, because the sorting of children creates different opportunities and different opportunities create different outcomes. The basic argument to move toward standards for all is, to Dr. Schmidt, a moral argument.

Identified Issue: Classroom/Instructional Practices: The Implemented Curriculum

Students often bring the perceptions of others regarding mathematics with them as they enter the mathematics classroom. The critical challenge for each instructional staff member is to encourage each child to form his or her own connection to mathematics. Research by the implemented curriculum team investigated best practices for supporting and fostering all students' learning and engagement. This included exploring best teaching practices as well as identifying recommendations about instructional materials.

Research Findings

Classroom/Instructional Practices: Implemented Curriculum Research Question 1: What instructional strategies/practices are effective in supporting different types of students (race/ethnicity, mobility, limited English, special education)?

Effective mathematics instruction for students requires a critical set of knowledge and skills, including a deep knowledge of mathematics content, effective teaching skills, and strategies to meet the needs of diverse learners. In addition, teachers in modern classrooms need to have the belief system that all students can learn at high levels, regardless of race, ethnicity, disability, gender, language, or socioeconomic status. Implementation of curriculum in contemporary classrooms needs to be based on high expectations, positive relationships, and culturally responsive instruction.

Classroom/Instructional Practices: Implemented Curriculum Research Question 2: What is the impact of 21st century technology, calculators, and instructional materials on student learning?

There are numerous instructional software supports available to schools in order to accelerate student learning, reinforce what has been taught, or to support students who are struggling to master mathematical concepts. Research in the area of instructional software, in general, has shown that the use of technology has a positive impact on student achievement. The use of calculators is an ongoing concern for educators in MCPS and nationally. The National Mathematics Advisory Panel reviewed 11 short-term studies which found "limited or no impact of calculators on calculation skills, problem solving, or conceptual development over periods of up to one year." However, the report cautions that at this time, there are no longitudinal studies on the long-term use of calculators.

As for instructional materials, textbooks produced in the United States are voluminous (600 to 1,000 pages). Textbooks from other countries are not as bulky as textbooks published in the United States, and include fewer topics. Because larger states drive the textbook market, smaller states and large school districts such as MCPS have limited influence over the extensive content included in each textbook.

Classroom/Instructional Practices: Implemented Curriculum Research Question 3: What school structures and organization support consistent implementation?

There are many school structures and organizational characteristics than can affect student learning. The effective schools research that has been conducted for decades confirms factors such as instructional leadership, a climate of high expectations, a safe learning environment, and frequent monitoring of student progress are critical to student success. More recently, considerable study has been conducted concerning the positive impact of a professional learning community culture and how it can provide benefits for staff and students. The studies the work group examined looked at a variety of school structure and organizational characteristics. Key findings include the importance of whole school reform, the potential of identifying and studying successful schools, the value of systemic study of instructional practice, the key role of student and teacher efficacy in mathematics success, the critical role of targeted job-embedded professional development, and the impact of teacher quality and practice. There are practices and strategies that MCPS has started that need to be fully implemented or considered for expansion (M-Stat study, Framework for Equity and Excellence, Professional Learning Communities Institute, Middle School Reform) and there are possibly some new efforts to be considered (close examination of current instructional practices, etc.). School structures and strategies that are promoting success for all students should be identified and replication of successful structures and strategies should be supported.

Classroom/Instructional Practices: Implemented Curriculum Research Question 4: How do children and adolescents learn mathematics?

Research over the past few decades shows that all students can learn to think mathematically. Skillful teaching in the mathematics classroom should address the student's need to develop the five interdependent and interwoven strands that comprise mathematical proficiency. These strands are understanding, computing, applying, reasoning, and engaging. Helping children acquire mathematical proficiency calls for written curriculum and teaching methods that address all its strands. How learners represent and connect pieces of knowledge is a key factor in whether they will understand it deeply and can use it in problem solving. Students come to school with preconceived notions of mathematics and how it connects to their world. Instruction on new mathematical concepts needs to connect students' preconceived ideas to the new concepts they are learning. Research shows that each person processes mathematics differently. These differences run along a continuum from a mathematical learning profile that is primarily quantitative to one that is primarily qualitative. The implication from research is that students are more likely to be successful in learning mathematics if teachers use instructional strategies that are compatible with students' learning profiles.

Classroom/Instructional Practices: Implemented Curriculum Recommendations

Guiding the recommendations below is the belief that, in order to effectively implement the written curriculum, a highly-skilled teacher should be in each classroom and be supported by effective structures. A highly-skilled teacher should use effective pedagogical strategies, flexibly

group students to meet the needs of all learners, and develop and utilize assessments embedded in instruction. School structures and schedules should support effective teachers by enabling collaboration, common planning time, and job-embedded professional development opportunities. The implemented curriculum should be aligned with the written curriculum and result in all students achieving mathematical proficiency by developing both conceptual understanding and procedural fluency.

1. Support the improvement of mathematics teaching through the development and use of an instructional practices rubric that includes but is not limited to fidelity of curriculum implementation, equitable practices, inquiry-based instruction, mathematics discourse, metacognitive strategies, and differentiation.

2. Develop and implement a self-assessment, incorporating the instructional practices rubric, for instructional staff members to identify content and pedagogical strengths and needs so that instructional staff members have data to guide their professional development.

3. Identify school structures and strategies that promote success for all students and work to support their replication in multiple locations by—
    - implementing school schedules that promote effective instruction and provide all students, including students receiving special education services and English Language Learners, with the mathematics instruction and support they need to succeed; and
    - supporting instructional staff members as they work in collaborative teams to review curriculum, plan instruction, discuss student progress, review student data, and make adjustments in teaching.

4. Monitor implementation of the MCPS Regulation IHB-RA, *School Academic Grouping Practices*, that establishes standards for ongoing, flexible grouping and regrouping of students to provide instruction differentiated to meet the needs of all learners.

    Provide research-based guidance on the appropriate use of calculators.

Curriculum: Assessed Curriculum

Educational assessment is the process of measuring and documenting knowledge, skills, attitudes, and/or beliefs. Assessment refers to activities teachers and other instructional staff members use to help students learn and to determine student progress, and can be informal or formal in design. Two general categories of assessment are used in education: assessment for learning, or formative; and assessment of learning, or summative. Formative assessment occurs during the instructional process and is intended to provide accurate and timely data on student progress. Summative assessment is intended to measure learning outcomes at the end of a unit or course and report those outcomes to students, parents, and administrators. Teachers and other instructional staff members use formative data to plan and modify instruction, and to provide students with useful feedback on their progress toward meeting standards. Both formative and

summative assessments are used nationally in K–12 mathematics, and are an integral part of teaching and learning in MCPS.

The current MCPS assessment program is designed to ensure that all students are college-ready by the end of Grade 12. In mathematics, MCPS administers local, state, and national assessments. The mathematics curriculum includes locally-developed preassessments, formative assessments, and unit assessments, as well as end-of-course exams for high school credit-bearing courses. To benchmark student progress nationally, MCPS administers the Terra Nova, second edition (TN2), a nationally norm-referenced assessment, to all Grade 2 students. MCPS also administers the Maryland School Assessments (MSA) in mathematics in Grades 3–8, and the High School Assessment (HSA) in Algebra 1. High school students are encouraged to participate in college-level courses, such as Advanced Placement (AP) and International Baccalaureate (IB), and take the associated national or international assessments. In addition, all students are encouraged to participate in the PSAT in Grade 10 and take the SAT or ACT college entrance examinations.

As the CCSS are implemented, the local and state assessments administered in MCPS will be modified to align with the curriculum. While the goals of the MCPS assessment program will remain the same, the number of local and state assessments administered may change, as well as the number and types of items included on individual assessments.

Assessment data are, and will continue to be, easily accessible to administrators, teachers, and other instructional staff members to inform instructional decisions and planning. MCPS also reports, and will continue to report, individual student results to parents to inform them of student progress and involve them in the instructional decision-making process.

Stakeholder Feedback

Upon gathering stakeholder feedback in all five areas, nearly seven percent of the feedback pertained to the assessed curriculum. The most frequently noted strengths of the assessed curriculum were components of the formative and unit assessments, as well as MCPS-generated reports for teachers and parents. Respondents' comments were individualized in regard to the aspects of the MCPS mathematics program, which related to the assessed curriculum that they would like to see changed, improved, and/or enhanced. The most common themes centered on unit and final assessments, assessment format, and the overall assessment process.

Identified Issue: Curriculum: The Assessed Curriculum

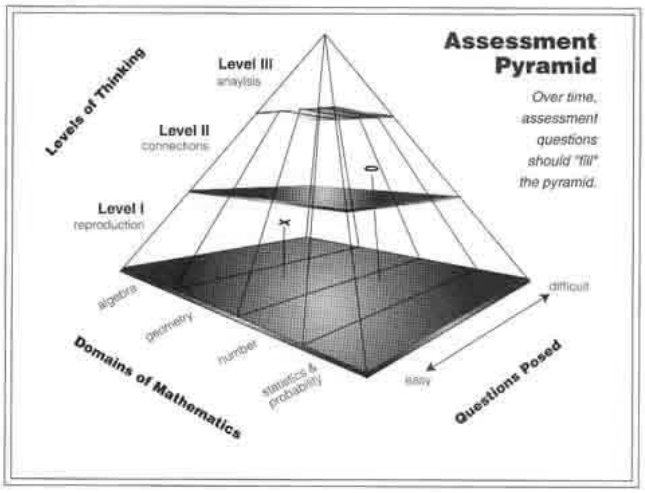
The work group's research questions reflect the common themes from stakeholder comments. Also incorporated in the responses below are comments by the expert speakers who underscored the importance of a coherent, rigorous, and focused curriculum, which includes both formative and summative assessments.

Research Findings

Curriculum: Assessed Curriculum Research Question 1: What is the purpose of the national, state, and local assessments given in MCPS? Do they overlap? How are end of unit assessments and end of course assessments aligned with the curriculum?

The nationally norm referenced assessments administered in MCPS, such as the TN2 and the National Assessment for Educational Process (NAEP), are designed to provide information on how our students perform compared to other students throughout the nation. The state-mandated assessments, such as MSA and HSA, are designed to assess progress on meeting state standards. The locally developed formative, unit, and end-of-course assessments are designed to support the teaching and learning process. Together, the assessments administered in MCPS provide a comprehensive view of student performance in mathematics.

The aim of classroom assessment is to provide data from which students, teachers, parents, other instructional staff members, and administrators can make decisions about the teaching and learning process. As noted in the figure to the right (de Lang, 1999), the most balanced assessments include questions from the applicable domains of mathematics and include varying levels of thinking.



The MCPS curriculum framework for mathematics contains the Maryland State Voluntary Curriculum (VSC) along with additional standards to meet the request for going above and beyond the VSC. MCPS end-of-unit assessments address curriculum standards. Two analyses completed by the Office of Shared Accountability (OSA) have found clear alignment between the MCPS end-of-unit and the end-of-course mathematics assessments. The number of items in each assessment is determined by the content and process standards in the MCPS curriculum framework. Adjustments to assessments occur as local or state standards change.

Curriculum: Assessed Curriculum Research Question 2: What are state by state alternatives to high stakes assessment in math?

High stakes assessments include both assessments that measure proficiency on state standards to meet the federal *No Child Left Behind Act of 2001* (NCLB) requirements and assessments required for graduation. Great variance exists due to how states interpret NCLB and define graduation requirements. Many states are aligning assessments with measures of college and career readiness. States are increasingly relying on nationally accepted college entrance tests, such as ACT and SAT, for the setting of high school graduation requirements. Some states are beginning to allow AP and IB exams as substitutes for end-of-course assessments.

The CCSS, adopted by MSDE on June 22, 2010, is the most recent step toward ensuring that students are receiving a high-quality education consistently, from school to school and from state to state. Maryland is participating with 28 other states in the Partnership for Assessment of Readiness for College and Careers consortium to pool resources and expertise for developing assessments based on the standards of the CCSS. The assessments will take a number of years to develop, validate, and pilot test.

Curriculum: Assessed Curriculum Research Questions 3 & 4: What are best practices in using formative and summative data to inform instruction? What is the relationship between formative and summative assessment that best supports instruction and student learning?

All aspects of a mathematics instructional program, including assessment, are inextricably linked. Formative assessment occurs during the instructional process and is intended to provide accurate and timely data on student progress. Summative assessment is intended to measure learning outcomes at the end of a unit or course and report those outcomes to students, parents, and administrators.

Research indicates that the best written and taught curricula explicitly address the differences between the purpose of formative and summative assessments. Best practices include opportunities for teachers and other instructional staff members to share knowledge, skills and effective strategies related to the development and use of both formative and summative assessments. Successful students own their learning and demonstrate that learning is not reflected simply in grades, but rather in mastery, retention and application of learned skills. Effective formative assessments encourage students to do so effectively as long as there has been training and development for students and instructional staff members in these self-reflective processes. Successful schools have mechanisms for communication with parents that capture and reflect on current status, which is different from grades. Research supports professional development in the skills to design assessment that is part of instruction, analyze formative information, adjust instruction accordingly, and provide meaningful feedback to students.

Curriculum: Assessed Curriculum Research Question 5: Why are SAT at 1650 and ACT at 24 predictive of college readiness?

SAT scores make a substantial contribution to the prediction of first-year grade point average in college. Reaching a minimum score of 24 on the ACT corresponds to successful performance on content-alike college courses, and students who reach that score are less likely to need remediation. Admission scores such as the SAT and/or ACT combined with a measure of high school grades produce higher validity coefficients than using either measure alone.
The highest level of correlation and therefore the greatest predictability comes from a combination of high school grade point averages, plus the ACT or all three individual scores on the SAT. If a student wishes to matriculate to Montgomery College, he/she will be required to take the Accuplacer to determine the need for remediation if he/she scores below 550 on either the Critical Reading section or the Mathematics section of the SAT. Similarly, a student must

score a minimum of 24 on the ACT to be exempt from remediation testing at Montgomery College.

Curriculum: Assessed Curriculum Research Question 6: What is assessed on national and international mathematics assessments such as NAEP, TIMSS, and PISA? What data are available on Maryland and/or U.S. student performance?

Due to global competition and demand for skilled workers, there is a push for assessment that allows for comparison of educational systems nationally and internationally. NAEP is a national assessment of students in Grades 4, 8, and 12. TIMSS, given to students in grades 4 and 8, and PISA, given to 15-year-olds, are international assessments that provide an opportunity to examine U.S. student performance on the content and skills deemed important in measuring mathematical proficiency across the country and world. The assessments do not report student-level data. The NAEP, TIMSS, and PISA are compared in the chart below.

Comparison of National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Program for International Student Assessment (PISA)—as of 2003

	NAEP	TIMSS	PISA
First given	1969	1995	2000
Grade tested	Grades 4, 8, and 12	Grades 4 and 8 (12th grade last given 1995)	15-year-olds
Assessment length	50 minutes all grade levels	72 minutes for Grade 4 90 minutes for Grade 8	120 minutes
Calculator use	Four-function calculators for Grade 4; scientific calculators for Grades 8 and 12	Students can use their own or school's (simple function) calculator during second half of test	Participating countries are given the discretion to use calculators or not
Content strand/ content domain	• Number sense, properties, and operations • Measurement • Geometry and spatial sense • Data analysis, statistics, and probability • Algebra and functions	• Number • Measurement • Geometry • Data • Algebra	• Change and relationships (functional thinking i.e., linear, exponential, periodic, and logistical growth) • Quantity (number sense, meaning of operations, mental arithmetic, and estimation) • Space and shape (recognizing shapes and patterns, understanding dynamic changes to shapes, similarities and differences, and two- and three-dimensional representations and relationships between them) • Uncertainty (data collection, analysis, and representation; probability; and inference

Comparison of National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Program for International Student Assessment (PISA)—as of 2003

	NAEP	TIMSS	PISA
Cognitive Domain	• Mathematical abilities • Conceptual understanding • Procedural knowledge • Problem solving • Mathematical power • Reasoning • Connections • Communication	• Knowing facts and procedures • Using concepts • Solving routine problems • Reasoning • Communicating mathematically (overarching dimension to be demonstrated through description and explanation)	• Competency clusters • Reproduction (reproduce routine tasks that are familiar) • Connections (demonstrate problem-solving competencies that are familiar, but not routine) • Reflection (develop solution strategies and apply them to new settings) • Situations • Personal (within immediate realm of student's experiences) • Educational/occupational (within student's school or work life) • Public (encounters within community or society) • Scientific (hypothetical scenarios or scientific applications of mathematics)
Question types	• Multiple choice • Short answer • Extended response	• Multiple choice • Written response (two-thirds short answer and one-third more extended answer)	• Equal number of multiple choice, closed constructed response, and open constructed response items • Organized as tasks so students can apply knowledge to authentic (real world) problem-solving situations

Curriculum: Assessed Curriculum Research Question 7: What is the balance between instruction and assessment to facilitate learning and increase student achievement?

Assessments often are used by teachers as an end product to determine what students have learned; however, they are an integral part of daily ongoing instruction, and are most useful when they are used to assess student progress and plan for future instruction. Research indicates that, in the ideal learning environment, instructional staff members and students work together to use assessment to monitor and evaluate student progress toward curricular indicators throughout the learning process. Regular use of formative classroom assessment improves student achievement on standardized tests, with the greatest gains among low-achieving students. Both formal and informal strategies are used to assess students during instruction. Knowledge about designing and utilizing effective formative assessment is required to produce the desired gains in student achievement. Ongoing professional development enhances the many complex skills involved in analyzing and using assessment data to improve daily instruction in mathematics.

Curriculum: Assessed Curriculum Recommendations

Guiding the recommendations below is the belief that assessment is not an event but an ongoing component of effective teaching and learning that prepares students for college and career

success. Assessments are an important and intrinsic component of the instructional program. Mathematics assessment in MCPS makes students' thinking about mathematical content, concepts, and processes visible to the teacher, and indicates progress toward meeting the CCSS. Teachers and other instructional staff members use assessment data to make daily instructional decisions and to provide meaningful feedback to students that empowers them to own their learning. Local, state, national and international summative assessments ensure that students are receiving a standards-based education that prepares them for success in the 21st century global economy.

1. Revise the MCPS mathematics assessment program to ensure it is aligned with the CCSS and measures a student's growth and achievement over time in all content standards, across all strands of mathematical proficiency (understanding, computing, applying, reasoning, and engaging), and at all levels of mathematical thinking (reproduction, connection, analysis).

2. Provide formative and summative assessments at each grade level/course that make students' thinking visible to the teacher and inform teaching and learning.

3. Build time into the school schedule for mathematics teachers to collaboratively plan ongoing formative assessments, examine assessment data, reteach, reassess, and provide effective individual student feedback.

4. Provide professional development on formative assessment practices including item development, data analysis, and individual student feedback.

5. Create an online forum that will enable instructional staff members to share their formative assessment items and practices.

6. Ensure the overall assessment program includes appropriate national and international norm-referenced assessments that provide useful national and international comparison data.

Acceleration Practices: Mathematics Targets and Acceleration

Acceleration is a term used to describe many instructional practices and is interpreted in different ways by different users. Acceleration can mean compacting curriculum, skipping units, grade levels, or courses to reach an adequate level of instructional challenge for the student, and helping underperforming students master foundational knowledge to quickly reach grade-level or above-grade-level standards. Currently the most common practice in MCPS is reflected in the second definition above—skipping units, grade levels, or courses as students have demonstrated mastery of potentially skipped items. Consequently, research focused on the impact and benefit of accelerating students into above grade-level courses. Curriculum compacting and bringing underperforming students up to level are acceleration practices within MCPS but were not the focus of this investigation. These aspects of acceleration, while important to student success in MCPS, were outside the scope of the K–12 Mathematics Work Group.

More students in MCPS than ever before are benefiting from a challenging curriculum. Many of these students are children who traditionally have been underenrolled in advanced courses—African American and Hispanic students, as well as students receiving special education, English for Speakers of Other Languages (ESOL), and Free and Reduced-price Meals System (FARMS) services. Nationally and locally, access to higher-level mathematics courses has been identified as a gateway to college readiness. MCPS set many of its targets in the context of this vision and made access to higher-level courses a focal point of the system's strategic plan. However, the very effort to expand access to these formerly restricted courses by setting enrollment and completion targets may have resulted in unintended consequences. The work group's findings indicate that moving students into advanced courses when they have not been adequately prepared may set students up for a difficult struggle and possibly failure.

Ms. Stack and Ms. Watts clarified steps taken by MSDE toward adoption of the CCSS and the impact on curriculum in the state of Maryland. The overarching focus of the CCSS at the elementary school level is on mastery of number concepts, signifying a shift toward deeper content mastery before moving on to other topics. This adjustment aligns strongly with the work group's research findings and stakeholder input and feedback.

The CCSS are divided into separate courses for Grades K–8 and secondary standards at the high school level. The authors claim, "The K–7 standards contain the prerequisites to prepare students for Algebra 1 by eighth grade." In the appendix on high school courses, the CCSS offer the traditional U.S. sequence of Algebra 1, Geometry, and Algebra 2 or the mathematically integrated sequence of Mathematics 1, Mathematics 2, and Mathematics 3 as is offered internationally. The CCSS also suggests an accelerated pathway, noting, "While the K–7 CCSS effectively prepare students for algebra in eighth grade, some standards from eighth grade have been placed in the accelerated seventh grade course to make the eighth grade Algebra 1 course more manageable." The changes brought about by alignment to the CCCS require further study and likely will impact the current acceleration model used in MCPS.

MCPS has begun aligning curriculum to the CCSS. The Elementary Integrated Curriculum, in voluntary implementation at 112 schools in Grades K–1 for the 2010–2011 school year is aligned with the CCSS. In initial comparisons to the 2001–2010 MCPS mathematics curriculum, the CCSS identify a number of concepts previously classified by MCPS as above grade level or part of the acceleration lane for an on-grade level designation. For example, some mathematics content that was in Grade 2 or in the acceleration lane for Grade 1 is now part of the required curriculum for all students in Grade 1. Some content also has been moved up a grade and some overall content has been added or deleted.

MCPS has demonstrated a decades-long commitment to accelerated and enriched instruction, adhering to the tenets in Board Policy IOA *Gifted and Talented Education*, that, "There will be a balance between accelerating the pace and enriching the instruction…" In the past 11 years, the balance in mathematics was shifted toward accelerating the pace; implementation of the CCSS will allow us to reset the balance.

Stakeholder Feedback

Stakeholder feedback on acceleration and targets reflected local and national research which posits that a solid foundation is necessary before accelerating students. While some stakeholders applauded the acceleration available in MCPS mathematics and felt that more should be done to engage students in accelerated mathematics, others questioned the rush to move students above grade level. The four most frequently noted themes in stakeholder feedback were as follows:

- The acceleration is moving students too quickly.
- There needs to be an increased emphasis on basics concepts.
- The placement process needs to be improved.
- There should be an improved respect and emphasis on the grade-level curriculum.

Expert Guest Speakers

Experts in the field of mathematics differed on their perspectives regarding acceleration, as is mirrored in the national debate and the discussions of the mathematics work group. Dr. Schmidt, a guest speaker and member of The National Mathematics Advisory Panel, described the Critical Foundation of Algebra— fluency with Whole Numbers, fluency with Fractions, and particular Aspects of Geometry and Measurement—without which it is difficult to move to the next level. This finding supported the stakeholder feedback that some students were being accelerated without the knowledge of critical foundational skills. At the same time, Dr. Schmidt recommended a decrease in the variations of mathematics courses from remedial to accelerated, because sorting students creates different opportunities. Drs. Chazan, Clark, and Johnson, of the University of Maryland, noted the importance of providing appropriate instruction for advanced students.

Identified Issue: Acceleration Practices: Mathematics Targets and Acceleration

Review of MCPS data on acceleration practices reveals a similar pattern to that of the national trends: many more students, including those who previously had not benefited from acceleration practices, entered and successfully completed advanced mathematics courses. Targets were established to encourage more students to complete Algebra 1 or higher in Grade 8, and those targets pushed schools to take even more aggressive steps toward the advancement of students in mathematics. However, some of the students participating in advanced mathematics courses were not successful, and upon further analysis, it was determined that a percentage of these students were enrolled in advanced mathematics (often by skipping a grade level of mathematics) without meeting proficiency on necessary foundational concepts. MCPS needs to redouble efforts to ensure students are properly placed in courses, while not using prerequisites as a gatekeeper.

Research Findings

Acceleration Practices: Mathematics Targets and Acceleration Question 1**:** What are the benefits and ramifications of accelerating students into above grade-level courses?

The National Mathematics Advisory Panel recognized that mathematically gifted students should be allowed to move through curriculum at a faster pace. This idea is reaffirmed in state regulations and MCPS policies supporting acceleration and enrichment of instruction. Currently 49 percent of MCPS Grade 5 students complete Grade 6 mathematics or higher and 65 percent successfully complete Algebra 1 or higher by Grade 8, although successful completion was defined as passing, which means some of these students earned a D—not a sufficient level of mastery. Review and revision of system wide targets as well as research on the Seven Keys to College Readiness indicate that successful completion should be considered a grade of C or higher. The state considers passing the Algebra HSA a sufficient measure for graduation. Regardless of variable measures, a consistent pattern appears: more students than ever before are benefiting from a challenging curriculum and many of these students are children who have been underserved by advanced courses in the past—African American, Hispanic, as well as students receiving special education, ESOL, or FARMS services. There also has been a significant increase in the number of students accelerated more than one level above the grade standard. For instance, the number of students enrolled in Honors Geometry and Algebra 2 in Grade 8 also has increased significantly over the past five years.

Nationally and locally, successful completion of Algebra 1 has been identified as the gateway to higher-level mathematics and science courses, which better prepare students to attend, persist, and graduate from college. MCPS set many of its mathematics targets in the context of this vision and made access to higher level courses a focal point of the system strategic plan. However, the very effort to expand access to these formerly restricted courses may have resulted in unintended consequences. The findings indicate that moving students into advanced courses when they have not been adequately prepared may set students up for a difficult struggle and possibly failure. Substantive research on the topic of acceleration agrees that a solid foundation is necessary before accelerating students.

Locally, MCPS designed a curriculum intended to provide the necessary foundation for reaching Algebra 1 by Grade 8 which includes acceleration items at each elementary grade level that permit students to accelerate up to one full school year above grade level without missing fundamental concepts. Instead of using performance on the Grade 6 acceleration items within the Grade 5 curriculum as the target, however, MCPS chose completion of Grade 6 mathematics in Grade 5 as the target. MCPS then monitored enrollment of Grade 5 students in Grade 6 mathematics as a strategy to reach the target. Consequently, schools responded by focusing on enrollment of Grade 5 students in Grade 6 mathematics, moving some students up to two years above grade level in challenge. System analysis shows that students who completed the Grade 6 acceleration within the Grade 5 curriculum were more successful in Algebra 1 than students who were skipped into Grade 6 mathematics in Grade 5, without proficiency in the Grade 5 above-grade-level assessments.

There is little research on accelerating students into advanced courses beyond Algebra 1 in middle school, such as Honors Geometry and Honors Algebra 2, other than it is beneficial for mathematically gifted students to have access to courses that challenge them. The research does not reflect how students' lack of preparation may impact performance in courses after Algebra 1, such as Geometry, and Algebra 2.

The work group found that the opportunities for acceleration embedded in each grade level of the elementary school curriculum provide a strong foundation for acceleration in middle school mathematics, including reaching successful completion of Algebra 1 by Grade 8. Students who were skipped into Grade 6 mathematics in Grade 5 without proficiency on the above-grade-level (Math 5) assessment items did not perform as well in Algebra 1 as those completing the embedded grade-level acceleration.

Acceleration Practices: Mathematics Targets and Acceleration Question 2: How do students who are accelerated quickly through the mathematics sequence compare on final measures to students who follow the built-in acceleration available at each grade level? For example, how do students taking Grade 6 mathematics in Grade 5 compare to students taking Grade 5 mathematics with built-in acceleration in terms of preparedness for Algebra 1 in Grade 8?

Review of MCPS data on acceleration practices reveals a similar pattern as national trends. Targets were established to encourage more students to complete Algebra 1 or higher in Grade 8. As a result, many more students, including those who were traditionally not served by acceleration practices, entered and successfully completed advanced mathematics courses. However, some of the students placed in the advanced mathematics courses were not successful, and upon further analysis, it was determined that a percentage of these students were placed without meeting proficiency standards, as determined by mathematics unit assessments. MCPS needs to redouble efforts to ensure students are properly placed in courses.

Acceleration Practices: Mathematics Targets and Acceleration Question 3: What are the most essential mathematics curriculum strands or topics to consider in determining whether a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging mathematics course for a student?

The research on skills and knowledge necessary for acceleration is focused on readiness for algebra. There is much support for algebra for all, but only when students exhibit demonstrable success in prerequisite skills—not at a prescribed grade level—should they focus explicitly and extensively on algebra, whether in a course title Algebra 1 or within an integrated mathematics curriculum. The research speaks to a strong arithmetic foundation prior to formal algebra, and this should not be confused with simple computational fluency. The National Mathematics Advisory Panel, and the work group's guest speakers, describe the critical foundation of algebra as—

- fluency with whole numbers, including a strong number sense, place value, computational fluency, and the ability to estimate results of computation and orders of magnitude;
- fluency with fractions, including a thorough understanding of positive as well as negative fractions; compare fractions, decimals and related percents; and
- particular aspects of geometry and measurement, including being able to find unknown lengths, angles, and areas.

The CCSS recognize the importance of the above-mentioned Critical Foundation of Algebra and the need for a strong foundation in number concepts and computation to prepare students for higher-level mathematics. As a result the CCSS emphasize number, measurement, and geometry in the elementary grades and focus more on other standards such as probability and statistics in the upper grades.

Acceleration Practices: Mathematics Targets and Acceleration Recommendations

Guiding the recommendations below is the belief that the MCPS mathematics program should be challenging and rigorous for all students and should be taught to mastery. Any acceleration should be based on the needs of the learner, supported by data, and flexible as the student moves through the course or content. Targets should be aligned with mastery of mathematical content.

1. Eliminate the practice of large numbers of students skipping grade levels in mathematics. Ensure that all students have access to in-depth content knowledge at each grade level or course as reflected in the CCSS.

2. Continue programs and acceleration for students who demonstrate exceptionally strong and consistent proficiency of all mathematical strands (understanding, computing, applying, reasoning, and engaging) represented in the CCSS.

3. Monitor, at the school and district levels, secondary course placement decisions to ensure equitable preparation and opportunities for advancement for all students, including those groups who have been underserved in the past: African American, Hispanic, special education, and English Language Learners.

4. Assess the impact of the implemented CCSS on the instructional program, including acceleration and targets.

5. Refocus the elementary mathematics target and Key Three of the Seven Keys to College Readiness (Complete Advanced Math in Grade 5) to reflect the implementation of the CCSS.

Teacher Preparation and Development: Teaching for Mathematical Proficiency

High quality mathematics professional development is job-embedded, data-driven, research-based, differentiated, sustained over time, and balanced between content and pedagogy. It is the vehicle by which educators acquire or enhance the knowledge, skills, and beliefs necessary to produce high levels of learning for all students. Teacher preparation programs provide a solid foundation upon which the career-long opportunities for teachers to continue to learn are built. Ongoing professional development for all teachers, instructional staff members, and instructional leaders of mathematics is essential to continuous improvement and student achievement. Professional development designed to improve the teaching and learning of mathematics helps instructional staff members understand mathematics content and how students learn that content. The impact and effectiveness of professional development is increased when groups of instructional staff members collaboratively reflect on and refine their instructional practices.

The MCPS Professional Growth System values continuous improvement and professional development for all staff. MCPS currently provides a staff development teacher in every school. In addition, the Elementary Integrated Curriculum provides online professional development for instructional staff members as well as the opportunity to collaborate, reflect, and share resources with others in online professional learning communities.

Research has examined the need for elementary school mathematics specialists to build instructional staff members' knowledge, capacity, and skills. In some MCPS elementary schools, mathematics content coaches (MCC) are available to strengthen instructional staff members' understanding of mathematics content. Findings from OSA suggest that "students from every subgroup appear to derive benefits from having MCCs in their schools." In every secondary school, there is an instructional leader (e.g., mathematics resource teacher) to support teacher learning and build teacher capacity.

Stakeholder Feedback

The greatest number of comments received regarding the strengths of teacher preparation and development noted the importance of the teacher to a student's learning. Respondents also commented on the variety of instructional methods, particularly focusing on hands-on activities and activities that support students' learning needs in mathematics. However, stakeholders also commented on the need to improve teachers' depth of content knowledge, especially at the elementary level.

Expert Guest Speakers

Almost every guest speaker who addressed the K–12 Mathematics Work Group commented on the importance of the teacher in the classroom. Dr. Hiebert stressed that we may change many things—curriculum, textbooks, structure of class periods, performance targets, and assessments—but if we fail to address teaching, none of these changes make their way into the classroom and impact students in meaningful ways. Dr. Leinwand noted the importance of strategies for creating a culture of professional interaction and growth and building communities of learners, including collaborative analysis of student work and collegial coaching and sharing. Drs. Chazan, Clark, and Johnson emphasized the need to change teacher preparation programs to impact mathematics teaching and learning systems.

Identified Issue: Teacher Preparation and Development: Teaching for Mathematical Proficiency

The focus of the teacher preparation and development work was to research and identify best practices related to professional development structure and substance. The research questions centered on features of effective mathematics professional development in order to lead to findings that would support the MCPS vision of schools and teachers engaged in self-sustaining professional learning communities.

Research Findings

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 1: What factors about teacher preparation programs and/or certification should be considered in recruiting teachers of mathematics?

There were no conclusive findings concerning the factors about teacher preparation programs and/or certification which should be considered in recruiting teachers of mathematics. Teacher preparation programs should be designed to include course work and field experiences that develop teacher proficiency with the content of the curriculum. Research examining differences between alternate routes to certification and traditional certification routes found that variations in student achievement were not strongly linked to teacher preparation route. Similarly, there is no consistent evidence of a positive relationship between the content and number of courses in mathematics taken by teachers and student achievement. In other words, variation in student achievement was not strongly linked to the teachers' chosen preparation route or other teacher characteristics, including SAT/ACT scores and levels of teacher training coursework. The key is the teacher's deep understanding of mathematics and ability to convey that understanding to students. A teacher with a deep understanding of mathematics can lead students to new knowledge by helping them discover relationships, solve problems, construct explanations, and draw conclusions.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 2: What features of professional development are most effective to help teachers improve their content knowledge and content-specific pedagogy?

Teacher learning needs to be generative, to serve as a basis for teachers to continue to learn from their practice. Effective professional development addresses the following components:

- Engaging participants in active learning communities
- Coherence
- Content knowledge equally balanced with pedagogy
- Evaluation of impact on teaching strategies and student learning
- Sustained learning over time

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 3: What does research say about the impact of school-based mathematics content support (e.g., mathematics content coaches, algebra lead teachers, resource teachers) in building teacher capacity and increasing student achievement?

The term mathematics specialist is used to describe three different models or roles: the lead teacher or mathematics coach, the specialized mathematics content teacher, and the pull-out mathematics specialist who provides intervention and support to selected students. Mathematics specialists as lead teachers or coaches are the most common models. These school-based mathematics specialists support the professional growth of teachers and establish communities of practice in their schools. There is some evidence that the support of school-based mathematics content support increases the likelihood that professional development will result in changes in

teachers' practice. It is difficult to isolate the impact of mathematics specialists on student achievement, but a spring 2010 joint position statement of the Association of Mathematics Teacher Educators, the Association of State Supervisors of Mathematics, the National Council of Supervisors of Mathematics, and the National Council of Teachers of Mathematics about elementary school mathematics specialists noted that available research indicates a positive impact on teachers and students. The paper cited studies describing changes in teachers' practice including more active engagement of students, effective planning, and using student work to inform instruction. In addition, Dr. Fennell, professor of education at McDaniel College and former president of the National Council of Teachers of Mathematics, advocated for elementary mathematics specialists when he spoke to the K–12 Mathematics Work Group.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Recommendations

Guiding the recommendations below is the belief that intensive and sustained high-quality professional development for all teachers and leaders of mathematics is essential to improve student achievement. High quality professional mathematics professional development is collaborative, job-embedded, data-driven, research-based, differentiated, and balanced between content and pedagogy. Professional development should be generative, and applied in a cycle of continuous improvement that results in mathematically proficient students and educators. In addition, and in order to break the cycle of teachers teaching the way they were taught, student/intern teacher practices and partnerships ensure mathematically proficient, confident, and competent educators. The recommendations for teacher preparation and professional development are grounded in the belief that continuous improvement and learning are essential for all professionals. The parents and students of MCPS should be confident that the teacher of mathematics in every classroom possesses the knowledge and skills necessary to enable every student to understand and use mathematics in a 21st century global society.

1. Provide time and structures for instructional staff members to engage in collaborative, job-embedded professional development, apply what they learn, and reflect, reinforce, or revise instructional practices. Develop a plan to evaluate the impact of professional development on student learning.

2. Offer online, face-to-face, and hybrid (combination of online and face-to-face) professional development opportunities that align with the written curriculum and balance content knowledge and pedagogy.

3. Designate a school-based mathematics specialist position in every elementary, middle, and high school with allocated release time whose primary role is to support the professional growth of mathematics instructional staff.

4. Expand and strengthen university program partnerships to—
    - provide teacher preparation aligned with MCPS goals for the teaching and learning of mathematics; and
    - place student teachers and interns in classrooms that provide models of effective mathematics teaching.

5. Continue to recruit and hire mathematics teachers with content expertise from a variety of professional backgrounds, including those who have pursued alternate routes to teacher certification. Involve content experts in the hiring process.

Conclusion

The K–12 Mathematics Work Group created recommendations to effectively meet the diverse needs of all students in a rigorous and challenging mathematics program and improve teaching and learning to prepare students for college and the world of work. These recommendations are predicated upon extensive research, exhaustive debates, and sound analytical methods. Just as the 2000 mathematics audit was one measure that guided our work in raising the bar and closing the gap for all students during the past decade, these recommendations set the stage for mathematics education in MCPS for the next decade. They are crafted to ensure all students have the opportunity to learn and meet the same high standards so that they can access the knowledge and skills necessary in their post-secondary lives. They are offered to the superintendent of schools to guide future decisions about curriculum and assessment, school structures, classroom/instructional strategies, acceleration practices, and teacher preparation to prepare all students for success as a productive citizen in the 21st century.

Upon acceptance of these recommendations, work will begin to create a timeline and action plan for implementation. Members of the work group are aware that implementation of the recommendations will require further decisions and work. The revision of the Maryland State Curriculum due to adoption of the CCSS will be needed before some are started. After implementation of curricula based on the CCSS, exhaustive study will be required to determine the impact on teaching and student learning. After study of the implementation, MCPS will assess the impact of the CCSS on student learning and engagement at the elementary level, then develop and implement equitable practices for students who consistently demonstrate proficiency with all mathematical strands (understanding, computing, applying, reasoning, and engaging) represented in the common core state standards for the grade level. After study of the implementation, MCPS will assess the impact of the CCSS on courses at the secondary level, then revise, develop, and implement course sequences for students who consistently demonstrate proficiency with all mathematical strands (understanding, computing, applying, reasoning, and engaging) represented in the CCSS for the grade level.

The current budget environment will necessitate examination of each recommendation's fiscal impact and decisions will be required about current programs and practices that may need to be altered to implement new recommendations. A timeline for preliminary action plan related to the recommendations is expected by spring, 2011.*

*Attachments L and M provide a glossary of definitions for the terms used throughout this report and a complete list of citations upon which the work group relied.

Attachment A

K–12 Mathematics Work Group Members

The following information lists K–12 Mathematics Work Group members in the positions they held at the time they began their participation. The work group was formed in January 2009.

Dr. Frieda K. Lacey, deputy superintendent of schools, Office of the Deputy Superintendent of Schools
Mr. Stephen L. Bedford, chief school performance officer, Office of School Performance*
Mr. Sherwin Collette, chief technology officer, Office of the Chief Technology Officer
Mrs. Carole C. Goodman, associate superintendent, Office of Human Resources and Development
Mr. Erick J. Lang, associate superintendent, Office of Curriculum and Instructional Programs
Ms. Jody A. Leleck, chief academic officer, Office of the Deputy Superintendent of Schools
Dr. Susan F. Marks, associate superintendent, Office of Human Resources and Development*
Mrs. Chrisandra A. Richardson, associate superintendent, Office of Special Education and Student Services
Dr. Stacy L. Scott, associate superintendent, Office of Shared Accountability*
Dr. Frank H. Stetson, acting chief school performance Officer, Office of School Performance
Mr. James J. Virga, associate superintendent, Office of Organizational Development
Dr. Carey M. Wright, associate superintendent, Office of Special Education and Student Services*
Ms. Aggie Alvez, director, Office of Communications and Family Outreach*
Ms. Rebecca Amani-Dove, administrative assistant, Office of Shared Accountability
Dr. Carl L. Baskerville, director, Curriculum Training and Development, Office of Organizational Development
Ms. Billie Jean Bensen, principal, Herbert Hoover Middle School
Ms. Ann E. Bedford, director School Support, Interventions, and Assessments, Office of Curriculum and Instructional Programs*
Mr. Martin M. Creel, director, Department of Enriched and Innovative Programs, Office of Curriculum and Instructional Programs
Ms. Teresa J. Brown, teacher, Grade 2, Viers Mill Elementary School
Ms. Theresa A. Cepaitis, director, Curriculum Projects, Office of Curriculum and Instructional Programs
Mr. Marc J. Cohen, principal, Dr. Martin Luther King Jr., Middle School
Ms. Bonita L. Cullison, teacher, Office of Human Resources and Development*
Miss Denise M. Defiore, assistant to the associate superintendent, Office of Organizational Development
Mrs. Nicola Diamond, executive assistant, Office of the Chief Operating Officer
Ms. Karen O. Emmerich, mathematics resource teacher, Julius West Middle School
Ms. Loretta M. Favret, principal, S. Christa McAuliffe Elementary School
Mr. Jeffrey L. Flowers, teacher, Special Programs, Poolesville High School
Dr. Christopher S. Garran, principal, Walter Johnson High School

*No longer with Montgomery County Public Schools

Miss Natalie M. Howard, teacher, Focus, Strathmore Elementary School
Mr. E. Hsiayuan Hsu, teacher, Magruder High School
Mr. James P. Koutsos, principal, Clarksburg High School
Ms. Barbara J. Leister, principal, Wyngate Elementary School
Mrs. Marti (Dawn) D. Lemon, teacher, Alternative Programs, Montgomery Village Middle School
Mr. Andrew W. Miller, supervisor, Innovative Professional Development, Office of Organizational Development
Mrs. Sally R. Murek, paraeducator coordinator, Office of Organizational Development
Mrs. Naomi R. Resnick, staff development content specialist, Office of Organizational Development
Mrs. Karen S. Roberts, acting supervisor, pre-K-12 mathematics, Office of Curriculum and Instructional Programs
Ms. Jody Silvio, executive assistant, Office of the Deputy Superintendent of Schools
Dr. Joanne Smith, principal, Glen Haven Elementary School
Dr. Kara B. Trenkamp, instructional specialist, Office of the Chief Technology Officer
Dr. Darryl L. Williams, principal, Montgomery Blair High School
Mrs. Andrea Q. Bernardo, parent
Ms. Tonya Easley, community member, NAACP
Ms. Merry Eisner, parent, Montgomery County Council of Parent Teacher Associations
Ms. Sabrina McMillian, parent, NAACP Parents Council
Dr. Rebecca K. Newman, president, Montgomery County Association of Administrators and Principals
Mr. Douglas G. Prouty, president, Montgomery County Education Association
Ms. Karen Smith, parent
Ms. Rebecca Smondrowski, curriculum committee chair, Montgomery County Council of PTAs

Attachment B

K–12 Mathematics Work Group

List of Stakeholders, Parent Teacher Associations, and Student Government Associations Solicited for Comment

Stakeholder Groups

- Accelerated and Enriched Instruction Advisory Group
- Asian American Parent Advisory Group
- Deputy's Minority Achievement Advisory Council
- Elementary Councils on Teaching and Learning
- Elementary School Principals
- High School Principals
- Korean Parents Group
- Latino Parents Focus Group
- Middle School Principals
- Montgomery College Focus Group
- Montgomery County Council of Parent Teacher Associations
- Montgomery County Junior Councils
- Montgomery County Regional Student Government Association
- National Association for the Advancement of Colored People (NAACP)
- Parent Advisory Council
- Secondary Councils on Teaching and Learning
- Special Education Advisory Committee
- Special Education Continuous Improvement Team Advisory Committee

Elementary School Parent Teacher Associations (PTA)

- Ashburton
- Bannockburn
- Bradley Hills
- Burning Tree
- Candlewood
- Carderock Springs
- Clarksburg
- Clearspring
- Farmland
- Forest Knolls
- Galway
- Garrett Park
- William B. Gibbs, Jr.
- Greenwood
- Harmony Hills
- Laytonsville
- Little Bennett
- Luxmanor
- Ronald McNair
- Oakland Terrace
- Piney Branch
- Potomac
- Ritchie Park
- Rock View
- Rosemary Hills
- Sligo Creek
- Somerset
- Stedwick
- Stonegate
- Takoma Park
- Twinbrook
- Watkins Mill
- Wayside
- Wood Acres
- Woodfield
- Woodlin
- Wyngate

Middle School PTAs

- William H. Farquhar
- Lakelands Park
- A. Mario Loiederman
- Parkland
- Thomas W. Pyle
- Ridgeview
- Rocky Hill
- Silver Spring International
- Takoma Park
- Tilden
- Westland

High School PTAs

- Montgomery Blair
- Albert Einstein
- Richard Montgomery
- Paint Branch
- Quince Orchard
- Springbrook
- Wheaton
- Walt Whitman

Student Government Associations

- John T. Baker Middle School
- Ronald McNair Elementary School
- Northwest High School
- John Poole Middle School
- Sherwood High School
- Takoma Park Middle School
- Julius West Middle School

Attachment C

K–12 Mathematics Work Group

Report of Survey/Focus Group Responses

The comments included in this report **do not** represent a statistical sample and the product is not a statistical analysis. The survey of stakeholders was narrative in nature and did not restrict the number or content of narrative responses—and both of those conditions limit the feasibility of analysis. For example, where one school's PTA may have summarized comments and sent three succinct bullet points to respond to a question, another school's PTA may have transcribed comments verbatim and submitted 30 individual comments. Therefore, the report presented below is just that, a report. It presents the most commonly conveyed themes for review and consideration as the K–12 Mathematics Work Group moves toward completion of its charge.

This report presents the prevalent themes within the research areas according to each survey question. Representative comments related to the prevalent themes within a research area for each of the survey questions are provided in Attachments B–F. Comments were selected by using a random pattern to ensure all stakeholder groups were included. Themes that totaled to approximately 70 percent of all responses within a research area were illustrated with representative comments.

Research Area—Curriculum: Written Curriculum

The broad range of content topics was the strength of the written MCPS mathematics program most frequently mentioned by survey respondents. The way in which units are designed to connect with upcoming units or parts of the unit also was an identified strength. Other strengths mentioned were the multiple enrichment programs/courses and the available resources (lessons, guides, and textbooks).

Individual and specific components of the written curriculum received the most comments from respondents noting aspects of the MCPS mathematics program to be changed, improved, and/or enhanced. These curricular components included the naming of the math classes, the alignment (or lack thereof) of units, the writing quality in questions, the order of indicators, and the logical flow of the curriculum. Comments were provided which indicated a belief that the curriculum would be improved by an emphasis on basic mathematics facts. Other comments mentioned a desire to see change in written parent resources (i.e., syllabi, solution guides for parents) and selected comments regarding textbooks, pacing, and the spiral nature of the curriculum.

The largest percentage of respondents did not believe their child was prepared for the knowledge he or she needed for his/her next steps due to the lack of basics in the written curriculum, although the next most common comment was a simple "Yes" with little elaboration. The spiral nature of the written curriculum received numerous comments divided between respondents who felt it helped prepare their student and respondents who felt it left their student unprepared. A

structure that is perceived to be deficient in the depth leading to mastery of the concepts, as well as the lack of textbooks and other resources for parents, were noted by some respondents who did not believe their children were prepared.

Most respondents sharing experiences they had, or wished they had, with the written curriculum cited a wish for increased basics in the written curriculum. There also were multiple comments regarding experiences with specific written curricula, such as Core Knowledge, Singapore Math, and Everyday Math. The underlying theme among these curricula was a perceived superiority of a linear progression. A number of respondents experienced a lack of time within the written curriculum to master the mathematical concepts. Other experiences mentioned in a few comments included wishes for an integrated curriculum, for more depth in the topics, and for more written parent resources as part of the curriculum.

Many respondents had suggestions to improve the written curriculum for mathematics teaching and learning. Some examples of specific curricula receiving positive and/or negative comments included: Singapore Math, Kumon, Chicago/Everyday Math, 21st Century Skills, Inquiry-Based Learning, Core Knowledge, and Saxon Math. These established curricula were mentioned in conjunction with general recommendations for content and sequencing. Other frequent recommendations for the improvement of the written curriculum were to focus on the mastery of the basics and to reduce the content in relationship to the time given to teach the content. Some respondents recommended ensuring an integration of mathematics with other subjects, providing improved parent resources, and selecting different textbooks.

Attachment D is a representative sample of the comments related to the prevalent themes within the area of the written curriculum for each of the survey questions.

Research Area—Classroom/Instructional Practices: Implemented Curriculum

To discern comments that applied to the research area *Classroom/Instructional Practices: Implemented Curriculum*, "implementation" was defined as the process for putting a design, plan, or policy into effect. For example, while a written curriculum may recommend a time frame for each of its units, the actual implementation will determine how much time is spent on an individual unit. There was significant overlap between those comments that were considered applicable to the research area *Classroom/Instructional Practices: Implemented Curriculum* and those comments that were considered applicable to the research area *Curriculum: Written Curriculum*.

The most frequently identified strength in the implemented curriculum was grouping practices—most often meaning grouping of students by ability, although some comments on grouping also mentioned the benefits of working in smaller groups and the flexibility to move from one group to another. The variety of instructional practices, such as the use of manipulatives and creative exercises, was another common theme. Respondents also commented that course options

available to students, including availability of challenge items to expand course content, were strengths. Some respondents had particular comments regarding the textbooks/study guides provided for use at home and identification of strengths in individual school activities.

Although not prevalent across all stakeholder groups, the paramount interest of elementary school principals was a variant of stakeholder support for grouping. Principals, too, believe grouping practices are a strength of instruction in the schools, but the principals specifically commented on a need for alignment within the curriculum. The current curricular progression allows for regrouping within a grade level, but grouping and regrouping across grade levels is problematic. By ensuring discrete topics are timed to occur within the curriculum during the same time period across all grade levels, elementary principals believe opportunities for grouping and regrouping according to student need would be significantly improved.

The most common theme of the responses to aspects of the MCPS mathematics program respondents would like to see changed, improved, and/or enhanced centered on timing—the perceived need for greater emphasis on the basic concepts of mathematics, the need for more time for in-depth study, the lack of time for practice, and the desire for all levels of math to study the same concepts at the same time. Grouping reappeared as a common theme, this time centering on those components respondents would like to see changed, improved, and/or enhanced, including a desire for greater homogeneous grouping for mathematics and smaller group/class sizes. Additional comments mentioned the variety of instructional practices, homework, a variety of course options, and the need for support as other aspects of the mathematics program that could be changed, improved, and/or enhanced.

Most who commented on student preparedness shared their concern for moving to the next step due to a lack of the basic concepts. Nearly as many respondents commented that students were unprepared due to the lack of mastery of mathematical concepts. Respondents also commented that the pace in which new concepts are introduced may leave students unprepared. Some respondents believed that their children were prepared for the next level, but seldom cited a reason and simply commented “yes.”

Respondents shared a number of experiences regarding the implemented curriculum, most complimenting or requesting varied instructional strategies be used, including opportunities for the children to experience real-life application of mathematical concepts. Respondents also shared experiences with staffing/scheduling; including situations where children travel from one school to the next for instruction, class size situations, homogeneous various heterogeneous grouping situations and class size situations. Experiences with the lack of basics and moving too fast were other common comments.

The most frequent recommendation for improving the implementation of mathematics was to vary activities by increasing opportunities to apply math to the real world and to use hands-on materials that make learning fun and creative. Many comments also recommended an increase

in the time spent teaching fundamental math concepts to ensure mastery of each concept. Further recommendations included increasing the use of Promethean Boards or other technologies, and grouping practices similar to those already mentioned.

Attachment E is a representative sample of the comments related to the prevalent themes within the area of the implemented curriculum for each of the survey questions.

Research Area—Curriculum: Assessed Curriculum

Fewer than seven percent of all comments received from the surveys and focus groups pertained to the assessed curriculum. Many of those comments were detail-specific and difficult to cluster within themes.

The most frequently noted strengths of the assessed curriculum within the MCPS mathematics program were components of the formative and unit assessments. In addition, respondents commented on the strengths of reports for teacher and parents.

Respondents' comments were individualized in regard to aspects of the MCPS mathematics program which related to the assessed curriculum that they would like to see changed, improved, and/or enhanced. The most common themes centered on finals/units tests, the specific construction of assessments, the overall assessment process, and recommendations for changes in grading and reporting guidelines.

Fewer respondents supplied comments regarding their child's preparation for mathematics or experiences regarding assessments than all other survey question areas. The widely varied responses included comments regarding assessing skills of each student, "teaching to the test," a perceived over emphasis on testing, and a perceived disconnect between unit/quarter grades and exams.

Respondents shared a limited number of experiences with the MCPS assessment program. As was typical for this research area, responses were individualized and varied. Many of the comments spoke to experience where it was perceived that the focus on assessment has become paramount in MCPS. Other comments noted the difference between ability to succeed on unit tests versus the inability to excel on final exams.

A majority of the suggestions offered for improvement of the MCPS mathematics teaching and learning program in the area of assessments centered on the guidelines for grading and reporting. Suggestions included a recommendation for greater access to completed assessments, individualized comments regarding the weight given particular activities for graduating (formative versus summative and homework), recommendations for a reduction of the emphasis on testing, and concerns regarding "teaching to a test." One unique recommendation suggested

every child be required to take the Maryland Functional Math Test or something similar before he/she could take Algebra.

Attachment F is a representative sample of the comments related to the prevalent themes within the area of assessed curriculum for each of the survey questions.

Research Area—Acceleration Practices: Mathematics Targets and Acceleration

As was typical for all research areas, identification of strengths received the fewest responses regarding Acceleration Practices: Mathematics Targets and Acceleration. The strengths most frequently identified included varied opportunities for all students and the availability of rigor at all levels. Other respondents listed direction to appropriate instruction as a strength, noting the perceived ability to be flexible and accelerate as necessary, or recognize when a student needs to slow down.

Respondents provided the greatest number of comments about the aspects of the MCPS mathematics program regarding Acceleration Practices: Mathematics Targets and Acceleration that they would like to see changed, improved, and/or enhanced. The four most frequently noted themes were—

1. The acceleration is moving students too quickly,
2. There needs to be an increased emphasis on basics concepts,
3. The placement process needs to be improved, and
4. There should be an improve respect and emphasis on the regular curriculum.

In addition, comments were made requesting MCPS improve clarity regarding central office expectations, improve staffing to accommodate grouping for acceleration, improve clarity regarding the best path to take for success in math (the trajectory), make accelerated options available from kindergarten forward, and provide all options at all schools. One individual stated a non-math comment that, “Math is too much of the focus, to the detriment of other subjects—(Whitman PTA)”

Respondents reflecting on their student’s preparedness in relationship to acceleration presented varied points of view on this topic. The most prevalent response was that students were missing basics due to acceleration. However, the next two most prevalent responses were the exact opposite viewpoints, with comments sharing concern that there is not enough acceleration and comments recommending a reduction in the emphasis on acceleration. Other respondents cautioned MCPS not to skip grades and to raise the level of mastery required before accelerations above percent. Several respondents simply affirmed the MCPS program by saying “Yes.”

A majority of the respondents who shared their child's experiences, or experiences they wished their child had, in relationship to acceleration that made or would have made their child stronger in mathematics, wished that their child had been given an opportunity to accelerate earlier. Another high portion of these respondents, however, related situations where they had concern regarding the non-academic impact of acceleration on the student. Other respondents relayed experiences when their child was moving too fast, was not served as well as possible by the placement process, or was left lacking basics.

Finally, respondents had nearly as many suggestions for the improvement of the MCPS mathematics teaching and learning program in respect to acceleration as they had identified areas for change, improved, and/or enhancement. The largest number of respondents recommended MCPS focus less on acceleration, while a large number of respondents questioned the composition of accelerated classes and recommended accelerating only select students. Additional recommendations were to review expectations, review grouping, increase program options, provide adequate staffing for acceleration to be successful, and to instill competency in basics.

Attachment G is a representative sample of the comments related to the prevalent themes within the area of mathematics targets and acceleration for each of the survey questions.

Research Area—Teacher Preparation and Development: Teaching for Mathematical Proficiency

Survey comments reflected a strong belief in the importance of teachers to the process of learning mathematics. The greatest number of comments received regarding the strengths of teacher preparation and development noted the importance of the teacher to a student's learning. Respondents also commented on the variety of instructional methods, particularly focusing on hands-on activities and activities that support students' learning needs in mathematics.

Teacher knowledge and expertise in the pedagogy required to teach mathematics were aspects of the MCPS mathematics program many respondents would like to see changed, improved, and/or enhanced. A variety of additional comments identified teacher commitment to students and the management of learning environments, as well as other classroom-center skills. In addition, instructional methods and professional development in basic mathematical concepts received comments for improvement.

Teacher preparation and development was the one research area in which the majority of respondents commented that their child was prepared with the mathematical knowledge he or she needed for his/her next steps—and it all depended on the teacher. Strong, caring teachers were given as reasons for mathematical preparation, although some comments noted there may be teachers who are not as effective as others. In addition, comments were made regarding the

perceived need to increase the commitment to teaching the basics and to communicating about lesson content and student progress.

Survey respondents shared many experiences regarding the positive impact of individual teachers on a student's strength in mathematics, although some cautionary comments were made to consider that a teacher also may have a negative impact. Respondents most frequently wished they or their child had more experience with varied teaching strategies to accommodate different learning styles and for more occasions when mathematics instruction included strategies other than pencil-paper classroom activities.

Respondents' perceptions of the knowledge and training of teachers received the greatest number of comments with suggestions for improvement in the research area of teacher preparation and development. Recommendations included improving general teaching ability, teaching for individual student needs, and increasing the depth of understanding with content. Other suggestions included a focus on teachers' commitment to each student's success and the need for strong communication with the home regarding daily instruction and student progress. There also were suggestions to vary instructional practices, to increase available professional staff and volunteers to support the mathematics teacher, and to improve consistency of teacher ability.

Attachment H is a representative sample of the comments related to the prevalent themes within the area of teacher preparation and development for each of the survey questions.

Attachment D

K–12 Mathematics Work Group

A Representative Sample of Comments Related to the Prevalent Themes Within the Research Area of Curriculum: Written Curriculum

Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?

Content (Comments in this theme comprised 41.4% of all comments received in the research area of Curriculum: Written Curriculum within the category of strengths.)

- Concepts students thought times tables, division, fractions, multiplication, decimals, subtract, percentage, algebraic concepts. *(John Poole MS SGA)*
- I think that challenging students is great. I also think the emphasis on critical thinking and understanding versus mere rote learning is wonderful. *(Piney Branch ES PTA)*
- Coverage of statistical concepts and problems. Recognizing qualitative shape of graphs with a word description of motion, change, etc. This does not need to wait for Algebra. Early introduction to Geometry with respect to perimeter, area, volume. It is so practical. *(Silver Spring International MS PTA)*
- Emphasis on memorizing the basic math facts. *(Wyngate ES PTA)*

Alignment/Spiraling (Comments in this theme comprised 25.0% of all comments received in the research area of Curriculum: Written Curriculum within the category of strengths.)

- About one quarter of the parents also specifically cited the spiraling approach to math instruction as a strength of the MCPS program. *(Bannockburn ES PTA)*
- I love that they expose kids to both on-grade level and above grade level math. *(Greenwood ES PTA)*
- Indicators and expectations are clearly identified. *(Montgomery College)*

Resources/Textbooks (Comments in this theme comprised 19.0% of all comments received in the research area of Curriculum: Written Curriculum within the category of strengths.)

- Clear lessons in guide. *(Individual teachers)*
- Variety of curriculum—plenty of good individual lessons. It continues to a high level—BC Calculus. Before revising anything: Decide the goal for middle level student to reach, is it to prepare for a successful life, managing the finances/assets? High math/advanced math can be learned in college. (*Montgomery County Councils of Parent Teacher Associations*)

Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?

Change curriculum (Comments in this theme comprised 36.1% of all comments received in the research area of Curriculum: Written Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- More practical applications of math—manipulatives, small group activities, interactive projects to help reinforce the concepts. *(Ashburton ES PTA)*
- Organization of the indicators and units is ineffective and confuses teachers and students, there is no logical sequence. *(Individual teachers)*
- More advanced math classes for students who come from middle school having taken Geometry and Advanced Algebra II. *(Springbrook HS PTA)*

Change emphasis to focus on basic facts (Comments in this theme comprised 25.3% of all comments received in the research area of Curriculum: Written Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- Would like to have middle school foundation concepts reinforced in high school. *(Northwest HS SGA)*
- More emphasis on learning the basic fundamentals. *(Rosemary Hills ES PTA)*

Spiral Curriculum (Comments in this theme comprised 9.0% of all comments received in the research area of Curriculum: Written Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- All grade levels should teach topics in the same order (allows for flexible grouping). *(Individual teachers)*

Question 3: Do you feel that your child is prepared with the mathematical knowledge he or she needs for his/her next steps? Next course? Why or why not? Explain.

Lacks basics (Comments in this theme comprised 30.8% of all comments received in the research area of Curriculum: Written Curriculum within the category of student's preparation.)

- More emphasis on basic math such as basic math facts!!! This sentiment is repeated over and over again. *(Candlewood ES PTA)*
- Basic facts are still a struggle for my child. I don't know why he seems so strong in other areas. *(Clarksburg ES PTA)*
- The curriculum is too broad and not focused enough on basic skills. My child was over accelerated and I think that each course causes new anxiety in my child because she does not feel prepared. *(Silver Spring International MS PTA)*

Yes (Comments in this theme comprised 13.7% of all comments received in the research area of Curriculum: Written Curriculum within the category of student's preparation.)

- Two-thirds of our parents who responded answered "yes" to this question. *(Ronald McNair ES PTA)*

Comments on "spiral curriculum" (Comments in this theme comprised 11.0% of all comments received in the research area of Curriculum: Written Curriculum within the category of student's preparation.)

- The idea of a spiraling curriculum is one that many parents are concerned about. The concern is that kids are being introduced to concepts before they are really ready to understand the concept and then move on before a real foundation is built. *(Clearspring ES PTA)*

More depth (Comments in this theme comprised 9.6% of all comments received in the research area of Curriculum: Written Curriculum within the category of student's preparation.)

- SLOW DOWN, drop some nonessential topics to ensure students have good basic conceptual foundation to build on. *(Springbrook HS PTA)*

Missing Mastery (Comments in this theme comprised 8.2% of all comments received in the research area of Curriculum: Written Curriculum within the category of student's preparation.)

- My daughter does fine, but (again, I attribute this to the fast pace and lack of repetition) I feel that she has never totally grasped money or time (although the 4th grade curriculum acts as if she is just reviewing these topics). *(Luxmanor ES PTA)*

Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?

Basics (Comments in this theme comprised 22.4% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- I would like to see more emphasis on BASICS. *(Parkland MS PTA)*
- Better elementary mathematics foundation. *(Twinbrook ES PTA)*

Specific program suggestion (Comments in this theme comprised 18.4% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- I appreciate the fact that my child has been challenged in math, but I would have preferred that the curriculum that was followed when her siblings attended Wayside. I believe that significant changes have occurred in the past four years, and quality has suffered somewhat in favor of acceleration. *(Individual)*
- Felt if there had been recognition of difference between calculation skills and reasoning skills when they built the curriculum, neither thinking would fall through the cracks or be held back. *(Special Education Continuous Improvement Team Advisory Committee)*

Time for mastery (Comments in this theme comprised 14.5% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- Respondents indicated that to facilitate a deeper mastery of basic math skills they wish there was more emphasis on timed drills, memorization, and arithmetic applications. *(Potomac ES PTA)*

More depth with topics (Comments in this theme comprised 10.5% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- Wish: Delve deeper into topics. Give textbooks to go home at very early grades. Make the kids write out times tables over and over again. I get that teachers don't have time to do this in class, but they never even assign this as homework. Middle school teachers have told me that one of the biggest things that holds average to weak math students back as they get into Algebra and above is not having times tables and prime factors of common numbers memorized. They have to start from scratch for each problem instead of being able to look at the numbers and know they are related. *(Garrett Park ES PTA)*

Integrate Curriculum (Comments in this theme comprised 7.9% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- More experiential, hands-on, real-world math related activities and instruction. *(Bannockburn ES PTA)*

Resources (Comments in this theme comprised 7.9% of all comments received in the research area of Curriculum: Written Curriculum within the category of student experiences.)

- Daughter in elementary school tried to figure out what was being taught in each unit and subject—and it is unintelligible (on the Web page) to parent. There are generic things some parents do better than others, but the ability to match what a parent does is frustrated with the opacity of the curriculum. When we started doing math night, what we found there were great things [the parents] could do, they just didn't know what they should be doing. Even something as basic as flashcards, they just needed to learn how to help their student. *(Deputy's Minority Achievement Advisory Council)*

Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?

Specific curricula/sequencing (Comments in this theme comprised 21.4% of all comments received in the research area of Curriculum: Written Curriculum within the category of suggestions for improvement.)

- A KUMON type program with its repetitive reinforcement of basic math skills would go a long way to improving students' math abilities. *(Bradley Hills ES PTA)*
- Consider using separate curriculum for students who are not on grade level to enable them the greatest chance of mastering the foundational skills and use different sensorial tools to teach those skills (touchmath, etc.). *(Stonegate ES PTA)*

Basics mastery (Comments in this theme comprised 18.8% of all comments received in the research area of Curriculum: Written Curriculum within the category of suggestions for improvement.)

- A better method would be to combine the reasoning set of skills with those gained from rote memorization, particularly in the lower elementary grades. *(Rock View ES PTA)*
- Oakland Terrace Elementary School parents primary feedback, in short, is early and more emphasis on the basics. (*Oakland Terrace ES PTA)*

Too much material—too little time (Comments in this theme comprised 17.5% of all comments received in the research area of Curriculum: Written Curriculum within the category of suggestions for improvement.)

- Less material taught over more time. Allow for repetition and lots of practice before introducing new (totally different) concepts. *(Luxmanor ES PTA)*
- Break large units into smaller, more manageable parts. *(Quince Orchard HS and Ridgeview MS PTAs)*

Integrated curriculum (Comments in this theme comprised 7.8% of all comments received in the research area of Curriculum: Written Curriculum within the category of suggestions for improvement.)

- What's all the rush...if we made the teaching of math more fun, applicable, and integrated, students wouldn't get bored in class and basic concepts could be learned more thoroughly. *(Forest Knolls ES PTA)*

Parent resources (Comments in this theme comprised 7.1% of all comments received in the research area of Curriculum: Written Curriculum within the category of suggestions for improvement.)

- Parents would like to see practice booklets/math books/progress reports on individual subjects sent home so that parents can help students at home to understand concepts. *(Ashburton ES PTA)*

Attachment E

K–12 Mathematics Work Group

A Representative Sample of Comments Related to the Prevalent Themes Within the Research Area of Classroom/Instructional Practices: Implemented Curriculum

Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?

Grouping (Comments in this theme comprised 25.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of strengths.)

- It is good that students are broken up by levels to allow students to advance at their own pace. *(Forest Knolls ES PTA)*
- I like the method of grouping kids into different groups based on level. *(Luxmanor ES PTA)*

Variety of instructional methods (Comments in this theme comprised 18.9% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of strengths.)

- I like the more creative parts of the curriculum: models, manipulatives, games, and the statistics activities that the kids design. I'm not even sure whether these were in the curriculum or add-ons. *(Tilden MS PTA)*
- Identifying research-based interventions—making sure teachers know about them and are provided materials. *(Special Education Continuous Improvement Team Advisory Committee)*

Course options (Comments in this theme comprised 16.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of strengths.)

- I like that there are more levels of math for each grade level, so the kids are put in classes that really fit them. *(Woodlin ES PTA)*
- The co-taught math classes—a lifesaver and wonderful. (*Special Education Continuous Improvement Team Advisory Committee)*

Resources/Textbooks (Comments in this theme comprised 11.5% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of strengths.)

- The school system has made extraordinary effort to be sure all kids have access to calculators. *(Deputy's Minority Achievement Advisory Council)*

Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?

Improve basics (Comments in this theme comprised 15.0% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- Slow down the instruction. Make sure every student masters the concepts at every grade level. Don't be in such a hurry to push ahead. *(Wyngate ES PTA)*
- They have been overloaded with math and they don't know the basics. Tried tutors and has helped tremendously with the basics. *(Special Education Advisory Committee)*

Improve timing of concepts (Comments in this theme comprised 14.0% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- The time spent on each unit is too limited and the students at best have a superficial understanding. *(Westland MS PTA)*

Improve grouping (Comments in this theme comprised 12.6% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- Students are placed in a math class at a given "level" at the beginning of the year but are not reevaluated and reassigned as appropriate. *(Little Bennett ES PTA*

Improve variety in implementing curriculum (Comments in this theme comprised 11.7% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- I'd like to see more fun math especially in kindergarten and 1st grade, and fewer equations. *(Takoma Park ES PTA)*

Homework (Comments in this theme comprised 8.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- Homework generally—if they can't do it, there's no sense sending them home with it. How is it being taught, so I don't do it the wrong way? *(Special Education Advisory Committee)*

Course options (Comments in this theme comprised 7.5% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- There should be other types of math classes available in high school that are at a higher level and crossover disciplines. For example, economics, or a regular (not just AP) statistics course. *(Paint Branch HS PTA)*

Improve Support (Comments in this theme comprised 7.5% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of aspects to be changed, improved and/or enhanced.)

- Recognize that LED students are extremely smart students who need to be able to have the tools they need to compete. *(Thomas W. Pyle MS PTA)*

Question 3: Do you feel that your child is prepared with the mathematical knowledge he or she needs for his/her next steps? Next course? Why or why not? Explain.

Basics missing (Comments in this theme comprised 21.3% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student's preparation.)

- No. Basics were not firmly in place before pushing her to next level. *(Springbrook HS PTA)*
- Not ready because students need help reading the textbooks, study skills, expectations, organization. *(Montgomery College)*

Lacking mastery (Comments in this theme comprised 20.5% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student's preparation.)

- NO, my child is NOT prepared because he has been introduced to too many different mathematical concepts in too little time. He has not been allowed adequate time and practice to master any of these myriad concepts. *(Rock View ES PTA)*
- Children had to relearn what they already knew because each unit is so short and there is not enough practice to enforce what they have learned. Believes extra period of math was extremely beneficial. *(Richard Montgomery HS PTA)*

Pace too fast (Comments in this theme comprised 17.2% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student's preparation.)

- I feel that my child will not be fully prepared for IM next year because the students are moving at a far too rapid pace, and they are not delving into Math B with the same careful and advanced focus that is occurring in middle school. *(Individual)*

- The teachers have so much content to cram into so little time the students don't have time to learn it—they learn for the test and then forget it. *(Wheaton HS PTA)*

Yes (Comments in this theme comprised 12.3% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student's preparation.)

- My child learned multiplication and division so now she is able to understand her math work this year. *(William B. Gibbs, Jr. ES PTA)*

Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?

Varied strategies (Comments in this theme comprised 40.9% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student experiences.)

- They wish there was more emphasis on timed drills, memorization, and arithmetic applications. *(Potomac ES PTA)*
- Need for "hands on" math; integration of math into other subjects; fewer worksheets, more computer learning/games. *(Wood Acres ES PTA)*
- Exercises using math to advantage in daily life. *(Twinbrook ES PTA)*
- He loves sports. Show how math can be used with sports statistics, the geometry of baseball pitching/batting, show how area of baseball field increases faster than the base length, etc. It would have engaged him more, but never done. *(Silver Spring International MS PTA)*

Staffing/Scheduling/Grouping (Comments in this theme comprised 15.3% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student experiences.)

- Wish we had more group work *(John Poole MS SGA)*
- Third grade, budget cuts, and loss of 60 students created staff reduction and limited differentiation. Don't have staff to differentiate further—is he being challenged adequately? Larger staff created greater differentiation. *(Parent Advisory Council)*

Moving too fast (Comments in this theme comprised 15.3% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student experiences.)

- More time is needed per objective to review and establish mastery before moving on to new topics. *(Little Bennett ES PTA)*
- I would be stronger in math if it moved slower. *(Julius West MS SGA)*

Experience with basics (Comments in this theme comprised 12.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of student experiences.)

- Consistently, there were requests for more focus and time spent on mastery of subjects rather than acceleration. However, there was an appreciation for acceleration and enrichment as a means of challenging students, but in conjunction with mastery of the basics. *(Ritchie Park ES PTA)*

Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?

Vary activities (Comments in this theme comprised 23.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of suggestions for improvement.)

- Overall the areas that could be strengthened are the creative uses of math—to help students have at least a glimmer of the enjoyment of being able to solve a quantitative problem, and to gain the confidence that they can solve a quantitative problem with confidence and flair, even if they know they are not a genius. Certainly, continue to make math fun and cool for the top students. But also work on ways to make math fun and cool for the middle and bottom, and for girls as well as boys. Mixing math with science (which could be made more advanced at MCPS) or invention or engineering by getting people to invent things and make devices and inventions could potentially get students involved who do not think of themselves as geeks. Have a solar device invention contest, or have a math challenge question of the day, or have a competition between middle schools for students in 6th grade math, or any of a wide range of things. *(Tilden MS PTA)*
- Make lessons fun and have the students interact more. *(Sherwood HS SGA)*

Ensure mastery of basics/fundamentals (Comments in this theme comprised 19.1% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of suggestions for improvement.)

- Drill the Basics: While there's a general agreement that math acceleration is good, so long as it's not overused and kids who aren't ready aren't pushed too far too fast, there's also agreement that rote, even boring, repetition and memorization of the basic math facts is getting lost. Some families are doing this on their own outside of school, but not many. Give depth rather than breadth when it comes to learning math and slow down the curriculum. *(Sligo Creek ES PTA)*
- Please stop confusing our children, and start asking them to memorize. It won't affect their development. It will improve their confidence. Abstract conceptual thought starts at puberty, not in elementary school. *(Individual)*

Technology/Calculators (Comments in this theme comprised 8.5% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of suggestions for improvement.)

- Have students become less reliant on their calculators when possible, to allow students more practice performing hand calculations, whereby they may gain a better understanding of number sense and math simplification strategies. *(William H. Farquhar MS PTA)*

Grouping (Comments in this theme comprised 7.4% of all comments received in the research area of Classroom/Instructional Practices: Implemented Curriculum within the category of suggestions for improvement.)

- Need to carefully review grouping practices to assist learning. *(Elementary Council on Teaching and Learning)*

Attachment F

K–12 Mathematics Work Group

A Representative Sample of Comments Related to the Prevalent Themes within the Research Area of Acceleration Practices: Mathematics Targets and Acceleration

Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?

Varied opportunities for all students (Comments in this theme comprised 43.5% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of strengths)

- The availability of above-grade level mathematics is a strength. *(Ashburton Elementary School [ES] PTA)*
- Program allows for students to move ahead when it is appropriate for them (continue and improve). *(Accelerated and Enriched Instruction Advisory Group)*
- More than half of the parents who responded to the survey generally considered differentiated classes and the opportunity for acceleration as strengths of the program; however, as indicated in Question 2, many felt the way in which these policies are implemented was not always in the best interests of the students. *(Bannockburn ES PTA)*
- The possibility for kids to take math at higher levels than their chronological grade would be the strongest point in my opinion. *(Bradley Hills ES PTA)*

Available rigor (Comments in this theme comprised 37.0% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of strengths)

- Acceleration is a misnomer—characterizing it as acceleration creates the wrong set of action. We know where we want children to get—the pace is mislabeled if it's called acceleration. If you are here you may require more work to get there—it isn't acceleration, it's just getting you there. *(DMAAC)*
- I like that the system aims high, and hopes to enroll many students in AP calculus. *(Burning Tree ES PTA)*
- Push, the way it is structured. From middle school on—you have basic math and it leads on to something higher. Seen that in my kids. They are challenged to take a higher course of mathematics (parent of 11th and 8th grader). Seen more rigor in middle school math. *(Latino Parents Focus Group)*

Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?

Moving too fast (Comments in this theme comprised 23.5% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of aspects to be changed, improved and/or

enhanced.)

- Slow down acceleration. *(Carderock Springs ES PTA)*
- First of all, we need to get rid of the emphasis on acceleration. Most students are not cognitively ready for Algebra in 7th grade, or even in 8th grade. This has two bad effects: potentially good students do poorly and the courses get watered down to the point where they do not really cover much of what used to constitute these courses. Second, more time needs to be spent on basic computational skills: multiplication, division, fractions. A student who wants to succeed in higher mathematics needs to be able to do these calculations without a calculator. (Why? For example, in calculus the fractions involve polynomials, not decimals. Also, students need a feeling for numbers that calculators do not give.) *(Farmland ES PTA)*

Improve emphasis on basic concepts (Comments in this theme comprised 17.6% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of aspects to be changed, improved and/or enhanced.)

- Students are moved too quickly through the curriculum and have a weak foundation. *(Ronald McNair ES PTA)*
- The primary concern expressed by parents is that students are being pushed too quickly in mathematics (and other subjects), with insufficient time to gain a solid foundation in the basics. This was especially noted by parents of students in 'advanced' math. *(Oakland Terrace ES PTA)*

Improve placement processes (Comments in this theme comprised 17.6% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of aspects to be changed, improved and/or enhanced.)

- I disagree with the aggressive math acceleration approach at MCPS. "Average" to "above average" students are routinely placed in grade-ahead math classes, skipping an entire year of foundational math and shortchanging them on the necessary repetition of basic math skills. The end result is kids in middle and high school with a poor grasp of number relationships (i.e., "number sense") and basic math calculation skills. *(Lakelands Park Middle School [MS] PTA)*
- Some students should not be pushed so much to move to a higher math. *(John T. Baker MS SGA)*

Improve respect and emphasis on regular curriculum (Comments in this theme comprised 11.8% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of aspects to be changed, improved and/or enhanced.)

- We need to slow down in the primary grades. The students are being accelerated too quickly. Match the curriculum with the level of reading and

writing. Provide on grade level math to students that are actually on grade level. The school I am in all the kids are above grade level. *(Montgomery County Councils of Parent Teacher Associations)*

Question 3: Do you feel that your child is prepared with the mathematical knowledge he or she needs for his/her next steps?

Missing basics (Comments in this theme comprised 22.1% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student's preparation.)

- No, both my kids were accelerated and "missed" getting a solid foundation, don't know their times tables, and have continued to pay for it. Everyone warned me we would end up with a tutor for Algebra II, and we did. This is a huge aggravation to the achievement gap! Not all parents can afford tutors! Rather than struggling to remediate and scaffold later, spend more time giving ALL kids the basics (even the "smart" ones badly need it) in elementary math and in Algebra I. *(Albert Einstein High School [HS] PTA)*
- Better preparation at elementary school level in basic facts and fractions would improve higher level math course readiness. *(Rocky Hill MS PTA)*

Not ENOUGH acceleration (Comments in this theme comprised 15.6% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student's preparation.)

- In summary, the county should really find a way to keep GT kids accelerated in math throughout their entire K–12 experience (and not just drop them off the GT track midway because they don't know what else to do with these kids and don't have the resources to handle them all). *(Galway ES PTA)*
- No, because they haven't been pushed. This year it seems that the teachers are all working together to help each other. I don't think that has been the case in the past. I think this is a very positive step. *(Watkins Mill ES PTA)*

Reduce emphasis on acceleration (Comments in this theme comprised 19.5% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student's preparation.)

- Concerned that there is too much pressure to accelerate students. *(Takoma Park MS PTA)*
- My older daughter was a good, not great, math student and accelerated through math too fast. She struggled in Algebra II and lost confidence in her math skills. In retrospect, I wish she had waited to take Geometry until 9th grade so she had a firmer math foundation in Algebra II. *(Montgomery Blair HS PTA)*

Don't skip grades (Comments in this theme comprised 9.1% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student's preparation.)

- One of my daughters was ill served by the rush to accelerate. She never took 4th and 5th grade math—apparently so they could get enough kids to fill up a class of 4th graders to take Math 6. She still has significant gaps in her knowledge. My other daughter had the opposite problem and did not get enough of the challenge. It is just very hard for the teachers to teach 2 or 3 grade levels to the same class—some did beautifully others fell well short. *(Garrett Park ES PTA)*

Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?

Opportunities to accelerate earlier (Comments in this theme comprised 31.3% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student experiences.)

- It would be helpful to differentiate those students able to perform more above grade level math beginning in kindergarten. Some of these kids could be challenged more and are entering elementary school very eager to learn. We should encourage this motivation and not let them get bored. *(Greenwood ES PTA)*
- The MCPS math course acceleration and enrichment opportunities have been a positive experience. Also, the math courses that have allowed homogenous groupings, where students of like ability levels may then work together in the classroom on problem-solving and exchanging math ideas, have been very rewarding. *(William H. Farquhar MS PTA)*
- Nationally, MCPS probably does well with pushing the math. However, my son is relatively bored in math. I'm glad that they started advancing a group of kids in math at each grade level and he's in the accelerated math class, but he's still bored much of the time. I don't think that the schools are doing a good job handling the more advanced kids. Considering that the U.S. doesn't rank especially high among industrialized nations in math, I have to think that our kids still aren't being pushed or supported enough in math. I know that I could accelerate my son on my own, but it gets to the point where they're so far ahead that you might as well home school them (but I'm definitely not doing that). In summary, the county should really find a way to keep GT kids accelerated in math throughout their entire K-12 experience (and not just drop them off the GT track midway because they don't know what else to do with these kids and don't have the resources to handle them all). *(Galway ES PTA)*

Impact on the student (Comments in this theme comprised 20.9% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student experiences.)

- My son would be a stronger math student if we had had the opportunity to remove the "above grade level" content on his math tests and quizzes. He found the "challenge" pages confusing and demeaning. *(Woodfield ES PTA)*
- Students are accelerated in math to achieve academic goals that MCPS has for students without regard to the social, emotional and personal goals of the student. Had we known that taking IM in 5th grade would lead to having to go to high school for math in middle school, we would not have agreed. Our school gave us no other options until we brought OAI. *(Individual)*

Moving too fast (Comments in this theme comprised 11.9% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student experiences.)

- I am happy with my child's exposure and experiences. I am not sure the students (even the advanced students) are mastering the material at the speed the curriculum races through the material. *(A. Mario Loiederman MS PTA)*

Placement (Comments in this theme comprised 10.4% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of student experiences.)

- Multiple concerns about placements in math courses and the processes used for parental involvement and notification. *(NAACP)*

Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?

Focus less on acceleration (Comments in this theme comprised 23.4% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- My daughter has really liked both of her math teachers thus far at Piney Branch Elementary School (PBES). But I would argue that PBES staff should focus less on the children testing well or being in accelerated classes. I believe there is a push for the children to learn faster instead of focusing on learning basics and enjoying how interesting math can really be. *(Piney Branch ES PTA)*
- The push to accelerate needs to be re-thought. The whole child should be considered (age, desire, reading level, number sense, developmental readiness, and teacher recommendation) before accelerating students in math. *(Quince Orchard HS and Ridgeview MS PTAs)*

Accelerate only "some" students (Comments in this theme comprised 17.0% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- Stop the practice of advancing children to meet some random ratio of having children in above-grade level math. Give struggling students the support they need to like the subject rather than be turned off by it. If a family decides advanced math is too much of a push on the child, don't fight moving the child back to grade level. *(Sligo Creek ES PTA)*
- Be realistic about what the kids are coming in with and not all kids have the same trajectory *(Secondary Council on Teaching and Learning)*

Review expectations (Comments in this theme comprised 12.8% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- Stop pressuring the teachers/schools to have a large number of accelerated students. *(Rosemary Hills ES PTA)*

Review grouping (Comments in this theme comprised 8.5% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- More separation in grades so that those who can do advanced work get it. *(Stedwick ES PTA)*

Increase program options (Comments in this theme comprised 8.5% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- Continue and expand students with the opportunity to learn math skills above their current grade level. *(Harmony Hills ES PTA)*

Provide staffing (Comments in this theme comprised 7.4% of all comments received in the research area of Acceleration Practices: Mathematics Targets and Acceleration within the category of suggestions for improvement.)

- Smaller class size, more than 70 percent mastery to be considered accelerated. *(Somerset ES PTA)*

Attachment G

K–12 Mathematics Work Group

A Representative Sample of Comments Related to the Prevalent Themes within the Research Area of Curriculum: Assessed Curriculum

Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?

Formative/unit assessments (51.9% of the responses to Question 1 fell into this category.)

- Formative assessments provide us with a common tool for assessing each indicator. *(Individual teachers)*
- Uniform assessments that monitor progress in each unit. *(Somerset ES PTA)*
- Have the same assessments across the county and we get a report with colors on it. The colors help teacher see where the holes are—can do by item or category. Really helpful. *(Elementary Council on Teaching and Learning)*

Reports (14.8% of the responses to Question 1 fell into this category.)

- Parents found meetings to go over the results of the unit tests (which are not sent home and must be kept at the school) were helpful and enlightening. *(Candlewood ES PTA)*
- Have the same assessments across the county and we get a report with colors on it. The colors help teacher see where the holes are—can do by item or category. Really helpful. *(Elementary Council on Teaching and Learning)*

Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?

Finals/unit tests (30.8% of the responses to Question 2 fell into this category.)

- Teaching to tests and not using enough applied examples. *(Stonegate ES PTA)*
- Constant quizzes, exit cards, and retesting until the child gets it right do not ensure the child has mastered the content, they just ensure the child can finally give back the answer desired for the data needed. There is no retention in this method. *(Wayside ES PTA)*

Construction of assessments (16.7% of the responses to Question 2 fell into this category.)

- Assessment of skills and abilities could be more comprehensive. The things my child is doing do not present a challenge. I don't know how long this will go on. *(Clarksburg ES PTA)*
- Expectations for certain concepts aren't correct. Some examples don't show all issues (missing row in stem-leaf plot). *(Asian American Parent Advisory Group)*

Processes (16.7% of the responses to Question 2 fell into this category.)

- It was also pointed out that students are tested on material not covered during that particular school year, i.e. taking the fifth grade math MSA after studying sixth or seventh grade math curriculum during that same year. *(Ronald McNair ES PTA)*
- Assessing all of the children on all of the items, including the challenges, makes no sense. Principal wants everyone tested on all challenges even though they haven't spent time and it is painful. *(Elementary Council on Teaching and Learning)*

Grading/reporting (11.5% of the responses to Question 2 fell into this category.)

- Opportunities to retake summative. *(Wheaton HS PTA)*

Question 3: Do you feel that your child is prepared with the mathematical knowledge he or she needs for his/her next steps? Next course? Why or why not? Explain.

Assessing skills (56.3% of the responses to Question 3 fell into this category.)

- There seems to be a disconnect between quarter grades and final exam grades. Many students who receive high grades each quarter are doing poorly on mid-term and final exams. Given the large number of 'A' students experiencing this problem, it may be caused by the work presented in class by the teacher, or the questions on the final exam not mirroring classroom work. Unfortunately, completed exams are not available for review. *(Quince Orchard HS and Ridgeview MS PTAs)*
- I think there has been too much pressure to pass kids, even when their level of understanding is not reflected by the grade received. Then, this trend is compounded as time goes by—kids understand less than the level of math that they are at. *(Tilden MS PTA)*

Too much testing/teaching to the test (25.0% of responses to Question 3 fell into this category.)

- Teachers teach to the unit assessments and not for mastery of a concept. I do not feel as though my child possesses all of the necessary conceptual knowledge and skills she needs as she moves from grade to grade. *(William B. Gibbs, Jr. ES PTA)*
- They are prepared for unit tests but not always to apply it or retain it for future use. *(Individual teachers)*

Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?

Too much focus on test (40.0% of responses to Question 4 fell into this category.)

- What I feel is still missing is an effort by the county to teach children to THINK versus just memorize routine steps and prepare for the standardized tests. Again, I got lucky with teachers who were willing to step outside the box and provide some real intellectual challenges, but the truth is their curriculum is overwhelmingly controlled by the unit tests which leave little room for real experimentation or analytical training. *(Laytonsville ES PTA)*

Variance between unit and final scores (26.7% of responses to Question 4 fell into this category.)

- Student is in honors and unit preview he gets he zooms through and does well, but when it comes to tests he does extremely poorly. He does review and does well, at this point I got a tutor, but the tutor doesn't know what to do. The reviews are so much easier than the test. The review sheets are county review but the test is much more difficult—teacher says because it is honors she expects the students to be more challenged. Between the review sheets and tests I don't know what is going on. Does well in other classes. *(Korean Parents Group)*

Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?

Grading standards/processes (36.7% of responses to Question 5 fell into this category.)

- Don't consider a "D" a satisfactory grade. (*Walt Whitman HS PTA)*
- Students must be able to take possession of their graded unit tests in order to see what they did wrong and how to correct it. These tests are an essential component in the preparation for midterm and final exams. MCPS should create new versions for future tests to allow for release of completed and graded tests. *(Quince Orchard HS and Ridgeview MS PTAs)*

Reduce emphasis on testing (10.0% of responses to Question 5 fell into this category.)

- The math curriculum seems to have lost its foundation because it is built around testing and not around the important math fundamentals all kids need to succeed. Too much time is spent teaching to the test and not enough on important drills, like learning multiplication tables in the early grades. Kids arrive in high school unable to do simple multiplications because they never learned their tables. *(Paint Branch HS PTA)*

Teaching to the test (10.0% of responses to Question 5 fell into this category.)

- Shift away from teaching to the test or memorizing too many factors or approaches. *(Stonegate ES PTA)*

Attachment H

K–12 Mathematics Work Group

A Representative Sample of Comments Related to the Prevalent Themes within the Research Area of Teacher Preparation and Development: Teaching for Mathematical Proficiency

Question 1: What aspects of the MCPS mathematics program do you consider to be strengths and do you believe should continue?

Excellent (experienced, knowledgeable) teachers (42.2% of the responses to Question 1 fell into this category.)

- "A great teacher makes all the difference!" Retain the teachers "with math degrees who love the program," are "enthusiastic, aware of each child's strengths/weaknesses, and make learning fun." (*Parkland MS PTA)*
- Excellent teachers with great energy and great skills. *(Takoma Park MS PTA)*
- Good teachers. *(Rocky Hill MS PTA)*
- We have some really exceptional, passionate teachers in math. Typically, these better teachers are going outside the proscribed curriculum when teaching math. They are including weekly math fact practice/quizzes. They are supplementing with old/ancient worksheets that worked back then and are useful now in establishing fundamental understanding. *(Montgomery County Councils of Parent Teacher Associations)*

Variety of instructional methods (24.4% of the responses to Question 1 fell into this category.)

- The interesting/fun activities that help the children learn and practice math concepts. *(Burning Tree ES PTA)*
- Use of manipulatives for hands-on math. *(Richard Montgomery HS PTA)*

Support for students (22.2% of the responses to Question 1 fell into this category.)

- Supporting students who need practice with mastering the basic facts. *(Harmony Hills ES PTA)*
- I find that most teachers are working to get the kids to the next level, which is good. *(Woodfield ES PTA)*

Question 2: What aspects of the MCPS mathematics program would you like to see changed, improved, and/or enhanced?

Knowledge and pedagogy (29.3% of the responses to Question 2 fell into this category.)

- Two students taught by the same teacher in third grade—where is the disparity? Is it the support? The teaching? There are significant problems if one student can progress and another can't and they're teaching the same thing. *(Deputy's Minority Achievement Advisory Council)*

- Middle school does not trust the judgment of a lot of the Algebra teachers and Math B teachers. Each school needs to designate an Algebra 1 team leader who will guide pacing. *(Secondary Council on Teaching and Learning)*

Teacher commitment to students (22.0% of the responses to Question 2 fell into this category.)
- Teachers should be more available to students to answer questions and give explanations. *(Accelerated and Enriched Instruction Advisory Group)*
- MCPS should train teachers not to label students because of their parents and they are not capable of doing things. *(Latino Parents Focus Group)*

Improve emphasis on basic concepts (17.1% of the responses to Question 2 fell into this category.)
- Need online video clips of effective lessons. (*Individual teachers)*

Processes (14.6% of the responses to Question 2 fell into this category.)
- They should regroup more often, some kids learn a lot in the middle of the semester. *(Asian American Parent Advisory Group)*

Question 3: Do you feel that your child is prepared with the mathematical knowledge he or she needs for his/her next steps? Next course? Why or why not? Explain.

Strong, caring teachers (41.0% of the responses to Question 3 fell into this category.)
- Yes. Some teachers were really able to make everything understandable. *(John T. Baker MS SGA)*
- Yes. Prepared for college by math program. The lunch support and other support from teachers were key. *(NAACP)*
- Geometry in 10th grade, the relationship with the teacher was so important. When she didn't have the relationship, the student struggled. This year, she has a connection with the teacher and is doing much better. *(Korean Parents Group)*
- Yes, our teacher would take the whole period if needed to explain a concept. *(Julius West MS SGA)*

Varies by teacher (30.8% of the responses to Question 3 fell into this category.)
- No. I was told a couple of years ago that MCPS math teachers cannot spend time teaching multiplication tables in class. I was told by my daughter's teacher that we needed to work on them independently at home. How can an entire county decide not to help kids with something as basic as multiplication? That affects everything from learning fractions and long division to mode/median and other higher-level concepts. *(Bradley Hills ES PTA)*
- If the math curriculum is taught correctly, my child should be prepared for her next step. Depending on which math teacher she has, without my constant

monitoring on her Algebra lesson, she will not be prepared for her next step. I think MCPS should test each math teacher's teaching skills as well as knowledge skills. If this is done already, then the standard should be set higher. I'm very disappointed with my daughter's Algebra teacher. *(Lakelands Park MS PTA)*

- There seems to be a wide discrepancy in the learning and workload based on the teacher. I would like to see more consistency. *(Farmland ES PTA)*

Question 4: What experiences has your child had, or what experiences do you wish your child had, that have made or would make your child stronger in mathematics?

Impact of individual teacher (55.2% of the responses to Question 4 fell into this category.)

- Currently have positive feedback from teachers. *(Carderock Springs ES PTA)*
- Had: The work that one teacher did with manipulatives, models, games, and activities helped cement some of the concepts. *(Garrett Park ES PTA)*
- My child was very fortunate to have first and second grade teachers who created a custom program for him and several others in the class to let them cover all official curriculum for their year, plus the next year. Without those teachers we likely would have left the system. (*Laytonsville ES PTA)*
- The quality of our math teachers at Northwest is outstanding. Our experiences in their classes have made a difference in learning mathematics overall. (*Northwest HS SGA)*
- The teacher makes the difference. Mrs. X kept saying you can do math… going to push you…encouraged…depends on teacher…Daughter now says she's good in math…she remembers Mrs. X. *(Latino Parents Focus Group)*

Varied strategies (20.7% of the responses to Question 4 fell into this category.)

- Encouraging the use of different strategies, more real-life applications. *(Ronald McNair ES PTA)*
- Different approaches. Children learn differently. (*Thomas W. Pyle MS PTA)*

Question 5: What suggestions do you have to offer for the improvement of the MCPS mathematics teaching and learning program?

Perceptions of knowledge and training (28.2% of the responses to Question 5 fell into this category.)

- Support ineffective teachers or let them go. *(Walt Whitman HS PTA)*
- Improve the knowledge/education of the elementary school teachers. Improve consistency among teachers. *(Montgomery County Councils of Parent Teacher Associations)*

Commitment (14.1% of the responses to Question 5 fell into this category.)

- Teachers should be sensitive to different learning levels. *(Stedwick ES PTA)*

Communication (14.1% of the responses to Question 5 fell into this category.)

- Better communication about the math curriculum and its grade level objectives to both parents and students. *(Ritchie Park ES PTA)*

Vary practices (10.3% of the responses to Question 5 fell into this category.)

- Improve training for teachers to help them utilize better differentiation practices. Emphasize depth of learning instead of breadth and speed. This school needs to communicate better with parents about their children's progress level and placement. Sometimes children are bypassing math topics and parents are not even made aware of it. *(Clarksburg ES PTA)*

Staffing and use of volunteers (9.0% of the responses to Question 5 fell into this category.)

- It seems that the kindergarten teachers (well, some of them) will have parents come into the classroom. Why don't all classes have an open-door policy? It seems to me that having another person in the room would be beneficial to both students and teachers. Sometimes that person can assist kids with questions while the teacher is working with a small group. It also prevents kids from getting into trouble if they're a little less focused. *(Watkins Mill ES PTA)*

Attachment I

K–12 Mathematics Work Group

Experts in the Field of Mathematics

Dr. Daniel Chazan is an Associate Professor in the Department of Curriculum and Instruction at the University of Maryland College Park and Director of the Center for Mathematics Education. Dr. Chazan's professional interests include: student-centered mathematics teaching, the potential of history and philosophy of mathematics for informing such teaching, the role of technology in supporting student classroom exploration, exploring possibilities for constructive links between educational scholarship and practice, and the preparation of future teachers.

Dr. Lawrence Clark is an Assistant Professor in the College of Education at the University of Maryland College Park. He is interested in articulating the ways in which American educational researchers of African descent engaged in collecting data on the African continent as a rich space to examine issues of personal, national, and cross-cultural identity. His research interests include influences on secondary mathematics teachers' instructional decisions, equitable mathematics learning environments, and professional development of secondary mathematics teachers.

Dr. Francis (Skip) Fennell is a mathematics educator and has experience as a classroom teacher, a principal, and a supervisor of instruction. He is currently Professor of Education at McDaniel College and recently completed a 2-year term as President of the National Council of Teachers of Mathematics. He served on the National Mathematics Advisory Panel that produced *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Dr. Fennell advocates that content and pedagogical knowledge must be continually and consistently nurtured and strengthened throughout one's career.

Dr. James Hiebert is Professor of Education at the University of Delaware. He recently served on the National Research Council committee that produced *Adding It Up and Helping Children Learn Mathematics*, was director of the Mathematics portion of the TIMSS 1999 Video Study, and is a principal investigator on the National Science Foundation funded Mid-Atlantic Center for Teaching and Learning Mathematics. His research interests include classroom teaching and learning in mathematics, including international comparisons of teaching methods as well as teacher preparation in mathematics.

Dr. Whitney Johnson is on the faculty at the University of Maryland. She is conducting research to understand how teachers utilize and develop their mathematical knowledge for teaching. In the context of large-size, high-poverty urban schools, the research seeks to understand how teachers of high-stakes mathematics courses communicate a sense of purpose to students for engaging with school mathematics. In this context, teachers' ability to connect students to critical mathematical ideas is especially challenging. Dr. Johnson is interested in how such teachers use their knowledge of data analysis and algebra to teach state mandated Algebra 1 content.

Dr. Steven Leinwand is Principal Research Analyst at the American Institutes for Research in Washington, D.C. where he supports a range of mathematics education initiatives and research. Mr. Leinwand served as Mathematics Supervisor in the Connecticut Department of Education for twenty-two years and is a former president of the National Council of Supervisors of Mathematics.

Dr. William H. Schmidt is a University Distinguished Professor at Michigan State University and is currently co-director of the Education Policy Center, co-director of the U.S. China Center for Research, and served as National Research Coordinator and Executive Director of the U.S. National Center which oversaw participation of the United States in the Third International Mathematics and Science Study. A past Chairman of the Department of Educational Psychology and former Acting Dean for Planning and Evaluation in the College of Education at Michigan State University, he also was head of the Office of Policy Studies and Program Assessment for the National Science Foundation.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 1: What is the ultimate outcome of the written curriculum for all students?** a. Milestones b. What does it mean to be mathematically literate? Proficient? c. How do we define curriculum and effectiveness?		
Key Findings	**Citation**	**Response to Key Findings**
"The study of mathematics is an exercise in reasoning. Beyond acquiring procedural mathematical skills with their clear methods and boundaries, students need to master the more subjective skills of reading, interpreting, representing and "mathematizing" a problem. As college students and employees, high school graduates will need to use mathematics in contexts quite different from the high school classroom. They will need to make judgments about what problem needs to be solved and, therefore, about which operations and procedures to apply. Woven throughout the four domains of mathematics — Number Sense and Numerical Operations; Algebra; Geometry; and Data Interpretation, Statistics and Probability"	Achieve, 2010	This finding relates to teachers' comments in the surveys about emphasis on procedural knowledge but not conceptual. The MCPS written curriculum should emphasize reasoning and conceptual understanding, and professional development should be provided to strength teachers' ability to teach and students' ability to retain these important understandings.
National Math Panel Report ~Refer to benchmarks in Table 2, page 20	National Mathematics Advisory Panel, 2008	Important benchmarks.
Proficiency as defined by the Panel is that students understand key concepts, achieve automaticity as appropriate, develop flexible, accurate, and automatic execution of the standard algorithms, and use these competencies to solve problems (pg. xvii).	National Mathematics Advisory Panel, 2008	This seems to align with the strands of mathematical proficiency, as a sub-detail to those.
There are five key, interwoven and interdependent strands including knowledge, skills, attitudes, and beliefs. Students must possess and use strands in an integrated manner, as each reinforces the other. • Conceptual understanding – comprehension of	National Research Council, 2001	These seem comprehensive and applicable across all grade levels. This framework could be a good starting point for MCPS curriculum and classroom teaching. Teachers should know about this. What is emphasized in the curriculum should be reflected in the

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 1: What is the ultimate outcome of the written curriculum for all students?** a. Milestones b. What does it mean to be mathematically literate? Proficient? c. How do we define curriculum and effectiveness?		
Key Findings	**Citation**	**Response to Key Findings**
mathematical concepts, operations, and relations – an integrated and functional grasp of mathematical ideas • Procedural fluency – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately – when and how to use them appropriately and skill in performing them • Strategic competence – ability to formulate, represent, and solve mathematical problems – mutually supportive relations between strategic competence and both conceptual understanding and procedural fluency • 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 - a belief that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics		assessments.
Mathematical proficiency as we have defined it cannot be developed unless regular time is allocated to and used for mathematics instruction in every grade of elementary and middle school. Substantial time should be devoted to mathematics instruction each school day, with enough time devoted to each unit and topic to enable students to develop understanding of the concepts and procedures involved. Time should be	National Research Council, 2001	The issue of time is a hot topic for teachers and parents, as reflected in their feedback. When the curriculum is rewritten, the concept of time as a problem factor should be considered.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 1: What is the ultimate outcome of the written curriculum for all students?** a. Milestones b. What does it mean to be mathematically literate? Proficient? c. How do we define curriculum and effectiveness?		
Key Findings	**Citation**	**Response to Key Findings**
apportioned so that all strands of mathematical proficiency together receive adequate attention.		
Mathematical proficiency is defined as: Expertise in handling mathematical ideas • Understanding of basic concepts • Fluency in performing basic operations • Ability to o exercise a repertoire of strategic knowledge – use mathematics to solve problems o reason clearly and flexibly and logically o maintain a positive outlook toward mathematics – use it to make sense of their world	National Research Council, 2001	This seems to align with other definitions and fits as a supporting detail.
In every grade in school, students can demonstrate mathematical proficiency in some form. Proficiency is acquired over time – through sustained periods of time doing math – solving problems, reasoning, developing understanding, practicing skills, building connections between previous and new knowledge.	National Research Council, 2001	All strands of proficiency (strategic competence, productive disposition) should be taught well and learned completely so that this can happen.
Assessment should provide additional opportunities for learning.	National Research Council, 2001	Our group concurs – and teachers should know how to use them in this manner.
Instructional materials need to provide guidance and assistance for teachers.	National Research Council, 2001	Research group concurs.
Teachers' professional development should be high quality, sustained, and systematically designed and deployed to help all students develop mathematical proficiency. Schools should support, as a central part of teachers' work,	National Research Council, 2001	Teachers must know how to teach what they teach. Our professional development and our curriculum should support this.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 1: What is the ultimate outcome of the written curriculum for all students?** a. Milestones b. What does it mean to be mathematically literate? Proficient? c. How do we define curriculum and effectiveness?		
Key Findings	**Citation**	**Response to Key Findings**
engagement in sustained efforts to improve their mathematics instruction. This support requires the provision of time and resources.		
The coordination of curriculum, instructional materials, assessment, instruction, professional development, and school organization around the development of mathematical proficiency should drive school improvement efforts.	National Research Council, 2001	We align and coordinate, but we should ensure the curriculum is substantive as well.
Algebra for all is an attainable goal provided that the curriculum includes explicit connections from Pre-K to middle school. – particularly representation, variables and functions, emphasizing the relationships and ways of representing relationships.	National Research Council, 2001	MCPS should continue to examine its progress toward achieving this goal and ensure all that can be done is being done to meet it.
"Algebra for all" is achievable if algebra is infused into the Pre-K to Grade 8 curriculum.	National Research Council, 2001	Research group concurs.
Mathematics education of yesterday is no longer viable. o Rote learning of arithmetic procedures are of less value o We are more exposed to numbers and quantitative ideas – we deal with math at a higher level o Failure to learn mathematics limits individual possibilities and hampers national growth o This demands substantial change in a careful and deliberate way o Provide opportunity and support for every child to become proficient	National Research Council, 2001	Teacher and parent comments reflect that this is a problem for us. Curriculum should be developed to turn this around.
Algebra for all is a worthwhile and attainable goal for middle school students. In some countries, by the end of eighth	National Research Council, 2001	This aligns with other sources. We don't want to lose this. Moving away from this in the name of equity is

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 1: What is the ultimate outcome of the written curriculum for all students?** a. Milestones b. What does it mean to be mathematically literate? Proficient? c. How do we define curriculum and effectiveness?		
Key Findings	**Citation**	**Response to Key Findings**
grade, all students have been studying algebra for several years, although not ordinarily in a separate course.		not equity at all.

Curriculum: Written Curriculum Research Question 1–Sources Cited:

Achieve. *Closing the Expectations Gap*. American Diploma Project, Arlington, Virginia: Achieve, 2010.

Each year, on the anniversary of the 2005 National Education Summit on High Schools, Achieve releases a 50-state progress report on the alignment of high school policies with the demands of college and careers. *Closing the Expectations Gap, 2010* is the fifth annual report in this series. The report details state progress implementing the American Diploma Project policy agenda.

National Mathematics Advisory Panel. *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, D.C.: United States Department of Education, 2008.

The essence of the Panel's message is *to put first things first*. There are six elements, expressed compactly here, but in greater detail later.

- The mathematics curriculum in Grades Pre-K–8 should be streamlined and should emphasize a well-defined set of the most critical topics in the early grades.
- Use should be made of what is clearly known from rigorous research about how children learn, especially by recognizing a) the advantages for children in having a strong start; b) the mutually reinforcing benefits of conceptual understanding, procedural fluency, and automatic (i.e., quick and effortless) recall of facts; and c) that effort, not just inherent talent, counts in mathematical achievement.
- Our citizens and their educational leadership should recognize mathematically knowledgeable classroom teachers as having a central role in mathematics education and should encourage rigorously evaluated initiatives for attracting and appropriately preparing prospective teachers, and for evaluating and retaining effective teachers.
- Instructional practice should be informed by high-quality research, when available, and by the best professional judgment and experience of accomplished classroom teachers. High-quality research does not support the contention that instruction should be either entirely "student centered" or "teacher directed." Research indicates that some forms of particular instructional practices can have a positive impact under specified conditions.

- NAEP and state assessments should be improved in quality and should carry increased emphasis on the most critical knowledge and skills leading to Algebra.
- The nation must continue to build capacity for more rigorous research in education so that it can inform policy and practice more effectively.

National Research Council. *Adding it up: Helping children learn mathematics.* Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

Adding it Up explores how students in Pre-K through 8th grade learn mathematics and recommends how teaching, curricula, and teacher education should change to improve mathematics learning during these critical years.

The committee identifies five interdependent components of mathematical proficiency and describes how students develop this proficiency. With examples and illustrations, the book presents a portrait of mathematics learning:

- Research findings on what children know about numbers by the time they arrive in Pre-K and the implications for mathematics instruction.
- Details on the processes by which students acquire mathematical proficiency with whole numbers, rational numbers, and integers, as well as beginning algebra, geometry, measurement, and probability and statistics.

The committee discusses what is known from research about teaching for mathematics proficiency, focusing on the interactions between teachers and students around educational materials and how teachers develop proficiency in teaching mathematics.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
The College Board path for secondary mathematics curriculum is: • Middle School Math I • Middle School Math II • Algebra I • Geometry • Algebra II	Rigol, 2009	Similar pathway that Achieve proposes.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
• Precalculus (TOC)		
College Board's path is a direct path to Algebra I in grade 8 as opposed to an accelerated path that is reflected in MCPS. (1)	Rigol, 2009	This corresponds to recommendations for a comprehensive middle school program for all, not just some students.
Fifty-five minutes or more of daily math instruction is recommended. "Although this recommendation goes beyond what is currently allotted for mathematics in many schools, this amount of time for mathematics is critical if students are to be successful in the mathematics and statistics necessary for college success." (xiii)	Rigol, 2009	Research group concurs.
"Central to the knowledge and skills developed in the middle school and high school years are the following broad classes of concepts, procedures, and processes: • Operations and Equivalent Representations • Algebraic Manipulation Skills • Quantity and Measurement • Proportionality • Relations, Patterns, and Functions • Shape and Transformation • Data and Variation • Chance, Fairness, and Risk" (xiii)	Rigol, 2009	Strands are similar to core curriculum, NCTM standards, and our curriculum. CB seems to break them into more categories, but the content is the same.
Path prepares students for AP Calculus in grade 12, (xvi)	Rigol, 2009	Matches our Keys.
"Students entering the middle grades are expected to have computational fluency with whole-number operations and to be developing a broad understanding to addition, subtraction, and multiplication with rational numbers." (xiii)	Rigol, 2009	One of MCPS's Seven Keys is for students to be doing middle school math in grade 5. Computational fluency with whole-number operations and a broad understanding to addition, subtraction, and multiplication with rational numbers should be a foundation reached before this Key.
"The Mathematics and Statistics College Board Standards for	Rigol, 2009	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
College Success includes a greater focus on statistics and probability than is currently seen in most classrooms. This decision was based on the ever-growing influence of statistics and probability in everyday life and in scientific and technology applications across our society." (xv)		
"States Need to Keep Pace with Rising Knowledge Demands- • Only nineteen states, and the District of Columbia, have aligned their high school graduation requirements with college and workplace expectations. • Twenty-six states require students to pass an exam before they graduate high school, but these tests tend to measure only 8th, 9th or 10th grade skills rather than the higher-level skills students need to succeed in college and the workplace. • Meanwhile, only ten states have testing systems with components that assess whether or not students have mastered college- and career-ready knowledge and skills"	Achieve, 2010	Maryland is not one of the states that has aligned requirements with expectations, even though we are an Achieve state.
"The American Diploma Project, led by Achieve, is committed to taking four college and career readiness action steps: • Align high school standards with the demands of college and careers. • Require all students to complete a college- and career-ready curriculum to earn a high school diploma. • Build assessments into the statewide system that measure students' readiness for college and careers. • Develop reporting and accountability systems that promote college and career readiness for all students."	Achieve, 2010	This aligns with other research findings, and our strategic plan in MCPS.
"The High School Benchmarks give a standard for **all students**	Achieve, 2010	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
for graduating and also focuses on the higher level tasks for those who plan to take calculus in college, a requisite for mathematics and many mathematics-intensive majors (These higher level tasks are recommended for all but required for those pursuing the higher levels of math in college.)"		
There are only 4 strands to the Benchmarks. (Number Sense & Numerical Operations, Algebra, Geometry & Data Interpretation, Statistics & Probability)	Achieve, 2010	Research group concurs.
The mathematics curriculum in Grades Pre-K–8 should be streamlined and should emphasize a well-defined set of critical topics in the early grades.	National Mathematics Advisory Panel, 2008	Matches other research findings. Our curriculum should be reviewed to ensure it matches up.
A focused, coherent progression of mathematics learning, with an emphasis on proficiency with key topics, should become the norm in elementary and middle school mathematics curricula. *Any approach that continually revisits topics year after year without closure is to be avoided.*	National Mathematics Advisory Panel, 2008	MCPS written curriculum should emphasize proficiency with key topic and the assessments should be constructed to support the importance of this proficiency.
A major goal of K-8 should be proficiency with fractions. Proficiency with **whole numbers** is a necessary precursor for the study of **fractions (this will have the most impact on problem-solving abilities)**, as are aspects of **measurement** and **geometry**. This cluster of skills and concepts are called the Critical Foundation of Algebra. (Specific recommendations on pgs. 17-19; also Table 2: Benchmarks for the Critical Foundations pg. 20-these should be used to guide curricula, instruction and assessments)	National Mathematics Advisory Panel, 2008	All K-8 mathematics teachers need to know how to teach fractions in a meaningful way.
Curriculum must simultaneously develop conceptual understanding, computational fluency, and problem solving (pg. xix).	National Mathematics Advisory Panel, 2008	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
School algebra should be consistently understood in terms of the Major Topics of School Algebra in Table 1 (pg. 16).	National Mathematics Advisory Panel, 2008	Research group concurs.
One difference between the US and other countries is between single-subject sequence and integrated approach at higher levels of math. There is no basis in research for preferring an integrated approach versus a single-subject sequence for higher-level math courses in upper grades.	National Mathematics Advisory Panel, 2008	Research group concurs.
Two major differences between our curriculum and top-performing counties: number of topics presented at each grade level and in the expectations for learning. The U.S. includes many topics at each grade level, with limited development of each, while top-performing countries present fewer topics in greater depth. Other countries are more likely to expect closure after exposure, development, and refinement of a particular topic, while US reviews and extend topics at successive grade levels.	National Mathematics Advisory Panel, 2008	Our curriculum writers should consider these differences.
The curriculum for Pre-K to Grade 8 should be focused on important ideas that are developed thoroughly and treated in depth in an integrated manner	National Research Council, 2001	Research group concurs.
Specific recommendations regarding the curriculum extend from building on informal knowledge and learning about number to developing algebraic thinking. Proficiency with number concepts should be linked to various representations across all strands. The ability to use estimation and perform mental arithmetic promotes a deeper "number sense". An emphasis on rational numbers, place values, including decimals, is essential.	National Research Council, 2001	Teachers and administrators need guidance on how to schedule time for mathematics and how to manage teaching in these recommended manners within the time constraints of the schedules in today's schools.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
The integrated and balanced development of all five strands of mathematical proficiency should guide the teaching and learning of school mathematics. Instruction should not be based on extreme positions that students learn, on the one hand, solely by internalizing what a teacher or book says or, on the other hand, solely by inventing mathematics on their own.	National Research Council, 2001	This balanced approach should considered by MCPS curriculum.
The curriculum has to be organized within and across grades so that time for learning is used effectively. o Instead of cursory and repeated treatments of a topic, the curriculum should be focused on important ideas, allowing them to be developed thoroughly and treated in depth.	National Research Council, 2001	Research group concurs.
The conceptual bases for operations with numbers and how those operations relate to real situations should be a major focus of the curriculum. Addition, subtraction, multiplication, and division should be presented initially with real situations. Students should encounter a wide range of situations in which those operations are used.	National Research Council, 2001	Inclusion of this concept should be a part of the MCPS written curriculum.
Children should learn single-digit number combinations with understanding.	National Research Council, 2001	Research group concurs.
Whether or not students are performing a written algorithm, they can use mental arithmetic to simplify certain operations with numbers. An emphasis on estimation and mental arithmetic enhances conceptual understanding and fluency. The curriculum should provide opportunities for students to develop and use techniques for mental arithmetic and estimation as a means of promoting deeper number sense.	National Research Council, 2001	Research group concurs.
The curriculum should provide opportunities for students to	National	Teachers and administrators need guidance on how to

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
develop a thorough understanding of rational numbers, their various representations including common fractions, decimal fractions, and percents, and operations on rational numbers. These opportunities should involve connecting symbolic representations and operations with physical or pictorial representations, as well as translating between various symbolic representations.	Research Council, 2001	schedule time for mathematics and how to manage teaching in these recommended manners within the time constraints of the schedules in today's schools.
The curriculum should devote substantial attention to developing an understanding of the decimal place-value system, to using its features in calculating and problem solving, and to explaining calculation and problem-solving methods with decimal fractions.	National Research Council, 2001	Research group concurs.
The curriculum should provide extensive opportunities over time for students to explore proportional situations concretely, and these situations should be linked to formal procedures for solving proportion problems whenever such procedures are introduced.	National Research Council, 2001	Research group concurs.
Teachers, curriculum developers, and researchers should explore the possibility of introducing integers before rational numbers. Ways to engage younger children in meaningful uses of negative integers should be developed and tested.	National Research Council, 2001	Research group concurs.
The formal study of algebra is both the gateway into advanced mathematics and a stumbling block for many students. The basic ideas of algebra as generalized arithmetic should be anticipated by activities in the early elementary grades and learned by the end of middle school. Teachers and researchers should investigate the effectiveness of instructional strategies in grades Pre-K–8 that would help	National Research Council, 2001	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
students move from arithmetic to algebraic ways of thinking.		
A different curriculum is needed for algebra in middle school. Some efforts to promote algebra for all have involved simply offering a standard first-year algebra course to everyone. Such efforts are virtually guaranteed to result in many students failure to develop proficiency in algebra, in part because the transition to algebra is so abrupt. Teachers, researchers, and curriculum developers should explore ways to offer a middle school curriculum in which algebraic ideas are developed in a robust way and connected to the rest of mathematics.	National Research Council, 2001	There are curricula and textbook series available that do this well.
Textbooks and other instructional materials should develop the core content of school mathematics in a focused way, in depth, and with continuity in and across grades, supporting all strands of mathematical proficiency. Textbooks and other instructional materials should support teacher understanding of mathematical concepts, of student thinking and student errors, and of effective pedagogical supports and techniques. Activities and strategies should be developed and incorporated into instructional materials to assist teachers in helping all students become proficient in mathematics, including students in low socio-economic status, English language learners, special education students, and students with a special interest or talent in mathematics.	National Research Council, 2001	When reviewing the written curriculum, all materials and activities should also be reviewed.
At the core of mathematics programs in prekindergarten through grade 2 are the Number and Operations and Geometry	National Council for Teachers of	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
Standards. For example, it is absolutely essential that students develop a solid understanding of the base-ten numeration system in prekindergarten through grade 2. They must recognize that the word ten may represent a single entity (1 ten) or ten separate units (10 ones) and that these representations are interchangeable. Using concrete materials and calculators in appropriate ways can help students learn these concepts.	Mathematics, 2000	
Understandings of patterns, measurement, and data contribute to the understanding of number and geometry and are learned in conjunction with them. Similarly, the Process Standards of Problem Solving, Reasoning and Proof, Communication, Connections, and Representation both support and augment the Content Standards.	National Council for Teachers of Mathematics, 2000	This makes the case for not dropping some strands in order to focus on number and algebra only.
As in all the grade bands, students in the middle grades need a balanced mathematics program that encompasses all ten Standards, including significant amounts of algebra and geometry.	National Council for Teachers of Mathematics, 2000	Research group concurs.
Algebra and geometry are crucial to success in the later study of mathematics and also in many situations that arise outside the mathematics classroom. Students should see that these subjects are interconnected with each other and with other content areas in the curriculum.	National Council for Teachers of Mathematics, 2000	Research group concurs.
Students' understanding of these crucial ideas should be developed over all three years in the middle grades and across a broad range of mathematics content. This approach is a challenging alternative to the practice of offering a select group of middle-grades students a one-year course that focuses narrowly on algebra or geometry. However, all middle-grades students will benefit from a rich and integrated treatment of mathematics content. By the end of the eighth grade, students	National Council for Teachers of Mathematics, 2000	Our data reflects that we do not do this for all students. The curriculum should foster equity in achievement.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 2:** What does the research say about international, national, and state curricula?		
Key Findings	**Citation**	**Response to Key Findings**
should have a solid background in algebra and other areas that will prepare them to enter substantive high school courses.		

Curriculum: Written Curriculum Research Question 2–Sources Cited:

Achieve. *Closing the Expectations Gap*. American Diploma Project, Arlington, Virginia: Achieve, 2010.

Each year, on the anniversary of the 2005 National Education Summit on High Schools, Achieve releases a 50-state progress report on the alignment of high school policies with the demands of college and careers. *Closing the Expectations Gap, 2010* is the fifth annual report in this series. The report details state progress implementing the American Diploma Project policy agenda.

National Council for Teachers of Mathematics. *Principles and Standards for School Mathematics*. Arlington, Virginia: National Council for Teachers of Mathematics, 2000.

The NCTM publication *Principles and Standards for School Mathematics* (widely known as *PSSM*) sets out the essential elements of a Pre-K–12 education in mathematics for present times and future expectations. These Standards were developed by the National Council of Teachers of Mathematics in consultation with teachers, others in education, the leading societies of US mathematicians, and the wider community. They were refined over a fifteen-year period from the initial drafting in 1985, through a first published edition in 1989, to the current Standards 2000. They have been widely, though not universally, accepted across the US, and used as the basis for many state standards, and for the developments of curriculum and assessment materials that were funded by the National Science Foundation.

National Mathematics Advisory Panel. *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, D.C.: United States Department of Education, 2008.

The essence of the Panel's message is *to put first things first*. There are six elements, expressed compactly here, but in greater detail later.

- The mathematics curriculum in Grades Pre-K–8 should be streamlined and should emphasize a well-defined set of the most critical topics in the early grades.
- Use should be made of what is clearly known from rigorous research about how children learn, especially by recognizing a) the advantages for children in having a strong start; b) the mutually reinforcing benefits of conceptual understanding, procedural fluency, and automatic (i.e., quick and effortless) recall of facts; and c) that effort, not just inherent talent, counts in mathematical achievement.

- Our citizens and their educational leadership should recognize mathematically knowledgeable classroom teachers as having a central role in mathematics education and should encourage rigorously evaluated initiatives for attracting and appropriately preparing prospective teachers, and for evaluating and retaining effective teachers.
- Instructional practice should be informed by high-quality research, when available, and by the best professional judgment and experience of accomplished classroom teachers. High-quality research does not support the contention that instruction should be either entirely "student centered" or "teacher directed." Research indicates that some forms of particular instructional practices can have a positive impact under specified conditions.
- NAEP and state assessments should be improved in quality and should carry increased emphasis on the most critical knowledge and skills leading to Algebra.
- The nation must continue to build capacity for more rigorous research in education so that it can inform policy and practice more effectively.

National Research Council. *Adding it up: Helping children learn mathematics*. Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

Adding it Up explores how students in Pre-K through 8th grade learn mathematics and recommends how teaching, curricula, and teacher education should change to improve mathematics learning during these critical years.

The committee identifies five interdependent components of mathematical proficiency and describes how students develop this proficiency. With examples and illustrations, the book presents a portrait of mathematics learning:

- Research findings on what children know about numbers by the time they arrive in Pre-K and the implications for mathematics instruction.
- Details on the processes by which students acquire mathematical proficiency with whole numbers, rational numbers, and integers, as well as beginning algebra, geometry, measurement, and probability and statistics.

The committee discusses what is known from research about teaching for mathematics proficiency, focusing on the interactions between teachers and students around educational materials and how teachers develop proficiency in teaching mathematics.

Rigol, Gretchen. *Admissions Decision-Making Models: How U.S. Institutions of Higher Education Select Undergraduate Students*. New York, New York: College Board, 2009.

This report represents the third phase in the College Board Admissions Models Project. The first two phases of the project are summarized in two monographs: Toward a Taxonomy of the Admissions Decision-Making Process (1999) identifies nine different philosophical approaches to admissions and related selection criteria; and Best Practices in Admissions Decisions (2002) builds on the Taxonomy and outlines various components of a best practices model for admissions decision-making. The purpose of this phase of the project was to examine exactly how institutions make admissions decisions. Information from more than 100 institutions, representing all levels of selectivity, forms the basis for this report.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 3:** What does research say about aspects of curricula that support equity in student learning for all students, including ELL and special education students?		
Key Findings	**Citation**	**Response to Key Findings**
Use what is known about how children learn, by recognizing: a) the advantages for children in having a strong start; b) the mutually reinforcing benefits of conceptual understanding, procedural fluency, and automatic recall of facts; and c) that effort, not just inherent talent counts in mathematical achievement.	National Mathematics Advisory Panel, 2008	Research group concurs.
Level of children's knowledge varies greatly across socio-economic and ethnic groups Immaturity can be overcome with targeted instruction • School and preschool programs should provide rich activities with numbers and operations from the very beginning, especially for children who enter without these experiences. • Efforts should be made to educate parents and other caregivers as to why they should, and how they can, help their children develop a sense of number and shape.	National Research Council, 2001	Our data reflects this. Our curriculum should be written to support changing outcomes of student learning.
Different ways of representing numbers, when to use a specific representation, and how to translate from one	National Research Council, 2001	Research group concurs.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 3:** What does research say about aspects of curricula that support equity in student learning for all students, including ELL and special education students?		
Key Findings	**Citation**	**Response to Key Findings**
representation to another should be included in the curriculum. Students should be given opportunities to use these different representations to carry out operations and to understand and explain these operations. Instructional materials should include visual and linguistic supports to help students develop this representational ability.		
During the middle grades, students solidify conceptions about themselves as learners of mathematics. They arrive at conclusions about their competence in mathematics, their attitudes, their interest, and their motivation. These conceptions will influence how they approach the study of mathematics in later years, which in turn will affect their later career and personal opportunities.	National Council for Teachers of Mathematics, 2000	There should be effective supports in place for middle school mathematics learning.
Learning, as it normally occurs, is a function of the activity, context and culture in which it occurs (i.e., it is situated). This contrasts with most classroom learning activities which involve knowledge which is abstract and out of context. Social interaction is a critical component of situated learning -- learners become involved in a "community of practice" which embodies certain beliefs and behaviors to be acquired.	Lave, 1991	It would be ideal to embrace this and make it the practice in our classrooms, consistently across the district and across grade levels.
First, equity is threatened by the underlying belief that not all students can learn mathematics. That is, whereas other countries believe that differences in student achievement are due to effort (Stevenson & Stigler, 1992), U.S. citizens tend to believe that mathematics achievement is more directly related to	Gutierrez, 2002	The written curriculum should reflect that we truly believe all students can learn at high levels.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 3:** What does research say about aspects of curricula that support equity in student learning for all students, including ELL and special education students?		
Key Findings	**Citation**	**Response to Key Findings**
ability at birth. Therefore, the belief goes, no amount of effort will compensate for those students who lack innate ability or talent. Such beliefs undermine efforts to develop support systems or improved teaching for students who historically have not performed well in mathematics.		
Another obstacle for addressing equity issues is the underlying deficit theory that tends to be applied to students who have been marginalized in mathematics. Most researchers and educators have moved beyond thinking that it is mainly the fault of students themselves, their families, or their cultures as to why they do not perform well in mathematics. Yet, even proponents of equity issues tend to frame their arguments in ways that suggest that benefits move from mathematics to persons and not the other way around. The assumption is that certain people will gain from having mathematics in their lives, as opposed to the field of mathematics will gain from having these people in its field. In other words, most equity research currently assumes the deficit lies within the students who need mathematics as opposed to, or in addition to, lying within mathematics, which needs different people.	Gutierrez, 2002	This may be a relatively new idea for MCPS educators. Ways to emphasize this should be explored.
U.S. debates about equity have revolved around the idea that, as a nation, we cannot simultaneously seek to achieve excellent work with our highest performing students and bring our lower performing students up to a higher level. The excellence versus equity debate	Gutierrez, 2002	Equity and Excellence are part of the MCPS strategic plan. Our actions and curriculum should play a role in achieving equity and excellence.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 3:** What does research say about aspects of curricula that support equity in student learning for all students, including ELL and special education students?		
Key Findings	**Citation**	**Response to Key Findings**
implies that the two goals are inherently in conflict, that the strategies that would be involved in bringing lower performing students up to a much higher standard (e.g., detracking, receiving higher quality teachers and resources) would be ones that would damage chances for higher performing students to excel.		
Boaler's (1997a, 1997b, 1997c) research with high-performing students suggests that students in traditional mathematics classrooms neither retain for very long the information they have learned nor can they explain in real-world or conceptual terms what they are doing in mathematics. In her 3-year study, she found that students who learned in reform-oriented classrooms did as well on tests of basic skills and better on tests of conceptual skills than their peers who learned in traditional mathematics classrooms.	Boaler, 1997	Surprising finding that makes us rethink tracking, especially at a time when tracking is at an all-time high in elementary schools.
Boaler and Greeno (2000) argued convincingly that the traditional instruction that most students learn does not prepare even the most successful (highest performing) students for further study of mathematics. In fact, students in the highest tracks of mathematics seem to become alienated from the subject and have little desire to continue their mathematical careers (Boaler, 1997c).	Boaler and Greeno, 2000	A curriculum that embraces more open problem-based ways of teaching could combat this.
Research has shown that students of all backgrounds can flourish in classrooms where, among other things, teachers have solid mathematical knowledge, teachers believe in their students, students are adequately	Gutierrez, 2002	All of our students, according to the data, are not flourishing.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Written Curriculum **Research Question 3:** What does research say about aspects of curricula that support equity in student learning for all students, including ELL and special education students?		
Key Findings	**Citation**	**Response to Key Findings**
supported to understand rigorous mathematics, real-world contexts are provided for their learning, and (on many occasions) students are encouraged to work in noncompetitive ways with their peers.		
"One of the central assumptions of the emergent perspective is that learning can be characterized as both a process of active individual construction and a process of mathematical enculturation. On the one hand, the emergent perspective goes beyond exclusively psychological approaches by viewing students' mathematical activity as being necessarily socially situated. Therefore, the products of students' mathematical development-increasingly sophisticated ways of reasoning-are seen to be related to their participation in particular communities of practice such as those constituted by the teacher and the students in the classroom. On the other hand, the emergent perspective questions the subordination of psychological processes to social processes and attributes a central role to analyses of individual students' mathematical activity," (Cobb, 2000, pg. 309).	Cobb, 2000	The emergent perspective could bring new ideas to the MCPS curriculum.
Hiebert et al. (1996) claim that the single most important principle for improving the teaching of mathematics is to allow the subject of mathematics to be problematic for students.	Hiebert, 1996	This could be a new concept for MCPS, and one that may need careful introduction to teacher, students, and parents.

Curriculum: Written Curriculum Research Question 3–Sources Cited:

Boaler, J. "Open and Closed Mathematics: Student Experiences and Understandings." *Mathematics Education Research Journal* 9 (1997): 325–342.

This paper reports on 3-year case studies of 2 schools with alternative mathematical teaching approaches. Students who followed a traditional approach developed procedural knowledge that was of little use to them in unfamiliar settings. Students who learned mathematics in an open-project-based environment developed a conceptual understanding that provided them with advantages in a range of assessments and situations.

Boaler, J., and J. G. Greeno. "Identity, agency, and knowing in mathematics worlds." In *Multiple perspectives on mathematics teaching and learning*, edited by J. Boaler, 171–200. Westport, Connecticut: Ablex, 2000.

Boaler and Greeno propose that broadened perspectives of math learning provide considerable insight both into students' mathematical understanding as well as the choices they make about life and work. They consider knowing and understanding mathematics as aspects of participation in social practices, particularly discourse practices, in which people engage in sense making and problem solving.

Cobb, P. "Design Experiments in Educational Research." *Educational Researcher* 32, no. 1 (2000): 9-13.

In this article, the authors first indicate the range of purposes and the variety of settings in which design experiments have been conducted and then delineate five crosscutting features that collectively differentiate design experiments from other methodologies. Design experiments have both a pragmatic bent—"engineering" particular forms of learning—and a theoretical orientation—developing domain-specific theories by systematically studying those forms of learning and the means of supporting them. The authors clarify what is involved in preparing for and carrying out a design experiment, and in conducting a retrospective analysis of the extensive, longitudinal data sets generated during an experiment. Logistical issues, issues of measure, the importance of working through the data systematically, and the need to be explicit about the criteria for making inferences are discussed.

Gutierrez, R. "Enabling the Practice of Mathematics Teachers in Context: Toward a New Equity Research Agenda." *Mathematical Thinking and Learning* 4, no. 2 and 3 (2002): 145–187.

In this article, Gutierrez addresses the need for a more clearly articulated research agenda around equity issues by proposing a working definition of equity and a focal point for research. More specifically, he asserts that rather than pitting them against each other, we must coordinate (a) efforts to get marginalized students to master what currently counts as "dominant" mathematics with (b) efforts to develop a critical perspective among all students about knowledge and society in ways that ultimately facilitate (c) a positive relationship between

mathematics, people, and equity on the planet. He makes this argument partly by reviewing the literature on (school) contexts that engage marginalized students in mathematics. Then, he argues that the place that holds the most promise for addressing equity is a research agenda that emphasizes enabling the practice of teachers and that draws more heavily on design-based and action research, thereby redefining what the practice of mathematics means along the way. Specific research questions are offered.

Hiebert, J. and Wearne, D. "Instruction, understanding, and skill in multidigit addition and subtraction." *Cognition and Instruction* 14 (1996): 251-283.

Conceptually based instruction on place value and two-digit addition and subtraction without regrouping was provided in four first-grade classrooms, and more conventional textbook-based instruction was provided in two first-grade classrooms. An observer compiled extensive notes of 20 lessons in each kind of classroom. Students who received conceptually based instruction performed significantly better on items measuring understanding of place value and two-digit addition and subtraction with regrouping and used strategies more often that exploited the tens and ones structure of the number system. Content and pedagogical differences between the instruction lessons are linked to the learning differences and are used to explain between-group differences in levels of performance and understanding. Observations are offered on the complex interactions between instruction, understanding, and performance.

Lave, Jean and Etienne Wenger. *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press, 1991.

In this book, Jean Lave, anthropologist, and Etienne Wenger, computer scientist, push forward the notion of situated learning--that learning is fundamentally a social process and not solely in the learner's head. The authors maintain that learning viewed as situated activity has as its central defining characteristic a process they call legitimate peripheral participation. Learners participate in communities of practitioners, moving toward full participation in the sociocultural practices of a community. Legitimate peripheral participation provides a way to speak about crucial relations between newcomers and old-timers and about their activities, identities, artifacts, knowledge and practice. The communities discussed in the book are midwives, tailors, quartermasters, butchers, and recovering alcoholics, however, the process by which participants in those communities learn can be generalized to other social groups.

National Council for Teachers of Mathematics. *Principles and Standards for School Mathematics*. Arlington, Virginia: National Council for Teachers of Mathematics, 2000.

The NCTM publication *Principles and Standards for School Mathematics* (widely known as *PSSM*) sets out the essential elements of a Pre-K–12 education in mathematics for present times and future expectations. These Standards were developed by the National Council of Teachers of Mathematics in consultation with teachers, others in education, the leading societies of US mathematicians, and the wider community. They were refined over a fifteen-year period from the initial drafting in 1985, through a first published edition in 1989, to the

current Standards 2000. They have been widely, though not universally, accepted across the US, and used as the basis for many state standards, and for the developments of curriculum and assessment materials that were funded by the National Science Foundation.

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National Research Council. *Adding it up: Helping children learn mathematics*. Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

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K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 1:** What instructional strategies/practices are effective in supporting different types of students (race/ethnicity, mobility, limited English, special education)?		
Key Findings	**Citation**	**Response to Key Findings**
Heterogeneous grouping does not "hold back" learning and performance of high achieving students. Heterogeneous grouping significantly increases achievement of students of color.	Burris, 2009	Provide teachers with guidelines for implementing heterogeneous groups and strategies to use grouping effectively.
Provide greater growth for students who begin school with lower skills	McCall, 2006	Ensure teachers have skills to assess student levels and strategies to meet the needs of students who have a wide variety of math skills and knowledge.
Build strong relationships with students so they will seek help more readily, engage in their studies more deeply and put forth the extra effort needed to overcome skill gaps	Ferguson, 2002	Train teachers and principals on how to establish positive relationships and classroom climate. Connect to the new MCPS Framework for Equity and Excellence and the Organizational Culture of respect
Adapt pedagogy to student needs. Effective instruction requires: deciding what aspects of a task to highlight, how to organize and orchestrate the work of students, what questions to ask students having varied levels of expertise, assessing strengths and weaknesses of each student, and selecting appropriate tools based on that assessment.	Barber, 2007	Ensure that new and experienced teachers have knowledge about effective pedagogy. Use a variety of strategies, including new teacher induction, face-to-face training, online training, webinars, peer observation, connections to Studying Skillful teaching, etc.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 1:** What instructional strategies/practices are effective in supporting different types of students (race/ethnicity, mobility, limited English, special education)?		
Key Findings	**Citation**	**Response to Key Findings**
Use metacognitive strategy instruction – questions to help students comprehend, make connections, understand similarities and differences with previous problems, develop appropriate problem solving strategies, and reflect on what new material they have learned	Slavin, 2008	Incorporate metacognitive strategies in curriculum guides and new resources that are being developed for teachers.

Classroom/Instructional Practices: Implemented Curriculum Research Question 1–Sources Cited:

Barber, Michael and Mona Mourshed. *How the World's Best Performing School Systems Come Out on Top.* McKinsey & Company. September 2007. http://www.mckinsey.com/App_Media/Reports/SSO/Worlds_School_Systems_Final.pdf .

The most efficient way to get sustained and substantial improvements in student outcomes is through instruction. There is the potential for a 22% efficiency improvement. Strategies like spending more money, reducing class size, and changing autonomy, typically fail because the dominant effect in a classroom is the teacher, not structural changes or funding (between 1980 and 2005 US per pupil spending increased 73%, after allowing for inflation and student teacher ratio decreased 18%).Variations in teacher quality completely dominate any effect of reduced class size. The United States can achieve educational equity; the PISA scores of the top performing systems show a low correlation between performance and home background. Includes lots of information about methods used by the best performing systems.

Burris, Carol Corbett, Jay P. Heubert, and Henry M. Levin. "Accelerating Mathematics Achievement Using Heterogeneous Grouping." *American Educational Research Journal* Volume 43, Number 1, June 2009: 105-136.

Heterogeneous grouping does not "hold back" learning and performance of high achieving students. Heterogeneous grouping has a significantly increases achievement of students of color.

Ferguson, Ronald F., Ph.D. *What Doesn't Meet the Eye: Understanding and Addressing Racial Disparities in High-Achieving Suburban Schools*. North Central Regional Educational Library. November 2002. http://www.ncrel.org/gap/ferg/conclud.htm.

> Standardized test scores and school grades reflect real disparities in academic knowledge and skill. Observable behaviors and homework completion rates make whites and Asians appear to be more academically engaged, and hard working. However interest in schoolwork among blacks, whites, and Hispanics in the same school, grade, and class are equal. Black and Hispanic students, who enter school less prepared, may be able to overcome skill gaps seeking help more readily and engaging in their studies deeply. Schools should endeavor to identify and address specific skill and knowledge deficits that underlie comprehension problems and respond in targeted ways with teachers who have strong content knowledge and are willing to 1) adapt their pedagogies to meet student needs, 2) maintain good relationships with students, and 3) provide strong encouragement, assurances that students have the ability to succeed and active support for success.

McCall, Martha S., Carl Hauser, John Cronin, Gage G. Kingsbury, and Ronald Houser. *Achievement Gaps: An Examination of Differences in Student Achievement and Growth*. Technical report, NWEA Growth Research Database, Northwest Evaluation Association (NWEA), November, 2006.

> The heart of the achievement gap is in how each individual student grows through his or her educational career. Students attending high poverty schools, African-American students and Hispanic students make less growth during the school year and lose more achievement during the summer than their peers who begin with the same skill level. As this cycle repeats, the difference of growth patterns each school year causes a large difference over the course of a student's academic career. This difference is more noticeable in mathematics than in reading. The effect seems particularly pronounced among high performers, which is unfortunate, since it means that high performing students attending less wealthy schools and high performing minority students do not gain the same reward from their academic efforts as their peers.

Slavin, Robert E., Cynthia Lake, and Cynthia Groff. *Effective Programs in Middle and High School Mathematics: A Best-Evidence Synthesis*. The Best Evidence Encyclopedia, Center for Data Drive Reform in Education (CDDRE), Johns Hopkins University School of Education, August 2008, Version 1.3.

> A systematic comparison of research about the effects of curricula, technology, school reform, and instructional process programs concludes metacognitive strategy instruction has been shown to significantly improve mathematics achievement of middle and high school mathematics significantly more than curricula, technology, and school reform.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 2:** What is the impact of 21st century technology, calculators, and instructional materials on student learning?		
Key Findings	**Citation**	**Response to Key Findings**
Instructional software has generally shown positive effects on students' achievement in mathematics as compared with instruction that does not incorporate such technologies.	National Mathematics Advisory Panel, 2008	• Identify mathematics instructional software and instructional technologies (hardware) in use in MCPS. • Utilizing existing information at the local and national levels, review the use and effectiveness of instructional software and technologies currently in use in MCPS. • As needed, identify additional researched-based instructional software and instructional technologies that are proven to improve student achievement. • Based on the findings, develop a system-wide implementation and communication plan.
A review research found limited or no impact of calculators on calculation skills, problem solving or conceptual development over periods of up to one year.	National Mathematics Advisory Panel, 2008 Waits, 2000	• There are no longitudinal studies on the long-term use of calculators. Although, there are concerns in MCPS and nationally on the over reliance of calculators by students', at this time there is no research evidence to support the claims.
Textbooks published in the United States are long and cover too much content in each grade-level or course. The extensive content, size, and weight are a barrier for use by teachers and students.	National Mathematics Advisory Panel, 2008	• Eliminate the use of printed textbooks and workbooks. Partner with textbook companies to produce online content that is accessible by teachers, students, parents, and administrators. Online content may include written instructional information, video instruction, practice problems, and links to support resources.

Classroom/Instructional Practices: Implemented Curriculum Research Question 2–Sources Cited:

National Mathematics Advisory Panel. *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, D.C.: United States Department of Education, 2008.

The report of the National Mathematics Advisory Panel provides a comprehensive research base for the teaching and learning of mathematical concepts in contemporary classrooms. Published in 2008, the report has been very influential in guiding the planning, delivery, and assessment of math instruction nation-wide. Among the key content is the statement that instructional software has generally shown positive effects on students' achievement in mathematics as compared with instruction that does not incorporate such technologies.

Waits, B. K. and F. Demana. "Calculators in Mathematics Teaching and Learning: Past, Present, and Future." In *Learning Mathematics for a New Century: 2000 Yearbook*, edited by M. J. and F. R. Curcio Burke, 51-56. Reston, Virginia: The National Council of Teachers of Mathematics, 2000.

This article, published by the National Council on Teaching Mathematics addresses the use of calculators and their effect on student learning at various levels of math instruction. Among the key points is a recommendation to eliminate the use of printed textbooks and workbooks. The recommendation is to instead partner with textbook companies to produce online content that is accessible by teachers, students, parents, and administrators. Online content may include written instructional information, video instruction, practice problems, and links to support resources.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 3:** What school structures and organization support consistent implementation?		
Key Findings	**Citation**	**Response to Key Findings**
US students lag behind other countries in math. Gaps emerge at middle school. Study found that whole school reforms got the best results in terms of positively affecting student performance in math.	Balfanz, 2006	MCPS has programs that support whole school reforms, including the Professional Learning Communities Institute and Middle School Reform. We should investigate how to apply these to support math achievement and how to expand the efforts.
Case study of urban high school in California with exceptional math results. Keys were development of quantitative reasoning,	Boaler, 2006	MCPS has schools that are demonstrating success in mathematics. We should take

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 3:** What school structures and organization support consistent implementation?		
Key Findings	**Citation**	**Response to Key Findings**
working together on complex problems. School structures included departmental collaboration, heterogeneous grouping, block scheduling.		efforts that study and publicize these successes (M-Stat, A&S meetings, etc.) and work to expand.
Researchers used videotaped math instruction form US and other countries to examine differences. Found U.S. teachers reinforced attention to lower-level math. Suggest teachers balance a skill emphasis with rigor and challenge in math.	Hiebert, 2005	MCPS should study current instructional practices in system classrooms and identify areas to celebrate and areas to improve.
Researchers studied algebra results for students in US and Japan. Found Japanese students had more positive beliefs about their math ability and scored higher.	House, 2008	MCPS should consider how we capture the student voice/perspective on math instruction and use the information to help build student efficacy and positive attitudes about math.
Study looked at TIMSS and PISA results and makes argument that both tests should be considered because the findings are sometimes inconsistent. Researcher points out school characteristics that should be studied more closely, including governance, curricula, instructional methods, approaches to testing, and accountability.	Koretz, 2009	How do MCPS schools compare to the best international practices? We should identify areas for study and action research.
Study examined TIMSS scores of eighth graders in the United States and the math courses they were taking. Found mismatches between math course titles and textbooks, which were found to negatively affect student scores. Researchers recommend close examination of the opportunities and math experiences provided to students in reform discussions.	Leland, 2001	Build on in-system research that has already been started (by an M-Stat team) to examine the relationship between student math courses, math experiences, and math achievement, especially in rigorous courses.
Researchers conducted a meta-analysis of studies examining the effects of different grouping strategies with classes. Found not all practices are equally effective, that small group instruction is most effective when teacher training is provided, that some grouping according to ability can be effective, and that cooperative learning methods can support student progress.	Lou, 2000	MCPS should examine the professional development we are providing to support teacher success with small group instruction in mathematics, especially at the secondary level.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 3:** What school structures and organization support consistent implementation?		
Key Findings	**Citation**	**Response to Key Findings**
Examined math experiences and outcomes of tenth grade math students in the US to compare performance of students in traditional algebra and geometry courses versus courses that had been redesigned to meet NCTM standards and reforms. Did not find relationship between reform practices and achievement in traditional classes. Suggest instructional changes need to occur in tandem with curriculum changes to make a difference in student achievement.	McCaffrey, 2001	MCPS should examine current instructional practices, especially in secondary mathematics, to analyze the relationship between revised curricula and teacher practice.
Researchers used data from Project STAR in Tennessee to examine the effect of small class sizes on student math achievement. Found that there was an effect on performance of "low-achieving" students, but it was not statistically significant. Effect was larger in reading than in math.	Nye, 2002	Examine how MCPS uses class size, both in total class and in small group instruction to identify promising strategies for helping to support student progress in math.
Researchers examined two teachers' approaches to promoting equity in their math classrooms, detailing teacher struggles and successes with implementing equitable practices with students. Teachers in the study did not have clear direction from their system about equity expectations and supports.	Reed, 2005	MCPS should use the newly passed Framework for Equity and Excellence to clarify expectations for equitable instruction in all subjects, including math and help teachers to understand how to promote equity and excellence for all students in their math classrooms.
Researchers looked at factors affecting student math performance. Found that a costly ten-student reduction in class size produced a smaller benefit than increasing teacher quality by one standard deviation. Reinforces the importance of teacher quality and its effect on student success.	Rivkin, 2005	MCPS should consider ways to determine teacher quality in mathematics (exemplary teachers and practices) and use the information to build capacity of all teachers.
Researchers used a teacher survey to examine implementation of instructional practices related to standards-based reform. Claim that the survey instrument is valid and reliable and a lower cost method of studying teacher implementation of curriculum.	Ross, 2003	MCPS needs to consider multiple avenues for gathering information about teacher practice in the classroom. Teacher surveys, when combined with observation samples and other methods, could be

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 3:** What school structures and organization support consistent implementation?		
Key Findings	**Citation**	**Response to Key Findings**
		useful in the process.
Researchers studied teacher implementation of standards-based curriculum. Study included examination of various teacher characteristics (background, experiences, etc.) Found student growth resulted when teachers followed recommendations. Confirmed the importance of targeted professional development.	Schoen, 2003	MCPS should consider how we are using job-embedded professional development to enhance the effectiveness of teachers of mathematics
Researchers examined a variety of factors in studying math achievement of students in the US, Japan, and Korea. One aspect they considered was school-level predictors. Found that there was a high correlation in all three countries between student math achievement and school disciplinary climate.	Shina, 2009	Efforts to improve math instruction and student success in MCPS should be conducted with an eye toward the full scope of effective schools research, which includes the establishment of a safe learning environment.
Researchers studied the longer term effects of the math courses that students take in middle school. Found that course-taking patterns have a significant effect on student achievement, even when controlling for other factors. Inequities that surface in grade 8 become more pronounced by grade 11.	Wang, 2003	MCPS should examine the course-taking patterns of students and how they correlate to student success in math. Build upon work already started by M-Stat teams.

Classroom/Instructional Practices: Implemented Curriculum Research Question 3–Sources Cited:

Balfanz, R. and V. Byrnes. "Closing the Mathematics Achievement Gap in High-Poverty Middle Schools: Enablers and Constraints." *Journal of Education for Students Placed at Risk* 11, no. 2 (2006): 143-159.

The mathematics achievement levels of U.S. students fall far behind those of other developed nations; within the United States itself, the students who are falling behind come predominantly from high-poverty and high-minority areas. This article reports on a series of analyses that followed 4 cohorts of students from 3 such schools through the 5th to 8th grades, where studies have found the mathematics achievement gap to develop most rapidly. The cohorts followed in these analyses attended schools implementing whole-school reform models that incorporated research-based, proven curricula, subject-specific teacher training and professional development, multiple layers

of teacher and classroom support, and school climate reforms. The research found that students at schools implementing the whole-school reform (WSR) models made greater progress in closing the mathematics achievement gap than at the other 23 high-poverty, high-minority schools in their district. Using the results from a Binary Logistic Regression model, we show which factors were key in enabling or constraining a student's ability to close the achievement gap during the middle school years. We conclude that various student-, classroom-, and school-level factors are all key in helping students to close the gap. WSR models, while often time- and cost-intensive, address issues at all of these levels and may be more able to affect the achievement gap than other, more simply implemented reforms.

Boaler, J. "Urban Success: A Multidimensional Mathematics Approach with Equitable Outcomes." *Phi Delta Kappan* 87, no. 5 (2006): 364-369.

The article focuses on the academic achievement of students in the Railside High School's mathematics program, in California. Students at Railside performed better in mathematics and had less of an educational achievement gap than students at other urban high schools. The mathematics program at Railside provided students with quantitative reasoning capabilities. Students worked together on complex conceptual problems. These students had a high work rate and developed respect for each other despite ethnicity, culture, gender, social class, or attainment level. Some of the features critical to student success at Railside include departmental collaboration, heterogeneous grouping, group-worthy problems, block scheduling, and student responsibility.

Hiebert, J., J. W. Stigler, et al. "Mathematics Teaching in the United States Today (And Tomorrow): Results from the TIMSS 1999 Video Study." *Educational Evaluation and Policy Analysis* 27, no. 2 (2005): 111-132.

The Third International Mathematics and Science Study (TIMSS) 1999 Video Study examined eighth-grade mathematics teaching in the United States and six higher-achieving countries. A range of teaching systems were found across higher-achieving countries that balanced attention to challenging content, procedural skill, and conceptual understanding in different ways. The United States displayed a unique system of teaching, not because of any particular feature but because of a constellation of features that reinforced attention to lower-level mathematics skills. The authors argue that these results are relevant for policy (mathematics) debates in the United States because they provide a current account of what actually is happening inside U.S. classrooms and because they demonstrate that current debates often pose overly simple choices. The authors suggest ways to learn from examining teaching systems that are not alien to U.S. teachers but that balance a skill emphasis with attention to challenging mathematics and conceptual development.

House, J. D. and J. A. Telese. "Relationships between student and instructional factors and algebra achievement of students in the United States and Japan: an analysis of TIMSS 2003 data." *Educational Research & Evaluation* 14, no. 1 (2008): 101-112.

Algebra knowledge is a critical part of middle-school mathematics achievement, and success in algebra is necessary for taking higher level mathematics courses and leads to higher scores on standardized tests. The purpose of this study was to simultaneously examine

relationships between mathematics beliefs, classroom instructional strategies, and algebra achievement of adolescent students in the United States and Japan using data from the TIMSS 2003 assessment. Students from both countries who earned higher test scores were more likely to indicate positive beliefs in their mathematical ability, whereas students who earned lower test scores expressed negative comparisons of themselves to other students. Considering instructional practices, students who frequently worked problems on their own tended to earn higher test scores. These results indicate that students' mathematics beliefs and classroom instructional practices were significantly related to algebra achievement for students in the United States and Japan.

Koretz, D. "How Do American Students Measure Up? Making Sense of International Comparisons." *Future of Children* 19, no. 1 (2009): 37-51.

In response to frequent news media reports about how poorly American students hire compared with their peers abroad, Daniel Koretz takes a close look at what these comparisons say, and do not say, about the achievement of U.S. high school students. He stresses that the comparisons do not provide what many observers of education would like: unambiguous information about the effectiveness of American high schools compared with those in other nations. Koretz begins by describing the two principal international student comparisons-the Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA). Both assessments, he stresses, reflect the performance of students several years before they complete high school. PISA, which targets fifteen-year-old students, measures students' abilities to apply what they have learned in school to real-world problems. By contrast, TIMSS tests fourth and eighth graders. Unlike PISA, TIMSS follows the school curriculum closely. Because the findings of the two tests are sometimes inconsistent, Koretz stresses the importance of considering data from both sources. He cautions against comparing U.S. students with an "international average," which varies widely from survey to survey depending on which countries participate, and recommends instead comparing them with students in other nations that are similar to the United States or that are particularly high-achieving. Many observers, says Koretz, speculate that the lackluster average performance of American students in international comparisons arises because many, especially minority and low-income U.S. students, attend low-performing schools. But both TIMSS and PISA, he says, show that the performance of American students on the exams is not much more variable than that of students in countries that are socially more homogeneous or that have more equitable educational systems. Koretz emphasizes that the international comparisons provide valuable information and are a useful source of hypotheses about American secondary schooling to be tested by researchers. Studies designed to explain differences between U.S. students and those in very similar countries, he says, might provide especially useful suggestions for changes in policy and practice.

Leland, S. C., W. H. Schmidt, et al. "Who Takes What Math and in Which Track? Using TIMSS to Characterize U.S. Students' Eighth-Grade Mathematics Learning Opportunities." *Educational Evaluation and Policy Analysis* 23, no. 4 (2001): 323-341.

Study examined TIMSS scores of eighth graders in the United States and the math courses they were taking. Found mismatches between math course titles and textbooks, which were found to negatively affect student scores. Researchers recommend close examination of the opportunities and math experiences provided to students in reform discussions.

Lou, Y., P. C. Abrami, et al. "Effects of Within-Class Grouping on Student Achievement: An Exploratory Model." *The Journal of Educational Research* 94, no. 2 (2000): 101-112.

In this meta-analysis, the authors attempted to develop a parsimonious model of factors that account for the significant variability in the findings on the effects of with-in-class grouping on student achievement. Two weighted least squares regression models were tested using 103 independent findings from 51 studies at elementary through postsecondary grades. Results indicate that the most important study features that accounted for 48% of the total variance include outcome measure source, teacher training equivalence, grouping basis, type of small-group instruction method, grade level, and relative ability of students. Goodness-of-fit statistics indicate that the model fits the data and that the remaining variance may be explained by sampling errors.

McCaffrey, D. F., L. S. Hamilton, et al. "Interactions among Instructional Practices, Curriculum, and Student Achievement: The Case of Standards-Based High School Mathematics." *Journal for Research in Mathematics Education* 32, no. 5 (2001): 493-517.

Examined math experiences and outcomes of tenth grade math students in the US to compare performance of students in traditional algebra and geometry courses versus courses that had been redesigned to meet NCTM standards and reforms. Did not find relationship between reform practices and achievement in traditional classes. Suggest instructional changes need to occur in tandem with curriculum changes to make a difference in student achievement.

Nye, B., L. V. Hedges, et al. "Do Low-Achieving Students Benefit More from Small Classes? Evidence from the Tennessee Class Size Experiment." *Educational Evaluation and Policy Analysis* 24, no. 3 (2002): 201-217.

Recent evidence about the effects of class size on academic achievement from randomized experiments points to positive effects of small classes. However, the evidence about the mechanism producing these effects is less clear. Some scholars have argued for mechanisms that would imply greater effects of small classes for low-achieving students. This article investigates possible differential effects of small classes on achievement using data from Project STAR, a four-year, large-scale randomized experiment on the effects of class size. We examined the differential effects of small classes for students in the bottom half and bottom quarter, respectively, of their class's achievement distribution in kindergarten. Although small class effects are somewhat larger for low-achieving students in reading, the

differential effects (interactions) are not statistically significant. Moreover, the small class effects for low-achieving students in mathematics are actually smaller than those for higher achieving students. Thus while there are unambiguous positive effects of small classes on achievement, there is no evidence for differentially larger effects of small classes for lower achieving students.

Reed, R. J. and N. Oppong. "Looking Critically at Teachers' Attention to Equity in their Classrooms." *Mathematics Educator*, 2005: 2-15.

Ensuring that all students are afforded high quality education is a task given to teachers under standards documents provided by professional organizations such as the National Council of Teachers of Mathematics and the National Board for Professional Teaching Standards. Falling under the generic title of equity, paying attention to the achievement of minority students-especially those historically underserved by schools-is required for good teaching. However, teachers are often left to define what equity means. In this study, we investigated how two National Board Certified Teachers defined equity and how they attended to it in their classrooms. We further explored how issues of race and socioeconomic status interfered with their attempts at providing equitable classroom experiences for all students.

Rivkin, S. G., E. A. Hanushek, et al. "Teachers, Schools, and Academic Achievement." *Econometrica* 73, no. 2 (2005): 417-458.

This paper disentangles the impact of schools and teachers in influencing achievement with special attention given to the potential problems of omitted or mismeasured variables and of student and school selection. Unique matched panel data from the UTD Texas Schools Project permit the identification of teacher quality based on student performance along with the impact of specific, measured components of teachers and schools. Semiparametric lower bound estimates of the variance in teacher quality based entirely on within-school heterogeneity indicate that teachers have powerful effects on reading and mathematics achievement, though little of the variation in teacher quality is explained by observable characteristics such as education or experience. The results suggest that the effects of a costly ten student reduction in class size are smaller than the benefit of moving one standard deviation up the teacher quality distribution, highlighting the importance of teacher effectiveness in the determination of school quality.

Ross, J. A., D. McDougall, et al. "A Survey Measuring Elementary Teachers' Implementation of Standards-Based Mathematics Teaching." *Journal for Research in Mathematics Education* 34, no. 4 (2003): 344-363.

Intensive case study is an expensive tool for measuring teachers' instructional practice. Previous research suggests that teacher self-report surveys provide a low-cost and relatively accurate picture of classroom practice. To examine the extent to which teachers implement mathematics education reform, we developed a 20-item survey based on nine dimensions of standards-based teaching. In this article, we provide evidence of the reliability (i.e., internal consistency) and validity of the instrument. The evidence consists of correlations of survey scores with a mandated performance assessment in Grade 6 mathematics, congruence with classroom observations of a small

sample of teachers, and demonstrations that teachers who are similar in their claims about using a standards-based text series differ in how they use the text in ways predicted by the survey.

Schoen, H. L., K. J. Cebulla, et al. "Teacher Variables That Relate to Student Achievement When Using a Standards-Based Curriculum." *Journal for Research in Mathematics Education* 34, no. 3 (2003): 228-259.

We report results from a study of instructional practices that relate to student achievement in high school classrooms in which a standards-based curriculum (Core-Plus) was used. We used regression techniques to identify teachers' background characteristics, behaviors, and concerns that are associated with growth in student achievement and further described these associations via graphical representations and logical analysis. The sample consisted of 40 teachers and their 1,466 students in 26 schools. Findings support the importance of professional development specifically aimed at preparing to teach the curriculum. Generally, teaching behaviors that are consistent with the standards' recommendations and that reflect high mathematical expectations were positively related to growth in student achievement.

Shina, J., H. Leeb, et al. "Student and School Factors Affecting Mathematics Achievement: International Comparisons Between Korea, Japan and the USA." *School Psychology International* 30, no. 5 (2009): 520-537.

The purpose of the study was to comparatively investigate student- and school-level factors affecting mathematics achievement of Korean, Japanese and American students. For international comparisons, the PISA 2003 data were analyzed by using the Hierarchical Linear Modeling method. The variables of competitive-learning preference, instrumental motivation and mathematics interest were used as student-level predictors on mathematics achievement. The variables of student-teacher relationship and school disciplinary climate were also used as school-level variables. The results of the study showed that different patterns of the relations between student- and school-level predictors and mathematics achievement were present among the three countries. Specifically, the predictor of competitive-learning preference was significant on mathematics achievement in Korea and Japan, but not in the US. For Korean and Japanese students, unexpectedly, mathematics interest was a stronger predictor than was instrumental motivation; in contrast, the pattern was the reverse for American students. For school-level predictors, school disciplinary climate was a significant predictor on the achievement differences in all three countries; however, the variable of student-teacher relationship turned out to be significant only in Japan. Implications of the results are discussed from the comparative perspectives of cultures and educational contexts of the three countries.

Wang, J. and P. Goldschmidt. "Importance of Middle School Mathematics on High School Students' Mathematics Achievement." *The Journal of Educational Research* 97, no. 1 (2003): 3-19.

The authors explored the consequences of middle school mathematics course taking, a measure of opportunity to learn, disparity in students' high school mathematics achievement, and achievement growth. Using 4-year longitudinal data from an ethnically and linguistically diverse district, they applied a 3-level hierarchical linear growth model to address potential inequity in course taking and its

consequences. The results indicate that course-taking patterns, even when controlling for prior achievement, play a prominent role in identifying performance differences. The distribution of mathematics course taking among various subgroups not only differed in Grade 8 but also became increasingly inequitable by Grade 11.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 4:** How do children and adolescents learn mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
The integrated and balanced development of all five strands of mathematical proficiency (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition) should guide the teaching and learning of school mathematics.	Mathematics Learning Study Committee, National Research Council, 1999 (p. 11)	• The goal of the MCPS mathematics program is that all students achieve mathematical proficiency. The mathematics curriculum guides provide instructional strategies and resources for attaining this goal. • Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
New and unfamiliar topics in mathematics usually cannot be fully grasped without some assistance from a text or a teacher. School-based instruction may play a larger part in most children's mathematical experience than it does on their reading experience.	Mathematics Learning Study Committee, National Research Council, 2001 (page 19)	This finding shows that the effectiveness of instruction may be a more critical factor in learning mathematics than in other areas.
Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp	Committee on Learning Research and Educational Practice,	This finding supports the need for professional development or resources that provide teachers with strategies for identifying their students' preconceived notions of

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 4:** How do children and adolescents learn mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.	National Research Council, 1999 (page 10)	mathematics and ways to connect instruction to students' experiences.
Verbatim memories of problem details are encoded separately from gist memories of the meaning of problem information in the brain; thinking in terms of gist often produces superior reasoning.	National Mathematics Advisory Panel, 2008 (page 4-9)	• This finding supports the need for professional development or resources that provide teachers with an understanding of how to provide instruction that focuses on the details of a problem as well as the gist of a problem. • This finding is connected to the finding on the strands of mathematical proficiency.
Each person processes mathematics differently, and these differences run along a continuum from primarily quantitative to primarily qualitative. Both types of learning styles are present in mathematics classrooms. Teaching to one style alone leaves out students with the other style. A suggested instructional sequence for introducing a new mathematical concept is to begin with an inductive approach to accommodate the qualitative learners and then move to a deductive approach for quantitative learners.	Sousa, 2008 (Pages 139-148)	This finding supports the need for professional development or resources that provide teachers with an understanding of mathematical learning styles and the implications for instruction.
● Regrouping practices (separating faster learners from slower learners) contributes to gap in achievement when students reach middle and high school ● Students in inquiry-oriented classrooms are more likely to develop mastery goals as opposed to performance or work-avoidance goals. ● Positive attitudes developed in inquiry-oriented classrooms persist over time.	Middleton, 1999	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 4:** How do children and adolescents learn mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
		instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
• Regrouping practices (separating faster learners from slower learners) contributes to gap in achievement when students reach middle and high school • Students in inquiry-oriented classrooms are more likely to develop mastery goals as opposed to performance or work-avoidance goals. • Positive attitudes developed in inquiry-oriented classrooms persist over time.	Stipek, 1998	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
Factors influencing student task engagement at high levels: • appropriate fit of task to learner • supportive teacher actions (scaffolding, pressing to provide explanation or to make connections) that do not reduce the cognitive demands of the task • planning for appropriate amount of time for task	Henningsen, 1997	These findings point to the need for more time devoted to master major concepts.
• Mixed-ability grouping results in higher achievement for average and lower ability students and does not significantly affect achievement levels for higher ability students. • Teachers need appropriate support (professional	Linchevski, 1998	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 4:** How do children and adolescents learn mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
development opportunities, common planning time) in order to effectively teach mixed ability classes		to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
Two features of instruction that are especially likely to promote conceptual understanding (and perhaps skill efficiency) are: • "making important mathematical relationships explicit" • "encouraging students to wrestle with important mathematical ideas"	Heibert, 2003	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
• Making mathematics culturally relevant improves achievement • Content integration helps promote cultural relevance in the classroom • Teachers need to be aware of hidden assumptions / biases they hold and work to make their teaching practices equitable • Effective teachers develop a positive identification with students so that they see them	Ladson-Billings, 1995	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Classroom/Instructional Practices: Implemented Curriculum **Research Question 4:** How do children and adolescents learn mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
as they see themselves • Students treated as competent are more likely to become competent		instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?
• Recommendations for instructional strategies generally call for teachers to structure learning environments that allow for mathematical discourse and the connection of mathematical ideas. • Teachers need to see themselves as perpetual learners and be given opportunities to reform their own personal understandings of mathematics (Ellis, 2003; Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). These experiences must be supported by mathematics educators who not only understand but are willing to take up the challenge of reflecting on one's instructional practices and critically examining the sorts of opportunities that are being created for students to develop mathematical understanding.	Ellis, 2005	• Determine what data is available from previous reports that will provide information about math classroom practices (implemented curriculum) in MCPS as it relates to the development of mathematical proficiency. • Develop a plan to examine classroom practices in MCPS to determine if there is a gap between the research and the curriculum that is implemented in MCPS classrooms. • Based on study of classroom practice in MCPS, determine the highest priority needs in terms of instructional practice. What practices need to increase in order to support math curriculum implementation? What needs to decrease? What do teachers need in order to accomplish this?

Classroom/Instructional Practices: Implemented Curriculum Research Question 4–Sources Cited:

Committee on Learning Research and Educational Practice. *How People Learn Bridging Research and Practice*. Edited by John D. Bransford, and James W. Pellegrino M. Suzanne Donovan. Vol. National Research Council. National Academy Press, 1999.

This report from the National Research Council makes several pertinent recommendations. The Council asserts that students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new

concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

Ellis, Mark W. and Robert Q. Berry III. "The Paradigm Shift in Mathematics Education: Explanations and Implications of Reforming Conceptions of Teaching and Learning." *The Mathematics Educator* 15, no. 1 (2005): 7–17.

Ellis and Berry argue in this article that new and unfamiliar topics in mathematics usually cannot be fully grasped without some assistance from a text or a teacher. Furthermore, they make the case that school-based instruction may play a larger part in most children's mathematical experience than it does on their reading experience.

Hiebert, J., Gallimore, H. Garnier, K. B. Givvin, H. Hollingsworth, J. Jacobs, A. M-Y. Chui, D. Wearne, M. Smith, N. Kersting, A. Manaster, E. Tseng, W. Etterbeek, C. Manaster, P. Gonzales, and J. W. Stigler. "Teaching Mathematics in Seven Countries: Results from TIMSS 1999 Video Study." *NCES* (National Center for Education Statistics, United States Department of Education) NCES 2003-013. (2003).

This comprehensive study of math instruction in numerous countries confirmed that students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

Henningsen, M., and M. K. Stein. "Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning." *Journal for Research in Mathematics Education* 28 (1997): 534-549.

In this article, Henningsen and Stein examine various factors that can support or interfere with student mastery of math concepts. They find that factors influencing student task engagement at high levels include appropriate fit of task to learner, supportive teacher actions (scaffolding, pressing to provide explanation or to make connections) that do not reduce the cognitive demands of the task, and planning for appropriate amount of time for task.

Ladson-Billings, G. "Making mathematics meaningful in multicultural contexts." In New *Directions for Equity in Mathematics Education*, edited by Elizabeth Fennema, and Lisa Byrd Adajian Walter G. Secada. Cambridge: Cambridge University Press, 1995.

In this book, prominent researcher Gloria Ladson-Billings stresses the importance of culturally responsive instruction in mathematics. Among her key points: making mathematics culturally relevant improves achievement, content integration helps promote cultural relevance in the classroom, teachers need to be aware of hidden assumptions / biases they hold and work to make their teaching practices equitable, effective teachers develop a positive identification with students so that they see them as they see themselves, and students treated as competent are more likely to become competent.

Linchevski, Liora and Bilha Kutscher. "Tell me with whom you're learning, and I'll tell you how much you've learned: Mixed-ability versus same-ability grouping in mathematics." *Journal for Research in Mathematics Education* 29 (1998): 533-554.

Linchevski and Kutscher examine the impact of various grouping strategies on the achievement of students in mathematics. Among their key points: Mixed-ability grouping results in higher achievement for average and lower ability students and does not significantly affect achievement levels for higher ability students, and teachers need appropriate support (professional development opportunities, common planning time) in order to effectively teach mixed ability classes

Mathematics Learning Study Committee, National Research Council. "Adding It Up Helping Children Learn Mathematics." Edited by Jeremy, Jane Swafford and Bradford Findell Kilpatrick. (National Academy Press) 2001.

This report from the National Research Council makes several pertinent recommendations. In particular, there is an emphasis on the integrated and balanced development of all five strands of mathematical proficiency (conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition). The authors contend that these strands should guide the teaching and learning of school mathematics.

Middleton, J.A. and P.A. Spanias. "Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research." *Journal for Research in Mathematics Education* 30 (1999): 65-88.

Middleton and Spanias examine the role of motivation in student achievement in mathematics. They find that regrouping practices (separating faster learners from slower learners) contribute to gap in achievement when students reach middle and high school . Furthermore, they argue that students in inquiry-oriented classrooms are more likely to develop mastery goals as opposed to performance or work-avoidance goals, and positive attitudes developed in inquiry-oriented classrooms persist over time.

National Mathematics Advisory Panel. *Foundations for Success*. U. S. Department of Education, 2008.

This publication by the National Mathematics Advisory Panel contains significant research on a variety of topics related to math instruction and student learning. Key points include: Verbatim memories of problem details are encoded separately from gist memories of the meaning of problem information in the brain; thinking in terms of gist often produces superior reasoning. This has implications for how to plan and deliver math instruction to students.

Sousa, David. How the Brain Learns Mathematics. Pages 139-148: Corwin Press, 2008.

In this book, researcher David Sousa links the latest studies on brain research to how students operate and learn in a math classroom. He argues that each person processes mathematics differently, and these differences run along a continuum from primarily quantitative to primarily qualitative. Both types of learning styles are present in mathematics classrooms. Teaching to one style alone leaves out students with the other style. Sousa suggests some techniques for addressing the needs of students.

Stipek, D., J. M. Salmon, K. B. Givvin, E. Kazemi, G. Saxe, and V. L. Macgyvers. "The value (and convergence) of practices suggested by motivation research and promoted by mathematics education reformers." *Journal for Research in Mathematics Education*, 1998: 465-488.

The researchers examine the role of motivation in student achievement in mathematics. They find that regrouping practices (separating faster learners from slower learners) contribute to gap in achievement when students reach middle and high school . Furthermore, they argue that students in inquiry-oriented classrooms are more likely to develop mastery goals as opposed to performance or work-avoidance goals, and positive attitudes developed in inquiry-oriented classrooms persist over time. Correlates with the studies done by Middleton and Spanias.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 1:** What is the purpose of the national, state, and local assessments given in MCPS? Do they overlap? How are end of unit assessments and end of course assessments aligned with the curriculum?		
Key Findings	**Citation**	**Response to Key Findings**
General purposes of assessments. An assessment system must be designed to improve student learning and not one single assessment can provide the information necessary to do that.	The National Association of State Boards of Education; 18.	The MCPS mathematics program has an assessment system designed to improve student learning. There are international assessments at selected schools (NAEP), national assessments at Grade 2 (TN2), state assessments (MSA), and local assessments (formative, end of unit, and teacher developed) that provide a variety of methods to measure student learning. Local assessments are designed to measure identified outcomes of all test takers within a grade/course for the purpose of improving student learning. MCPS BOE Policy IFA establishes that a variety of assessments will be used to measure the learned curriculum

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 1:** What is the purpose of the national, state, and local assessments given in MCPS? Do they overlap? How are end of unit assessments and end of course assessments aligned with the curriculum?		
Key Findings	**Citation**	**Response to Key Findings**
International Math Assessments International assessments are designed to measure identified outcomes for all test takers of the assessment across countries.	The National Center for Education Statistics; 3.	See statement above.
National assessments National assessments are designed to measure identified outcomes among all test takers of the assessment within a country.	The National Association of State Boards of Education; 17	See statement above.
State assessments State assessments are designed to measure identified outcomes all test takers of the assessment within a state. Currently most states use the state assessments as measures of NCLB or exit exams.	The National Association of State Boards of Education; 10 and 20	See statement above.
Local assessments The MCPS Board of Education (BOE) Policy IFA states that the learned curriculum is measured using assessments. The MCPS math courses include formative/summative assessments designed to measure the learned curriculum.	The National Association of State Boards of Education; 12-14 Board of Education	See statement above. Teachers can supplement the systems assessments with their own assessments.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 1:** What is the purpose of the national, state, and local assessments given in MCPS? Do they overlap? How are end of unit assessments and end of course assessments aligned with the curriculum?		
Key Findings	**Citation**	**Response to Key Findings**
Question 2 The MCPS mathematics end of unit assessments are clearly aligned to the MCPS curriculum framework, which is aligned to the Maryland State Department of Education's Voluntary State Curriculum and noted by content category, grade level, content subcategory and assessment limit. The formative/summative assessment items were locally developed to directly measure the indicator that is associated with the content being measured.	The National Association of State Boards of Education; 17 and 18 Office of Instruction and Program Development	There is a very clear connection between the MCPS mathematics curriculum and the local assessments that have been developed to measure the learned curriculum. The clear connection is evidenced in the MCPS mathematics end of unit assessment scoring guides and the content indicators in the MCPS mathematics instructional framework. This process creates a very clear and measurable alignment with the MCPS curriculum as identified in the BOE Policy IFA.

Curriculum: Assessed Curriculum Research Question 1–Sources Cited:

Board of Education of Montgomery County. *Policy IFA: Curriculum*. February 13, 2001, 1 – 7.

This document, developed by the Montgomery County Board of Education and regularly updated, provides policies and regulations that guide all work of the MCPS school system.

The following information is an excerpt from the BOE Policy document, IFA, on measuring the learned curriculum.

Learned Curriculum

a) The superintendent shall recommend to the Board of Education assessment approaches for determining the effectiveness of instruction at system, school, and classroom levels. Assessments shall evaluate the extent to which students master international, national, state, and local standards and the extent to which teachers enable students to meet those standards.
b) A variety of assessment approaches will be used to determine the effectiveness of the written curriculum, the taught curriculum, and instructional programs and courses, including pre-assessment, formative assessment, and summative assessment.
c) The assessed curriculum shall include the following components:
   (1) National and international assessments as appropriate

(2) State-level assessments as required
(3) Local assessments
(4) An electronic information management system at the classroom, school, and central office levels that will provide teachers, principals, central office, other instructional staff, and parents with regularly reported individual student data to support coordination of instructional planning, student assessment and placement, instructional delivery, and program evaluation
(5) A program evaluation component

d) Teacher assessment of students on the curriculum standards shall be ongoing. Teacher-made tests, as well as local assessments, shall be used to determine patterns of student achievement. Teachers and supervisors shall use test results to assess the status of individual student achievement, to continuously regroup students for instruction, to identify general achievement trends of various groups of students, and to modify curriculum and/or instruction as warranted by assessment results.
e) Principals shall review assessments with teachers to ensure the assessments are congruent with the written curriculum.
f) A systematic process shall be in place for assessing/testing student performance. This process shall provide for the acquisition, analysis, and communication of student performance data to:
(1) Measure student progress and diagnose student needs
(2) Guide teachers' instruction at appropriate levels
(3) Guide students' learning
(4) Guide system-wide improvement of curriculum alignment and programmatic decisions (5) Communicate progress to parents to support learning

Office of Instruction and Program Development. *Curriculum Framework for Prekindergarten Through Grade 3*. Mathematics Curriculum Framework:3. 2001.

This document provides the goals, enduring understandings, overview of mathematical content, and the instructional approach for the mathematics curriculum framework that was being developed in MCPS in 2001. The content was developed by the mathematics instructional team and reviewed and approved by the MCPS BOE.

The following quote is taken from the MCPS Mathematical Curriculum Framework, page 3; "Assessment is an ongoing process that guides instruction and monitors student progress to include mastery of mathematics content and higher level thinking skills. Pre-assessment, formative, and summative assessments provide for student, peer, and teacher evaluation. These types of assessment enable teachers to modify their instruction to support improved learning at each grade level for all students. Assessment should be focused on the development and achievement of mathematical proficiency."

National Association of State Boards of Education. *Reform at a Crossroads: A Call for Balanced Assessment and Accountability Systems*. NASBE Study Group on Assessment Systems for the 21st Century Learner, 1 – 29. October 2009.

In response to the increased expectations, states are reexamining the standards and assessments that are used to drive and measure attainment of essential knowledge and skills. The authors of this document, a workgroup from the National Association of State Boards of Education, researched and shared current best practices on balanced assessment systems that provide instructional and accountability practices that enhance student achievement.

Information gained from testing should ultimately help improve learning. But in order to more closely connect assessment and instruction, the roles of assessment must be expanded to measure complex skills in ways that reflect what we have learned from research regarding how people learn and how to assess an individual's progress in developing competency in a subject area. For teachers to adopt practices that are directed at developing deep conceptual understanding and higher order thinking and communication skills, assessments for purpose of accountability must also measure more than recall of factual knowledge or performance of isolated skills. p.12

In order to focus on what learners need, teachers must pay close attention to the progress of each student along this path, or "developmental corridor," leading to a standard of expected performance. They need to tailor instruction to take the learner to the next level that is challenging but attainable. This requires assessments that make clear to both teachers and student where students are along the developmental corridor. P. 13

A key principle of learning is paramount: teachers must start with what students currently understand and know about a topic and build from there. Assessments can be designed to identify current student thinking, identify conceptual errors, and then move the student toward more sophisticated understandings. P.14

Local in-school performance assessments serve as the dominant mode of testing in most of the high-achieving countries around the world (e.g. Hong Kong, Singapore, Finland, and Sweden). These measures incorporate rich assessment tasks at the classroom level such as research papers, presentations, and lab experiments. At the high school level, these countries often use a combination of centralized, national exams (with primarily open-ended and essay items) and locally developed tests. p.17

The foundational premise is that an assessment system must be designed to improve student learning, but recognize that no single test would suffice. Inherent in the design of all tests are trade-offs and constraints that derive from their specific purposes. The sharp contrast between classroom and large assessments, for example, arises because they serve distinct purposes and provide different information to different audiences. p.18

Teachers are central to the process of developing, administering, and scoring school-based classroom assessments. In this way, the deployment of in class performance measures serves as robust teacher development that fosters teacher-buy-in and readiness to adopt new instructional practices. Teachers are trained to administer and evaluate student work using collaboratively determined criteria specified through standardized rubrics and scoring guides. This not only serves to ensure quality and consistency, it strengthens the connection between assessment and instruction and helps teachers "learn to calibrate their understanding of the standards to common benchmarks. P. 17

Another advantage of collective scoring is that rather than grading in isolation, teachers must collaborate to set the criteria for judging student efforts. This helps teachers gain multiple perspectives on learning and leads to improving instructional practices based on a shared definition of what constitutes master or competency. Embedding performance measures at the classroom level permits a finer grain analysis that allows teachers to assess student learning along a number of dimensions such as the ability to frame a problem, generate hypotheses, organize information, persist in problem solving, and frame a coherent oral and/or written response. Local scoring provides immediate feedback to teachers and students affording the opportunity to diagnose how students are progressing and why they may be struggling. p.17-18

The purpose of state assessments is to measure the standards that the state has established for student knowledge and skills at identified grades levels (p.10) for the purpose of accountability and improving teaching and learning. p.20 Of these purposes, assessments for improving teaching and learning are most notably absent. While we have depended heavily on using educational assessment for high-stakes individual and programmatic decisions, it is largely recognized that current assessment and accountability systems will not achieve our fundamental aims of improving the quality of teaching and learning for all students. Large-scale assessments tend to measure a narrow range of knowledge and skills drawn from the lower end of the standards through the use of multiple-choice formats. Skills that represent higher levels of cognitive demand are difficult to measure with multiple-choice tests. As a consequence, teachers and administrators shape curriculum and instruction to target a more narrow range of content skills. State tests adhere to older testing and learning theories that characterize achievement as reflecting individual student's innate abilities that remain relatively stable over time and context. State tests tend to measure discrete facts in a few core content areas rather than capturing the complex knowledge and skills considered requisite for the 21st century learner. Current assessments are limited in improving teaching and learning for all students-which has been the major goal of education reform. Accountability tests provide a single snapshot of achievement based on how well the student performs relative to his/her peers or in terms of a cuts score that assigns the individual to a performance band. These measures offer little diagnostic information as to what specific instruction or supports students need relative to their level of competence and conceptual development with in particular subject area. The results of the RAND analyses of standards-based assessment and accountability systems showed that, overall, tests rather than standards tend to drive instruction: schools and teachers spend more time and resources on tested subjects and on content included lint he test.

The National Center for Education Statistics. "U.S. Participation in International Assessments." Institute of Educational Sciences, 2 – 7. 2009.

This document provides statistics, comparisons and participation information on 4 international assessments that the United States participates in; Progress in International Reading Literacy Study (PIRLS), Trends in International Mathematics and Science Study (TIMSS), Program for International Student Assessment (PISA), Program for the International Assessment of Adult Competencies (PIAAC).

Third International Mathematics and Science Study (TIMSS) purpose is to measure the mathematics and science knowledge and skills broadly aligned with curricula of the participating countries. The Program for International Student Assessment (PISA) purpose is to measure how well students can apply their knowledge and skills to problems within real-life contexts. PISA is designed to represent a "yield" of learn at age 15, rather than a direct measure of attained curriculum knowledge. The Program for International Assessment of Adult Competencies (PIAAC) purpose is to measure competencies believed to underlie personal and societal success. PIAAC is designed to measure the association of these competencies with social and economic outcomes. p.3

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Curriculum: Assessed Curriculum **Research Question 2:** What are state by state alternatives to high stakes assessment in Math?		
Key Findings	**Citation**	**Response to Key Findings**
Some studies have linked state high stakes tests with mixed results in terms of math and reading performance. High school graduation exams have been linked to decreases in AP, SAT and ACT scores when compared with the nation as well as to unintended negative consequences for racial minorities and for students receiving LEP and FARMS services.	Amrein, December 2002	MSA/HSA can be responsible for unintended consequences in terms of lowering student performance on national tests.
Very soon, all states will have Pre K - 20 data assessment systems with clear college- and career-ready indicators. There will continue to be debate over whether state standards for college- and career-readiness are rigorous enough and valid. But, national and international benchmarking may soon guide	Gleason, 2000	MCPS can benefit from monitoring state and national standards for additional support for its college readiness efforts.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 2:** What are state by state alternatives to high stakes assessment in Math?		
Key Findings	**Citation**	**Response to Key Findings**
states in setting standards that allow U.S. graduates to compete internationally.		
There is increasing discussion at the state level to use local assessments to meet graduation and subject area requirements. Many states are in the process of creating assessments, particularly end-of-course exams that can be used for demonstrating mastery of content and readiness for college credit-bearing courses. For math, many states are either using college entrance exams or currently piloting Algebra II exams. It may be a while before colleges are ready to accept these results.	Achieve Inc., Feb 2009	End-of-course assessments in Math are increasingly being counted for high stakes assessments. MCPS should gear its assessments in Math to meet rigorous, college oriented standards.
At least ten states require students to take a national college admissions exam as part of the state assessment system. Arkansas, Colorado, Illinois, Kentucky, Maine. Michigan and Wyoming administer national college entrance exams to all students as part of their state assessment system. Tennessee requires ACT as a part of the state's assessment system.	The National Association of State Boards of Education, 2009	National tests in Math could be used to measure college readiness.
Consideration by states of nationally accepted or local assessments as alternatives to state developed and managed tests raises the prospect of a dramatic evolution in the relationship between national, state and local	Gleason, November 2000	Greater local control and management of the assessment process guided by state and or national standards and quality control could mean significant changes in the current assessment scene, not to mention the decrease

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Key Findings	**Citation**	**Response to Key Findings**
assessments.		in local burden from state assessments.
Vermont developed on demand performance tasks and mathematics portfolios developed at the state level with extensive teacher involvement. Initially used as the primary assessment, they have become voluntary to provide teachers with real-time feedback and to support the state's professional development system.	Darling-Hammond, 1955	Teacher developed performance tasks can drive improved instruction.
Connecticut uses performance tasks that look at student achievement across the disciplines including math through on demand experiments that require hypotheses, data collection and analysis. New England Common Assessment Program uses student work on performance tasks and portfolios as evidence of student learning.	Darling-Hammond, 2009	Performance tasks could become a key to end of course assessment. They may at some point count toward state accountability measures. Performance tasks can be across disciplines for efficiency and integration of learning.
North Carolina designed a performance-based and rubric-scored component of the state's new assessment system. Implementation has been put on hold until 2015.	Public Schools of North Carolina, 2010	Rubric scoring of performance tasks is becoming more favorable and can simplify scoring on a large scale.
The Ohio Governor has proposed replacing their current graduation test with a four-part requirement including ACT test, end of course exams, senior thesis and community service project aligned to college and career expectations.	The National Association of State Boards of Education, 2009	National tests can be used as a component of a certification process for graduation. Such tests could be used locally as a substitute for end of course assessments.

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Curriculum: Assessed Curriculum **Research Question 2:** What are state by state alternatives to high stakes assessment in Math?		
Key Findings	**Citation**	**Response to Key Findings**
In Oklahoma, students not passing an end of instruction test may substitute corresponding subject sections of the ACT as alternatives.		
Pennsylvania may require graduation exams in core subject areas that count for 1/3 of course grades starting in 2015.	The National Association of State Boards of Education, 2009	State tests may be used as a part of local assessments and grading that counts toward graduation.

Curriculum: Assessed Curriculum Research Question 2–Sources Cited:

Achieve. *Closing the Expectations Gap.* American Diploma Project, Arlington, Virginia: Achieve, 2009.

Each year, on the anniversary of the 2005 National Education Summit on High Schools, Achieve releases an annual 50-state progress report on the alignment of high school policies with the demands of college and careers. Closing the Expectations Gap, 2009 is the fourth annual report in this series. The report details state progress implementing the American Diploma Project policy agenda. The report, which tracks efforts by states to set expectations for high school graduates that are in line with the demands of college and careers, shows progress in a majority of states towards making the high school diploma more meaningful – particularly in the area of standards – though there is still considerable work to be done.

Specifically, the report's findings include:

- All but six states have aligned, or plan to align, their end of high school standards in English and mathematics with college and career readiness expectations. Twenty-three states have completed this work.
- In 2005, only two states required students to complete a college- and career-ready curriculum in order to earn a high school diploma. Today, 20 states and the District of Columbia have set their graduation requirements at the college- and career-ready level.
- Only 10 states have assessments rigorous enough to measure whether high school students have met college and career readiness standards. Twenty-three additional states are planning to put such assessments in place in the next several years.
- Before 2006, only three states had P-20 longitudinal data systems and regularly matched student-level K-12 and postsecondary data to measure progress and improve the transition from high school into college or the workplace. Now, 12 states have P-20 data systems, and all but one state are working to put such a system in place.

- School accountability systems in most states are currently not anchored in the goal of graduating all students college- and career-ready. In most cases, the expectations for schools are much lower. States are beginning to develop more ambitious goals and broaden the indicators used to report on school progress and hold schools accountable for improvement.

Amrein, Audrey L. and David C. Berliner. *Analysis of Some Unintended and Negative Consequences of High Stakes Testing*. Education Policy Studies Laboratory, Dec 2002.

An analysis of the impact of state testing on student performance.

Darling-Hammond, Linda, Jacqueline Ancess, and Beverly Falk. *Authentic Assessment in Action*. New York: Teacher's College Press, 1955.

This text examines, through case studies of elementary and secondary school classrooms, how five schools have developed "authentic", performance-based assessments of students' learning and how this work has interacted with and influenced the experiences students encounter.

Darling-Hammond, Linda and Raymond Pecheone. "Reforming Accountability: Using Performance Assessments to Focus Learning on Higher Order Skills." In *Meaningful Measurement: The Role of Assessments in Improving High School Education in the 21st Century,* edited by Lindsay Pinkus. Washington, D.C.: Alliance for Excellent Education, 2009.

A study of state assessments and methods of accountability.

Gleason, Barbara, Kristen Lockhart and Gene Carter. *Raising the Ante for Students, Teachers, and Schools*. ASCD InfoBrief, ASCD, November 2000, No. 23.

A discussion of raising standards for students, teachers and schools.

National Association of State Boards of Education. *Reform at a Crossroads: A Call for Balanced Assessment and Accountability Systems*. NASBE Study Group on Assessment Systems for the 21st Century Learner, 1 – 29. October 2009.

A presentation of the findings of the year-long study group on trends in state assessment and accountability.

Public Schools of North Carolina. *North Carolina Graduation Requirements*. 2010. www.ncpublicschools.org/gradrequirements/.

Discussion of the North Carolina’s involvement in the national Diploma Project.

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Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
We believe that it is important to begin with the conceptual framework of the general purposes of assessment. The three broad purposes of assessment are: 1. to assist learning, 2. to measure individual achievement, and 3. to evaluate programs. The purpose of an assessment determines priorities, and the context of use imposes constraints on the design. Thus it is essential to recognize that one type of assessment does not fit all.	Pellegrino, 2003	The bottom line is that formative and summative assessments have very different purposes and serve different needs for both the teacher and the learner. While this fact may be widely accepted, it is in fact not widely practiced. Most assessments that are currently used are "summative."
"Summative" assessments are designed to be administered at the end of the time period assigned to a set of long-term learning objectives. These assessments describe the extent of student learning (content and/or skills) relative to content standards.	Heritage, 2008 The National Association of State Boards of Education, 2009	MCPS includes summative assessments as part of the curricular units to determine mastery of learning objective for the individual unit. There are also course exams in some courses.
"Formative" assessments are central to the learning process, giving the teacher a vehicle for determining how the student is progressing toward the learning objective and informing adjustment to the instruction while giving the learner feedback that re-enforces progress, allows for correction of misconceptions and	Wiggins, 2004 The National Association of State Boards of Education, 2009 Heritage, 2008	There is an assumption in MCPS that teachers are using formative assessments, primarily teacher-made, to provide timely feedback to students and adjust instruction. There are three essential elements of formative assessments:

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
facilitates self-directed learning to the targets.		1. eliciting evidence about learning to close the gap between current and desired performance; 2. providing feedback to students; and involving students in the assessment and learning process. Learning progressions are foundational to these elements (Heritage, 2008)
There are five attributes that make formative assessment most effective: • *Learning Progressions*—(clearly articulate the sub-goals of the learning goal). • *Learning Goals and Criteria for Success*—(Identified and communicated to students.) • *Descriptive Feedback*—(Students given evidence-based feedback linked to the intended instructional outcomes and criteria for success. • *Self- and Peer-Assessment*—(Providing students an opportunity to think meta-cognitively about their learning.) • *Collaboration*—A classroom culture in which teachers and students are partners in learning should be established. An effective information system "designed to	Wylie, 2008 Wiggins, 2004	The nature of effective formative assessment practices is very complex. It is important to determine if those practices are being implemented successfully in instruction, in math and all subjects. Currently, do teachers have an adequate understanding of both the role of formative assessments and how to execute them? Is professional development needed in this area. The MCPS Teacher Professional Growth System requires the use of formative assessments in standard 4, "**Teachers continually assess student progress, analyze the results, and adapt instruction to improve student achievement."** Performance evaluations should reflect the use and effectiveness of the

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
give maximum support to performance" should: 1. Identify the expected accomplishments. 2. State the requirements of each accomplishment. If there is any doubt that people understand the reason why an accomplishment and its requirements are important, explain this. 3. Describe how performance will be measured and why. 4. Set exemplary standards, preferably in measurement terms. 5. Identify exemplary performers and any available resources that people can use to become exemplary performers. 6. Provide frequent and unequivocal feedback about how well each person is performing. This confirmation should be expressed as a comparison with an exemplary standard. Consequences of good and poor performance should also be made clear. 7. Supply as much backup information as needed to help people troubleshoot their own performance. 8. Relate various aspects of poor performance to specific remedial actions. The role and purpose of formative		assessment program used by a teacher. Relative to students and parents, we question whether the focus on "grades" as an end in and of themselves is in conflict with an understanding and use of formative assessments. We would posit that the current culture is one in which students see—and or value--"grades" as their only real feedback on performance. This would appear to be true given the desire to have grades posted frequently within the time period allotted to a long-term learning objective. "Grades" in and of themselves do not provide meaningful feedback; while grading the assessments, the teacher may gain information about particular issues the student or students are having in the learning progression, there is no substantive information in the grade itself.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
assessments is more complex than a snapshot of skills at the moment. Assessments that are a part of classroom instruction should make students' thinking visible to the teacher and the student so that the best instructional strategies can be selected for future learning. One of the most important roles for assessment is to provide timely and informative feedback to students during instruction and learning so that their practice and learning of a skill will be effective and efficient.	Pellegrino, 2003	
Assessment is an ongoing process that guides instruction and monitors student progress to include mastery of mathematics content and higher level thinking skills. Pre-assessment, formative, and summative assessments provide for student, peer, and teacher evaluation. These types of assessment enable teachers to modify their instruction to support improved learning at each grade level for all students. Assessment should be focused on the development and achievement of mathematical proficiency.	Office of Instruction and Program Development, 2001	We reviewed Grade 4 Unit 2 assessment, several fifth grade math lesson plans, grade 5 pre-assessment guidelines from the 2003 curriculum guide, April 2006 Formative Assessment Memos and the current formative assessment schedule for math 6, 7, Algebra prep and Algebra 1. Observations from this review: 1. There seems to be an emphasis on summative testing, which is probably the genesis of the cry of "too much testing." 2. Formative assessments are defined in some documents, but their purpose and use may not be clear in the curricular documents. It is not clear that these

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Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
		measures can be simple and should be constant 3. The "Formative assessment Schedule" seems to meet the need to provide grades, not necessarily meaningful feedback; grades appear to be the sole feedback that students get. 4. Since grades are the primary source of feedback, the culture is one in which Edline reporting becomes the only thing that matters for students, teachers and parents. 5. There are opportunities for the kinds of formative assessments that are recommended in the literature (during the focus lesson and the independent practice). 6. The indicators are the steps in the "learning progression" toward mastery of the "enduring understandings" or long-term learning objective.
The MCPS instructional program includes the elements of the "learning progression" and the "system to give maximum support to performance." However elements that could be improved are "descriptive feedback, self- and peer-assessment and a culture of collaboration in the learning environment."	Wiggins, 2004	If teachers use these concepts, instruction will be more effective. The current curriculum describes how performance will be measured, and the following concepts must be explicit in that curriculum. 1. Set exemplary standards, preferably in

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 3:** What are best practices in using formative and summative data to inform instruction? **Research Question 4:** What is the relationship between summative and formative assessment that best supports instruction and student learning?		
Key Findings	**Citation**	**Response to Key Findings**
		measurement terms. 2. Identify exemplary performers and any available resources that people can use to become exemplary performers. 3. Provide frequent and unequivocal feedback about how well each person is performing. This confirmation should be expressed as a comparison with an exemplary standard. Consequences of good and poor performance should also be made clear. 4. Supply as much backup information as needed to help people troubleshoot their own performance. 5. Relate various aspects of poor performance to specific remedial actions.

Curriculum: Assessed Curriculum Research Questions 3 and 4–Sources Cited:

Heritage, M. "Learning Progressions: Supporting Instruction and Formative Assessment." *National Center for Research on Evaluation, Standards, and Student Testing (CRESST)* (Graduate School of Education and Information Studies, University of California, Los Angeles), 2008.

This article describes the nature and importance of clearly articulated “learning progressions” as a core element of effective formative assessment practices. The article defines learning progressions, and discusses their foundational role in formative assessment practices. It then provides several examples of learning progressions and discusses key principles in constructing a learning progression.

National Association of State Boards of Education. *Reform at a Crossroads: A Call for Balanced Assessment and Accountability Systems*. NASBE Study Group on Assessment Systems for the 21st Century Learner, 1 – 29. October 2009.

Presents the findings and recommendations of NASBE's 2009 Study Group on Assessment Systems for the 21st Century Learner which examined the need for rethinking assessments to create a new paradigm for measuring the skills and knowledge graduates need to succeed. The study group determined that not only have advances in technology, assessment design, and research on learning made these changes feasible, but they are absolutely necessary to truly prepare students for the challenges of school and beyond. Ultimately, the paradigm needs to shift to include a system of formative assessments that dictates that information gained from testing should ultimately help improve learning. The study group's recommendations for state boards include:

- Systems must be designed to include assessments of learning and assessments for learning.
- States should collect qualitative and quantitative measures, including student growth over time across the entire achievement continuum, as well as other indicators of school progress.
- States must establish consistent teacher development standards that position assessment literacy as a major component for teacher licensure, accreditation for preparation programs, and teacher evaluations.

Office of Instruction and Program Development. *Curriculum Framework for Prekindergarten Through Grade 3*. Mathematics Curriculum Framework:3. 2001.

This document provides the goals, enduring understandings, overview of mathematical content, and the instructional approach for the mathematics curriculum framework that was being developed in MCPS in 2001. The content was developed by the mathematics instructional team and reviewed and approved by the MCPS BOE.

The following quote is taken from the MCPS Mathematical Curriculum Framework, page 3; "Assessment is an ongoing process that guides instruction and monitors student progress to include mastery of mathematics content and higher level thinking skills. Pre-assessment, formative, and summative assessments provide for student, peer, and teacher evaluation. These types of assessment enable teachers to modify their instruction to support improved learning at each grade level for all students. Assessment should be focused on the development and achievement of mathematical proficiency."

Pellegrino, J.W., Chudowsky, and Glaser. *Knowing What Students Know, The Science and Design of Educational Assessment*. Washington, D.C.: Center for Education, Division of Behavioral and Social Sciences and Education, National Research Council, National Academy Press, 2003.

Explains how expanding knowledge in the scientific fields of human learning and educational measurement can form the foundations of an improved approach to assessment. These advances suggest ways that the targets of assessment-what students know and how well they

know it-as well as the methods used to make inferences about student learning can be made more valid and instructionally useful. Principles for designing and using these new kinds of assessments are presented, and examples are used to illustrate the principles. Implications for policy, practice, and research are also explored.

Wiggins, G. *Assessment as Feedback, New Horizons for Learning*. 2004. http://www.newhorizons.org.

This article makes the case for the role of clear and specific feedback as a key component of effective assessment practices. The author describes the difference between feedback and evaluation and discusses reasons why such feedback is often lacking in instruction.

Wylie, E. C. *Formative Assessment: Examples of Practice, Formative Assessment for Teachers and Students (FAST)*. State Collaborative on Assessment and Student Standards (SCASS) of the Council of Chief State School Officers, 2008.

Provides a series of short vignettes that clarify a definition of formative assessment and provide examples of various aspects of formative assessment in practice across different subject areas and grade bands. Each vignette is annotated to describe the formative assessment practices that are highlighted in the vignette.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 5:** What is it about SAT at 1650 and ACT at 24 that make them predictive of college readiness?		
Key Findings	**Citation**	**Response to Key Findings**
SAT scores 'confirm a lot of what is important in high school reform' – the importance of rigorous coursework and high expectations.	Gewertz, September 2009	Access to more rigorous academic preparation linked to college readiness. SAT scores linked to college readiness. College readiness therefore linked to access to rigorous academic preparation.
College-readiness levels have remained within two-tenths of a percentage point of where they've been since 2005.	Gewertz, August 2009	MCPS regularly outperforms the nation and as recent 7 Keys supporting data suggests, more of our students are leaving high school college ready than in most parts of the country. This affirms the attention our system has been placing on increasing access to advanced courses and increasing the level of rigorous instruction in all classrooms.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 5:** What is it about SAT at 1650 and ACT at 24 that make them predictive of college readiness?		
Key Findings	**Citation**	**Response to Key Findings**
MCPS student 2009 ACT scores were between 1.1 and 1.6 points higher than the state of Maryland averages.	Scott, 2009	If nothing else, there are serious financial implications to this data. Lack of "college readiness" often requires students to take non-credit bearing courses before they can enroll in credit bearing courses. MCPS graduates are less likely to have to incur this expense of remediation.
AP and IB exam participation and performance are highly correlated with SAT and ACT performance and students who take these exams are more likely to perform well in college and the workplace than students who have not taken these rigorous exams.	Von Secker, 2009	This report suggests a correlation between an SAT combined scores of 1650 or higher or ACT composite scores of 24 or higher and performance on AP/IP (college level) courses.
Only the ACT reports College Readiness Benchmark Scores which indicate the chance of obtaining a C or higher in corresponding credit-bearing college courses	ACT, 2009	A score of 24 on the ACT is a legitimate benchmark to suggest the likely college readiness of an MCPS graduate. The benchmark score for Algebra is 22.
The best combination of predictors of first-year grade point average is high school grade point average and SAT scores.	Korbin, 2008	SAT scores make a substantial contribution to the prediction of first-year grade point average. Admission scores such as the SAT in combination with a measure of high school grades produces higher validity coefficients than using either measure alone. The highest level of correlation and therefore the greatest predictability comes from a combination of high school grade point averages, and all three individual scores on the SAT.
The SAT and other variables based on high school performance did predict college grades	Rock, 1995	May need to consider an 8th key – GPA

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 5:** What is it about SAT at 1650 and ACT at 24 that make them predictive of college readiness?		
Key Findings	**Citation**	**Response to Key Findings**
in different fields.		
At the highest levels of success in college (first year GPA greater than or equal to 3.5), the SAT was an equally effective or a slightly better predictor of college success than high school grade point average. For the least selective colleges, high school GPA was a slightly better predictor at the 3.5 level	Korbin, 2006	Continues the theme that both HS GPA and SAT should be used in predicting college readiness.
A 1650 on the SAT corresponds to a 550 on the math section. Montgomery College requires students to earn a 550 or higher to enroll in MA110, Survey of College Math, to MA160, Elementary Applied Calculus I; and a 600 or higher to enroll in MA 180, Pre-Calculus.	Montgomery College, 2009	Our 7th Key benchmark, 1650 on the SAT, is aligned with entering Montgomery College college-level math courses. Students who earn these scores are less likely to require remediation when they enter college.

Curriculum: Assessed Curriculum Research Question 5–Sources Cited:

ACT. *ACT Profile Report – National: Graduating Class 2009*. ACT, 2009.

This report provides information about the performance of 2009 graduating seniors who took the ACT as sophomores, juniors, or seniors; and self-reported at the time of testing that they were scheduled to graduate in 2009. The report focuses on: performance, access, course selection, course rigor, college readiness, awareness, and articulation.

Gewertz, Catherine. "2009 SAT Scores Declined or Stagnated, College Board Reports." *Education Week*, September 1, 2009.

In this article, the author discusses declining mean SAT scores since their peak at 2005. There is a focus on the persistent gaps in performance across racial and ethnic subgroups as well across socioeconomic lines.

Gewertz, Catherine. "Scores on ACT Show Majority of Students Not College-Ready: Fewer than 25 Percent Do Well Across All Subjects." *Education Week*, August 25, 2009.

In this article, the author discusses the relatively small increase in performance of students on the ACT.

Korbin, Jennifer and Rochelle S. Michel. *The SAT as a Predictor of Different Levels of College Performance*. College Board, 2006.

This study employed logistic regression to predict the probability that a student would be successful in achieving a FGPA at various levels, based on that student's SAT scores and high school grade point average.

Korbin, Jennifer L, Brian F. Patterson, Emily J. Shaw, Krista D. Mattern, and Sandra M. Barbuti. *Validity of the SAT for Predicting First-Year College Grade Point Average*. College Board, 2008.

This report presents the results of a large-scale national validity study of the SAT. In March, 2005, the College Board introduced a revised SAT, with an additional section in writing and minor changes in content to the verbal and mathematics sections. The results show that the best combination of predictors of first-year grade point average is high school grade point average and SAT scores.

Montgomery College. *Assessment and Placement: Who Must Take Assessment Testing*. 2009. http://www.montgomerycollege.edu/Departments/AssessCtr/assessment-testing.html.

This page on the Montgomery College website provides information on SAT and ACT scores that are required for a matriculating student to be exempt from additional assessment testing to determine the need for remediation.

Rock, Donald A., Nancy W. Burton, and Lawrence J. Stricker. *Feasibility of Using the SAT in Academic Guidance*. College Board, 1995.

This study appraised the validity of SAT scores, grades in high school courses, and the number and difficulty level of these courses for predicting college grades in various fields of study. The objective of the study was to provide SAT takers with predictions of their academic performance in different academic fields for guidance purposes. The possible impact of this feedback on the flow of students into specific major fields was also assessed. Data on an entering class at a large state university provided the basis for this study. It was found that the SAT and other variables based on high school performance predicted college grades in different fields of study by taking into account marked variations in grade distributions among the fields. These predictions of letter grades could be potentially useful to students in making decisions about college courses and majors.

Scott, Stacey L. *ACT Performance and Participation for MCPS Students Show Increases Over Five Years*. MCPS Memorandum, August 20, 2009.

Memorandum to MCPS High School Principals that draws their attention to a report outlining student achievement on the ACT assessment of college readiness by the Class of 2009 in Montgomery County Public Schools. This report shows a steady increase in participation among MCPS students and a steady increase in performance.

Von Secker, Clare. *Closing the Gap: Seven Keys to College Readiness for Students of all Races/Ethnicities*. Accountability Update. Office of Shared Accountability, Montgomery County Public Schools: February, 2009.

This document provides information that can be used to understand the MCPS "Seven Keys to College Readiness" and describes what the system is doing to monitor college and work readiness of its students.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 6:** What is assessed on national and international mathematics assessments such as NAEP, TIMSS and PISA? What data are available on Maryland and/or U.S. student performance?		
Key Findings	**Citation**	**Response to Key Findings**
There are similarities and differences in the administration, content, and format of NAEP, TIMSS, and PISA. The comparison chart attached (see Attachment 1) displays information related to: • How long the assessments have been in use • Length of each assessment administration • Framework for assessment • Content strand/content domain assessed • Cognitive domain assessed • Question types – assessment format • Calculator use during assessment • Use of manipulatives/math tools during assessment	Neidorf, 2006 Gonzales, 2004 Baldi, 2006 Gonzales, 2009 U.S. Department of Education, 2009	MCPS curriculum appears to be aligned with NAEP and TIMSS in what is taught and assessed. Work on national standards could consider the value in and resources needed to assess competency clusters or situational applications of mathematics. • NAEP has been developed within the context of the United States, while TIMSS and PISA reflect a global perspective on the importance of math topics and skills. • PISA is an 'exit exam' given when students complete compulsory education in most countries. NAEP and TIMSS assess students at grades 4 and 8. • NAEP and TIMSS appear to be similar in

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 6:** What is assessed on national and international mathematics assessments such as NAEP, TIMSS and PISA? What data are available on Maryland and/or U.S. student performance?		
Key Findings	**Citation**	**Response to Key Findings**
		the content strands (number sense, measurement, geometry, data, algebra). PISA appears to focus more on mathematical thinking, relationships between concepts. • NAEP and TIMSS appear to focus on mathematical abilities – facts, procedural knowledge, reasoning, problem-solving, communication. PISA uses competency clusters and situational application of mathematics.
The achievement gap between students from rich and poor families is much more pronounced in the United States than in other high-performing nations around the world. Studies measuring the impact of family background on international assessments found that the US ranks in the top quarter of the most unequal countries based on the performance gaps for students from different family backgrounds. Other countries such as Japan, Korea, Finland and Canada do a much better job of leveling the educational opportunities for students from lower-income families."	National Association of State Boards of Education, 2009	This is aligned with MCPS mathematics data on students receiving Free and Reduced-price Meals System services. (Montgomery, 2009) MSA Elementary Math Proficiency: • 91.0% for all • 81.6% for students receiving FARMS services (FARMS students) MSA Middle School Math Proficiency • 78.2% for all • 57.9% for FARMS students Algebra HSA Proficiency • 92.0% for all • 81.6% for FARMS students Successful Completion of Advanced Math in Grade 5 • 48.8% for all • 24.0% for FARMS students

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 6:** What is assessed on national and international mathematics assessments such as NAEP, TIMSS and PISA? What data are available on Maryland and/or U.S. student performance?		
Key Findings	**Citation**	**Response to Key Findings**
		Successful Completion of Algebra by Grade 8 • 65.5% for all • 41.6% for FARMS students
Nationally, only 55 percent of black students and 58 percent of Hispanic students graduate on time with a regular diploma.	National Association of State Boards of Education, 2009	MCPS graduation rate in 2009 was 87.4% for all students; 81.6% for African American students and 77.2% for Hispanic students. While this exceeds national data there is a gap with a 93.2% graduation rate for White students and 95.3% rate for Asian American students. MCPS (2009)
"Study Group Recommendations: States should participate in national and state-level international assessments such as NAEP, PISA and TIMSS in order to examine student attainment in an international context and thereby ensure that students are receiving an education that prepares them for the 21st century global economy."	National Association of State Boards of Education, 2009	NAEP (see Attachment 2) • Maryland (and MCPS) participates in NAEP. • In 2009 Grade 4 students in Maryland scored 244, 5 points above the national average of 239. • In grade 8, student in Maryland scored 288, 6 points above the national average of 282. • NAEP scores in Maryland have risen faster than in the nation since 2000 (22 points at grade 4 compared to 15 in the nation; 16 points at grade 8 compared to 10 for the nation). TIMSS (see Attachment 3a and 3b) • At Grade 4 students in the United States scored 518 in 2003 and 529 in 2007 as compared to Singapore's highest score of

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 6:** What is assessed on national and international mathematics assessments such as NAEP, TIMSS and PISA? What data are available on Maryland and/or U.S. student performance?		
Key Findings	**Citation**	**Response to Key Findings**
		594 in 2003 and Hong Kong's highest score of 607 in 2007. • At Grade 8 students in the United States scored 504 in 2002 and 508 in 2007 as compared to Singapore's highest score of 605 and Chinese Taipei's highest score of 598 in 2007. PISA (see Attachment 4) • United States' 15-year-old students scored 483 in 2003 as compared to Finland's highest score of 544. • In 2006 United States' 15-year-old students scored 474 as compared to Finland's highest score of 548.

Curriculum: Assessed Curriculum Research Question 6–Sources Cited:

Anderson, Nick. "Fourth-Graders' Math Scores Stall After Two-Decade Climb." *The Washington Post*, October 14, 2009.

The author of this article discussed the newly released results of the National Assessment of Educational Progress assessment for mathematics for fourth and eighth grade students. Maryland was one of the few states to show a gain in fourth-grade math while showing no significant changes in eighth-grade scores.

Gonzales, Patrick, Juan Carlos Guzman, Lisette Partelow, Erin Pahlke, Leslie Jocelyn, David Kastberg, and Trevor Williams. *Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003*. Publication Number NCES 2005005, National Center for Educational Statistics, 2004.

The Trends in International Mathematics and Science Study has been used since 1995 to measure mathematics and science knowledge and skills in fourth and eighth graders. In this document the authors summarize and highlight the initial findings on the performance of U.S. students relative to their peers in other countries on the TIMSS assessment.

Gonzales, Patrick, Trevor Williams, Leslie Jocelyn, Stephen Roey, David Kastberg, and Summer Brenwald. *Highlights from TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in International Context*. Publication Number: NCES 2009001, Washington, D.C.: Institute of Education Sciences, National Center for Education Statistics, 2009.

The Trends in International Mathematics and Science Study is used to measure mathematics and science knowledge and skills in fourth and eighth graders. In this document the authors compare the performance of U.S. students in mathematics and science achievement with their peers in other countries in 2007. There were thirty-six countries that participated at grade four in 2007 and forty-eight at the eighth grade.

Montgomery, County Public Schools. *MCPS Annual Report*. Rockville, Maryland: Montgomery County Public Schools, 2009.

This document is put out by Montgomery County Public Schools annually to report details on the school system's performance on milestones and data points supporting the strategic plan's goals.

National Association of State Boards of Education. *Reform at a Crossroads: A Call for Balanced Assessment and Accountability Systems*. NASBE Study Group on Assessment Systems for the 21st Century Learner. Draft 2009.

The National Association of State Board of Education has been looking into the need for state education systems to reexamine their standards and assessments that are essential to the success of students in the 21st century. As expectations increase for students, testing experts and analysts believe that education cannot continue in its current accountability format.

Neidorf, Teresa, Marilyn Binkley, Kim Gattis, and David Nohara. *Comparing Mathematics Content in the National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Program for International Student Assessment (PISA) 2003 Assessments*. Publication Number NCES 2006029, National Center for Education Statistics, 2006.

The National Center for Educational Statistics collected information to compare the content of three mathematics assessments conducted in 2003: the NAEP fourth- and eighth-grade assessments; the Trends in International Mathematics and Science Study (TIMSS), which also assessed mathematics at the fourth- and eighth-grade levels; and the Program for International Student Assessment (PISA), which assessed the mathematical literacy of 15-year-old students.

Stéphane, Ying Jin, Melanie Skemer, Patricia J. Green, and Deborah Herget Baldi. Highlights from PISA 2006: *Performance of U.S. 15-Year-Old Students in Science and Mathematics Literacy in an International Context.* Publication Number: NCES 2008016, National Center for Education Statistics, 2006.

The Program for International Student Assessment (PISA) is an international assessment that measures 15-year-olds' capabilities in reading, mathematics, and science every 3 years. During the 2003 assessment mathematics was the focus and this report provides major findings for mathematics literacy and problem solving.

United States Department of Education. *Mathematics Framework for the 2009 National Assessment of Educational Progress*. Washington, D.C.: Institute of Education Sciences, National Center for Education Statistics, 2009.

The National Assessment of Educational Progress (NAEP) is a measure of trends in reading, mathematics, science, writing, U.S. history, civics, geography, and other subjects for U.S. elementary and secondary students. This report looks at the mathematics results reported for student achievement in grades 4, 8, and 12 at the national level and for grades 4 and 8 at the state and for large urban districts that volunteered to participate.

Attachment 1
Comparison of National Assessment of Educational Progress, Trends in International Mathematics and Science Study, and Program for International Student Assessment (as of 2003)

	NAEP	TIMSS	PISA
First assessment given	1969	1995	2000
Grade level/age tested	Grades 4, 8, and 12	Grades 4 and 8 (12^{th} grade last given 1995)	15-year-olds
Assessment length	50 minutes all grade levels	72 minutes for Grade 4 90 minutes for Grade 8	120 minutes
Calculator use	• Specifies calculators are to be provided • 4-function calculators for Grade 4 • Scientific calculators for Grades 8 and 12	• Students can use their own or school's (simple function) calculator during 2^{nd} half of test	• Participating countries are given the discretion to use calculators or not
Content strand/content domain	• Number sense, properties, and operations • Measurement • Geometry and spatial sense • Data analysis, statistics, and probability • Algebra and functions	• Number • Measurement • Geometry • Data • Algebra	• Change and relationships (functional thinking i.e., linear, exponential, periodic, and logistical growth) • Quantity (number sense, meaning of operations, mental arithmetic, and estimation) • Space and shape (recognizing shapes and patterns, understanding dynamic changes to shapes, similarities and differences, and 2- and 3-dimensional representations and relationships between them) • Uncertainty (data collection, analysis, and representation; probability; and inference

Attachment 1
Comparison of National Assessment of Educational Progress, Trends in International Mathematics and Science Study, and Program for International Student Assessment (as of 2003)

	NAEP	TIMSS	PISA
Cognitive domain	Mathematical abilities • Conceptual understanding • Procedural knowledge • Problem solving Mathematical power • Reasoning • Connections • Communication	• Knowing facts and procedures • Using concepts • Solving routine problems • Reasoning • Communicating mathematically (overarching dimension to be demonstrated through description and explanation)	Competency clusters • Reproduction (reproduce routine tasks that are familiar) • Connections (demonstrate problem-solving competencies that are familiar, but not routine) • Reflection (develop solution strategies and apply them to new settings) Situations • Personal (within immediate realm of student's experiences) • Educational/occupational (within student's school or work life) • Public (encounters within community or society) • Scientific (hypothetical scenarios or scientific applications of mathematics)
Question types	• Multiple choice • Short answer • Extended response	• Multiple choice • Written response (two-thirds short answer and one-third more extended answer)	• Equal number of multiple choice, closed constructed response, and open constructed response items • Organized as tasks so students can apply knowledge to authentic (real world) problem solving situations
Manipulatives	• Rulers, protractors, and	• Rulers and geometric shapes	• Items using manipulatives are

Attachment 1
Comparison of National Assessment of Educational Progress, Trends in International Mathematics and Science Study, and Program for International Student Assessment (as of 2003)

	NAEP	TIMSS	PISA
	geometric shapes can be used for some tasks	can be used on some extended problem solving and inquiry tasks	neither specified in the framework nor reflected in the assessment
Framework	• Developed within context of U.S. system • Defines achievement levels (basic, proficient, advanced) intended to provide descriptions of what students should know and be able to do at each grade level	• Reflects a consensus across diverse participating countries about what mathematics topics are appropriate and important to assess at Grades 4 and 8	• Reflects a consensus across Organization for Economic Cooperation and Development (OECD) countries about what knowledge, skills, and abilities reflect mathematical literacy and preparedness for adult life

Attachment 2
Comparing Mathematics Scores from the National Assessment of Educational Progress (NAEP)

	Grade 4		Grade 8	
Year	**National**	**Maryland**	**National**	**Maryland**
2009	239	244	282	288
2007	239	240	280	286
2005	237	238	278	278
2003	234	233	276	278
2000	224	222	272	272

SOURCE: United States Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000, 2003, 2005, 2007, and 2009 Mathematics Assessments.

Attachment 3a
Comparing Mathematics Scores from the Trends in International Mathematics and Science Study (TIMSS) in Grade 4[a]

Grade 4

2003		2007	
Country	**Score**	**Country**	**Score**
Singapore	594	Hong Kong	607
Hong Kong	575	Singapore	599
Japan	565	Chinese Taipei	576
Chinese Taipei	564	Japan	568
Belgium-Flemish	551	Kazakhstan	549
Netherlands	540	Russian Federation	544
Latvia	536	England	541
Lithuania	534	Latvia	537
Russian Federation	532	Netherlands	535
England	531	Lithuania	530
Hungary	529	**United States**	**529**
United States	**518**	Germany	525
Cyprus	510	Denmark	523
Moldova, Republic of	504	Australia	516
Italy	503	Hungary	510
Australia	499	Italy	507
New Zealand	493	Austria	505
Scotland	490	Sweden	503
Slovenia	479	Slovenia	502
Armenia	456	Armenia	500

[a]First twenty countries and their scores as provided by the source identified below.
SOURCE: International Association for the Evaluation of Educational Achievement (IEA), Trends in International Mathematics and Science Study (TIMSS), 2003 and 2007.

Attachment 3b
Comparing Mathematics Scores from the Trends in International Mathematics and Science Study (TIMSS) in Grade 8[a]

Grade 8

2003		2007	
Country	**Score**	**Country**	**Score**
Singapore	605	Chinese Taipei	598
Korea, Republic of	589	Korea, Republic of	597
Hong Kong	586	Singapore	593
Chinese Taipei	585	Hong Kong	572
Japan	570	Japan	570
Belgium-Flemish	537	Hungary	517
Netherlands	536	England	513
Estonia	531	Russian Federation	512
Hungary	529	**United States**	**508**
Malaysia	508	Lithuania	506
Latvia	508	Czech Republic	504
Russian Federation	508	Slovenia	501
Slovak Republic	508	Armenia	499
Australia	505	Australia	496
United States	**504**	Sweden	491
Lithuania	502	Malta	488
Sweden	499	Scotland	487
Scotland	498	Serbia	486
Israel	496	Italy	480
New Zealand	494	Malaysia	474

[a]First twenty countries and their scores as provided by the source identified below.
SOURCE: International Association for the Evaluation of Educational Achievement (IEA), Trends in International Mathematics and Science Study (TIMSS), 2003 and 2007.

Attachment 4
Program for International Student Assessment (PISA) in Mathematics Literacy
15-Year-Old Students

2003		2006	
Country	**Score**	**Country**	**Score**
Finland	544	Finland	548
Korea, Republic of	542	Korea, Republic of	547
Netherlands	538	Netherlands	531
Japan	534	Switzerland	530
Canada	533	Canada	527
Belgium	529	Japan	523
Switzerland	527	New Zealand	522
Australia	524	Belgium	520
New Zealand	524	Australia	520
Czech Republic	517	Denmark	513
Iceland	515	Czech Republic	510
Denmark	514	Iceland	506
France	511	Austria	505
Sweden	509	Germany	504
Austria	506	Sweden	502
Germany	503	Ireland	501
Ireland	503	France	496
Slovak Republic	498	United Kingdom	495
Norway	495	Poland	495
Luxembourg	493	Slovak Republic	492
Hungary	490	Hungary	491
Poland	490	Luxembourg	490
Spain	485	Norway	490
United States	**483**	Spain	480
Italy	466	**United States**	**474**
Portugal	466	Portugal	466
Greece	445	Italy	462
Turkey	423	Greece	459
Mexico	385	Turkey	424
United Kingdom	-	Mexico	406

SOURCE: Organization for Economic Cooperation and Development (OECD), Program for International Student Assessment (PISA), 2003 and 2006.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 7:** What is the balance between assessment and instruction to facilitate learning and increase student achievement?		
Key Findings	**Citation**	**Response to Key Findings**
Traditional beliefs about scientific measurement and standardized testing are in conflict with new theories of curriculum, instruction, learning, and assessment. Teachers can hold beliefs that are more consistent with traditional standardized testing and that they believe that assessment needs to be an official event separate from instruction. High-stakes testing changes the focus of teachers in a way that distracts from core curriculum, high standards, and their knowledge of effective instructional strategies. To make assessment more informative and more tied to learning, we need to create a learning culture where students and teachers have a shared expectation that finding out what makes sense and what doesn't is a joint and worthwhile project essential to taking the next steps in learning.	Shepard, 2000	MCPS currently provides formative and summative assessment within the mathematics curriculum. The stakes are high regarding state testing, and as a result, there is a great focus on improving student achievement on those assessments. Changing the culture, as suggested by the author, while operating under a state mandated focus on standardized testing, is a challenging undertaking. Strategies suggested in the article for teachers that need to be improved include; being able to anticipate conceptual pitfalls, having a repertoire of tasks that will help students gain a deep knowledge of the subject matter, providing effective feedback on student performance, providing clear criteria by which student work will be assessed, providing opportunities for students to analyze their own work.
Research shows that the regular use of formative assessment improves student achievement on standardized tests by 15 to 25 percentile points with the largest gains made by low achievers.	Chappuis, 2009	MCPS currently encourages the use of formative assessment in curricula, through the use of technology, and in the PGS. In addition, programs to improve the capacity of building leaders such as PLCI are being utilized in some schools.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 7:** What is the balance between assessment and instruction to facilitate learning and increase student achievement?		
Key Findings	**Citation**	**Response to Key Findings**
"Assessments will produce no formative benefits if teachers administer them, report the results, and then continue with instruction as previously planned-as can easily happen when teachers are expected to cover a hefty amount of content in a given time." Strategies that improve student learning include developing the student's ability to monitor their own progress, make decisions, and reflect on the learning process.		Additional staff development opportunities for math teachers should include strategies for developing effective formative assessments, using them to plan for instruction, and involving students in the process of assessment. Teachers must have a clear understanding of how to analyze and use formative assessments in planning for daily instruction, and increased opportunities for staff development are needed.
Contemporary assessment is defined as "a move towards an emphasis on formative assessment with the main purposes of advancing students' learning and informing teachers as they make instructional decisions." The ability of teachers to read student's mathematical work and observe and listen to mathematical discourse are portrayed as the ideal methods of assessment in the mathematics classroom, however these practices are complex and challenging when put into practice.	Evan, 2005	MCPS currently encourages the use of mathematical discourse during instruction. County assessments require students to explain and justify solutions to problems. Additional staff development on interpreting student responses during classroom discussions and in written responses is needed. More training is also needed in identifying and addressing common misconceptions on particular concepts presented in the curricula. Suggestions for improving teachers' ability to interpret assessment data include learning about: students' ways of learning mathematics and students' common

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Curriculum: Assessed Curriculum **Research Question 7:** What is the balance between assessment and instruction to facilitate learning and increase student achievement?		
Key Findings	**Citation**	**Response to Key Findings**
		misconceptions; presenting tasks that require students to explain and justify their solutions; and attributing value to students' original solutions and paying attention to their processes of solving problems by transforming their listening mode from evaluative to interpretive.
The use of item analysis in grade level discussions leads to conversations about effective instructional approaches and strategies for re-teaching concepts that have not been mastered by individuals or groups of students. The teachers in the school that was cited in the article realized the need to improve instruction, better understood the content standards and how they were assessed. In addition they learned how to design assessment items that diagnosed student misconceptions, and they began to check for student understanding more frequently.	Fisher, 2007	• MCPS currently encourages schools to use data discussions and common assessments. • Additional staff development opportunities for resource teachers and building administrators should include strategies for leading data discussions, creating a climate where teachers feel comfortable analyzing and discussing their instructional practices, changing the instructional focus from the summative assessment to the use of frequent formative assessment strategies and effective instructional practices.

Curriculum: Assessed Curriculum Research Question 7–Sources Cited:

Chappuis, J., S. Chappuis, and R. Stiggins. "Formative Assessment & Assessment for Learning." In *Meaningful Measurement: The Role of Assessments in Improving in Improving High School Education in the Twenty-First Century*. Washington, D.C.: Alliance for Excellent Education, 2009.

The article describes the characteristics of formative assessment, with a particular focus on those formative assessment practices that engage and empower students in their own learning, or assessments for learning. They also describe challenges related to the effective use of formative assessment and recommended actions for policymakers.

Evan, Ruhama. "Using Assessment to Inform Instructional Decisions: How Hard Can It Be?" *Mathematics Education Research Journal*, 2005: Volume 17, Number 3, 45-61.

In this article, two problems associated with the expectation that teachers use contemporary assessment techniques are examined. The first problem relates to teachers' sense-making of assessment data. Illustrative cases revealed that teachers' processes of interpretation of students' understanding, knowledge and learning of mathematics draws on a rich knowledge base of understandings, beliefs, and attitudes. Consequently, the process of sense-making of students' mathematical understandings involves ambiguity and difficulty. The second problem relates to ways of helping teachers adopt contemporary assessment approaches. A professional development activity served as the example examined. Three aspects of what the course instructor promoted with respect to contemporary assessment were analyzed: (1) the assessment methods and tools advocated in the course, (2) the degree to which the integration of assessment with instruction was promoted, and (3) the purposes for assessment highlighted in the course. It appeared that attention was paid to the use of contemporary assessment tools, but this was associated with traditional assessment purposes. Learning to use the new assessment tool did, however, influence instruction and fostered greater integration of assessment and instruction than before—a characteristic of contemporary assessment. The article concludes with a discussion of the current expectation that teachers use assessment data to improve instruction.

Fisher, Douglas, Donna Kopenski. "Using Item Analyses and Instructional Conversations to Improve Mathematics Achievement." *Teaching Children Mathematics*, 2007: Volume 14, Number 5, 278 – 282.

This article describes the significant gains in student achievement in an urban elementary school when teachers worked together to develop, administer, and review assessment items. In grade-level teams, teachers completed item analyses and engaged in instructional conversations about students' needed instruction.

Shepard, Lorrie A. "The Role of Assessment in a Learning Culture." *Educational Researcher*, 2000: Volume 29, Number 7, pp 4 – 14.

This article presents a historical framework of classroom assessment, highlighting the key tenets of social efficiency curricula, behaviorist learning theories, and scientific measurement. The author offers a contrasting social-constructivist conceptual framework that blends key ideas from cognitive, constructivist, and socio-cultural theories. Elaborates on ways that assessment practices should change to be consistent with and support social constructivist pedagogy.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 1:** What are the benefits and ramifications of accelerating students into above grade-level courses?		
Key Findings	**Citation**	**Response to Key Findings**
Acceleration is beneficial to many students.		
a. The National Mathematics Advisory Panel recommended that, "Mathematically gifted students with sufficient motivation appear to be able to learn mathematics much faster than students proceeding through the curriculum at a normal pace, with no harm to their learning, and should be allowed to do so."	United States Department of Education, 2008	MCPS will need to maintain acceleration options for students demonstrating that they are adequately prepared.
b. Creating a goal, including a back-mapped curriculum, that encourages all students to reach Algebra I by Grade 8 may help deal with issues of flagging math achievement and dropout in high school. -SREB	Collins, 2009	Resetting the trajectory of middle school curriculum for all students to reach Algebra 1 by Grade 8 may be a worthwhile goal and have fewer side effects than simply setting targets in the current structure of courses. However, some researchers suggest that the goal should be successful completion of Algebra 1 – and not specify a particular grade level for this accomplishment.
c. "There is a relationship between the percentages of eighth-graders taking Algebra I and those scoring at the NAEP proficient level- defined as "demonstrated concept"." -SREB		
d. "…state leaders need to ensure that the courses leading to Algebra I – from the early grades through the middle grades- build a foundation step by step and are sufficiently rigorous.: - SREB		It is not clear that students must access Algebra 1 in Grade 8 to garner the benefits of a challenging course or to be well-prepared for college. Students who successfully complete Algebra 1 in Grade 9 can
e. MCPS parents indicate that opportunities for	Montgomery County	

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 1:** What are the benefits and ramifications of accelerating students into above grade-level courses?		
Key Findings	**Citation**	**Response to Key Findings**
acceleration are beneficial and much appreciated, but also express concern about too much focus on acceleration.	Public Schools, Report of Survey/Focus Group Responses	successfully complete Algebra 2 by Grade 11, though the rate of students who accomplish this is low, which suggests that Algebra 1 in Grade 8 is key to continuing student success in high school mathematics. Though this is not a topic directly related to the acceleration sub-group, it is important for consideration in setting system targets.
f. Algebra 1 has been identified as a gateway course to college preparedness and consequently has been seen as a key milestone in closing the achievement gap. Algebra 1 completion has also been held up as competitiveness issue for the United States in the world economy.	Loveless, 2009	
g. MCPS has echoed the concern that all students be provided access to advanced courses. The establishment of benchmarks for math acceleration in the strategic plan is part of system efforts to address equity issues.	Montgomery County Public Schools. "Our Call to Action: Pursuit of Excellence."	
Acceleration is beneficial – for students who are adequately prepared. There are students who are not adequately prepared being placed in advanced courses at the national and local levels.		
a. "The national average in eighth grade math [on NAEP] has been rising steadily, increasing by 8 points from 2000 to 2007, from 237 to 281. But one group stands out for not participating in the score increase – eighth graders in advanced classes. Their NAEP scores have declined from 299 in 2000 to 295 in 2007, a loss of 4 scale points."	Loveless, 2009 (Pages 21-22)	
b. "High achievers – students scoring at the 90th percentile or above [on Grade 8 NAEP] – made up 27.0 percent of the advanced classes in 2000. In 2005, the percentage dropped to 20 percent. Low achievers more than doubled as a proportion of	Loveless, 2009 (Pages 24-25)	

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 1:** What are the benefits and ramifications of accelerating students into above grade-level courses?		
Key Findings	**Citation**	**Response to Key Findings**
advanced classes, increasing from 3.0 percent in 2000 to 7.8 percent in 2005. Although appearing to be trivial, this small percentage adds up to approximately 120,000 students nationwide, a number that is growing and a phenomenon that, until now, has been viewed as an accomplishment, not a cause for worry."		This is the first report to document the failings of the national trend to accelerate students into advanced courses. This effort to accelerate traditionally excluded students, born out of good intentions, appears to be damaging some of the very children it intended to support.
c. "The average NAEP score for eighth graders in advanced math classes is 291. The national average for all eighth graders is 279. On the same NAEP scale the national average for fourth graders is 238. The misplaced eighth graders [defined by the author as the 120,000 students in the 10th percentile] score an average of 211, which is 27 points below the national average for fourth grade."	Loveless, 2009 (Page 25)	
d. MCPS review of acceleration practices (which is detailed in Research Questions 2 and 3) revealed that when the first class with a significant number of students who skipped Math 5 reached Algebra 1 in Grade 8, the number of D's and E's on the final exam doubled.	Montgomery County Public Schools, MCPS Mathematics Acceleration Practices	MCPS has mirrored the national trend of placing too many under-prepared students in advanced courses. This has had negative consequences for the very students it was meant to support.
e. Middle school math resource teachers expressed concern that some students were placed in advanced math courses who were not adequately prepared in order to help their school reach system targets for enrollment – and that some of these students had been skipped over Grade 5 math – in effect creating a double skipping for some students.	Montgomery County Public Schools, Comments on Acceleration by Middle School Math Resource Teachers	
f. MCPS stakeholders' responses to survey and focus groups questions indicate a strong concern about	Montgomery County Public Schools, Report of	

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 1:** What are the benefits and ramifications of accelerating students into above grade-level courses?		
Key Findings	**Citation**	**Response to Key Findings**
the adequacy of preparation for when children are accelerated. "The three most noted themes were that acceleration is moving children too quickly, that there needs to be an increased emphasis on basic concepts, and that the placement process needs to be improved."	Survey/Focus Group Responses	
The impact of accelerating beyond Algebra 1 is unclear. There is little research on the impact of acceleration beyond Algebra 1 in Grade 8, such as Honors Geometry and Algebra 2. However, the large numbers of students now enrolling in these courses likely face the same perils as their Algebra 1 peers if they are not adequately prepared, especially if they demonstrated a weak mastery of Algebra 1. The Middle School Math Resource Teachers recommended that it should be a requirement that any Grade 6 or Grade 7 student enrolled in Algebra 1 should be required to take Investigations in Mathematics as a prerequisite.	Montgomery County Public Schools, Comments on Acceleration by Middle School Math Resource Teachers	Further study is required of how students who complete Algebra 2 early (in Grade 8 or 9) fare in preparedness for competitive colleges. The University System of Maryland is changing its math admissions requirements to include a "substantial" math course in senior year Investigations in Mathematics is designed as a course that will deepen student understanding of the conceptual basis of mathematics before Algebra and build a strong foundation for later study of Calculus. Clarifying and narrowing pathways to Algebra 1 and beyond in middle school is recommended.

Acceleration Practices: Mathematics Targets and Acceleration Research Question 1–Sources Cited:

Collins, Marilyn and Crystal Thomas. "Keeping Middle Grade Students on the Path to Success in High School: Increasing Engagement and Achievement in SREB States." *Change to Lead Series*, 2009.

This report documents the stall of progress in middle grades reading and math achievement. It analyzes results on state assessments and the National Assessment of Education Progress (NAEP) and indicates steps that will help states regain progress in achievement. It also

lays out five specific strategies states can use to keep middle grades students on the path to success: (1) Implement the recommendations of the SREB Committee to Improve Reading and Writing in Middle and High Schools; (2) Provide an accelerated curriculum to all students not achieving on grade level as they enter the middle grades; (3) Restructure the middle grades math curriculum to help students prepare for Algebra I by eighth grade; (4) Improve professional development and the regulations for certification (and re-certification) of middle grades teachers--as well as teacher preparation--to ensure that more middle grades teachers are qualified to teach their assigned subjects; and (5) Build on adolescents' aspirations for college and careers to engage them in educational and career planning. Four appendices are included: (1) Percent of Eighth-Graders Scoring At or Above NAEP Basic and Proficient Levels in Math and Percent Enrolled in Pre-Algebra, Algebra I or Higher; (2) Recommended Major Topics of School Algebra; (3) Benchmarks for the Critical Foundations of Algebra: Guideposts for State Frameworks and School Districts; and (4) Percent of Public School Teachers Assigned to Teach Math Classes Who Hold Credentials Math: Grades 7-12, 2004. (Contains 2 footnotes, 2 figures and 9 tables.)

Loveless, Tom. "Part II: The Misplaced Math Student." *The 2008 Brown Center Report on American Education: How Well Are American Students Learning?*, January 2009.

The author describes the impact of the national trend of placing more students in Algebra 1 by Grade 8. Original analyses include a comparison of state Grade 8 NAEP results to the percent of state student body enrolled in advanced courses, a statistical description of the students taking advanced courses in Grade 8, and characteristics of the lowest performing students (as measured by NAEP) enrolled in advanced courses. The author concludes that the moral imperative to enroll students in Algebra 1 has been fraught with consequences for the least prepared students as well as their well-prepared peers.

Montgomery County Public Schools. "Policy IOA, Gifted and Talented Education." *Board of Education Policies*, 2009.

This policy proscribes that “accelerated and enriched curricula will be provided to all students who have the capability or motivation to accept the challenge of such a program.” In addition to acceleration it is expected that there will be a balance of opportunities for enrichment, to learn in depth.

Montgomery County Public Schools. "Comments on Acceleration by Middle School Math Resource Teachers ." *A Discussion with the Acceleration Subgroup of the Math Workgroup*. Unpublished.

Members of the acceleration subgroup of the Math Workgroup interviewed middle school resource teachers regarding their experiences with acceleration practices and their impact.

Montgomery County Public Schools. "Report of Survey/Focus Group Responses." K-12 Mathematics Work Group, 2009.

A wide variety of stakeholders expressed comments on the five sub-group areas of the Math Workgroup. Comments on acceleration ranged from appreciation of the opportunities MCPS affords by accelerating to concerns about too much acceleration.

Montgomery County Public Schools. "MCPS Mathematics Acceleration Practices." 2009.

This information is a result of the work of the Advanced Math in Grade 5 M-Stat team during the 2008–2009 school year that looked at the preparedness of students for Advanced Math in Grade 5 and the pathways students took from Grade 5 to Algebra.

Montgomery County Public Schools. *Our Call to Action: Pursuit of Excellence, The Strategic Plan.* 2009.

The strategic plan for Montgomery County Public Schools, including system milestones, data points, targets, and a description of major system initiatives. This plan, originated in 1999, set direction for system reform efforts, including opening access for, and improving achievement of students in advanced mathematics courses.

United States Department of Education. "Foundations for Success: The Final Report of the National Mathematics Advisory Panel." Washington, D.C., 2008.

This far-reaching report established by Presidential order researched major topics in mathematics education and based findings on scientific, peer-reviewed studies. Specific topics related to math acceleration included research on foundational skills for Algebra 1 and teaching mathematically gifted students.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 2:** How do students who are accelerated quickly through the mathematics sequence compare on final measures to students who follow the built-in acceleration available at each grade level? For example how do students taking Grade 6 math in Grade 5 compare to students taking Grade 5 (with built in acceleration) in terms of preparedness for Algebra 1 in Grade 8?		
Key Findings	**Citation**	**Response to Key Findings**
Students in accelerated math in Grade 5 are more likely to take accelerated math courses in middle school. "Students who successfully complete Math 6 in Grade	Von Secker, Clare	

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Acceleration Practices: Mathematics Targets and Acceleration **Research Question 2:** How do students who are accelerated quickly through the mathematics sequence compare on final measures to students who follow the built-in acceleration available at each grade level? For example how do students taking Grade 6 math in Grade 5 compare to students taking Grade 5 (with built in acceleration) in terms of preparedness for Algebra 1 in Grade 8?		
Key Findings	**Citation**	**Response to Key Findings**
5 are more likely to continue to take accelerated mathematics courses upon entry to middle school (Figure 7). Among a cohort of MCPS students who were enrolled in Grade 6 in 2006 and Grade 8 in 2008, 80% who completed Math 6 prior to Grade 6 also completed Algebra 1 or higher. In contrast, 29% of Grade 8 students who did not successfully complete Math 6 prior to Grade 6 successfully completed Algebra 1."		
Some students may have been placed in advanced math courses who were not adequately prepared. Middle school math resource teachers commented that they have moved many more students into advanced course and were proud of their success. A few resource teachers reported that they felt that in an effort to reach system targets some students were placed in courses for which they were not adequately prepared. They also noted that some students were skipped in elementary school and again in middle school, exacerbating preparedness issues.	Montgomery County Public Schools, Comments on Acceleration by Middle School Math Resource Teachers	The definition of "adequately prepared" varies from teacher to teacher and school to school. Keeping children out of a class because they do not complete their homework is different than keeping a child out who has not demonstrated mastery of necessary content. It is important for MCPS to establish criteria and implement a system for course placement decisions that standardizes definitions and practices.
Students who were not adequately prepared but were skipped ahead did not perform as well as their peers who were adequately prepared. • "African American, Hispanic, FARMS, special education, and ESOL students had lower participation and successful completion rates in	Montgomery County Public Schools (2009) MCPS Mathematics Acceleration Practices	

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 2:** How do students who are accelerated quickly through the mathematics sequence compare on final measures to students who follow the built-in acceleration available at each grade level? For example how do students taking Grade 6 math in Grade 5 compare to students taking Grade 5 (with built in acceleration) in terms of preparedness for Algebra 1 in Grade 8?		
Key Findings	**Citation**	**Response to Key Findings**
Math 6 or higher, and were more likely to be accelerated into Math 6 without demonstrating proficiency in Math 5 content. • Students who missed Math 5 and did not meet Math 4 above-grade proficiency were less likely to succeed in Math 6. • Students who were prepared for Math 6 in Grade 5 by attaining proficiency in Math 4 with acceleration tended to be successful in Math 7. • Similar patterns are observed for Algebra 1 students in Grade 8. • When the first class of Grade 5 students who had been skipped rather than accelerated within their grade-level course reached Algebra in Grade 8, the number of D's and E's on the Algebra final exam doubled."		

Acceleration Practices: Mathematics Targets and Acceleration Research Question 2–Sources Cited:

Von Secker, Clare. *Closing the Gap: Seven Keys to College Readiness for Students of all Races/Ethnicities*. Accountability Update. Office of Shared Accountability, Montgomery County Public Schools: February, 2009.

The MCPS college-readiness trajectory identifies seven keys to attainment of the knowledge and skills needed for college and career readiness. MCPS developed the college-readiness trajectory by looking backwards from the goal of college and career readiness and linking successful attainment of one key with the likelihood of successful attainment of a subsequent key.

Montgomery County Public Schools. "Comments on Acceleration by Middle School Math Resource Teachers." *A Discussion with the Acceleration Subgroup of the Math Workgroup*. Unpublished.

Members of the acceleration subgroup of the Math Workgroup interviewed middle school resource teachers regarding their experiences with acceleration practices and their impact.

Montgomery County Public Schools. "MCPS Mathematics Acceleration Practices." 2009.

This document is a result of the work of the Advanced Math in Grade 5 M-Stat team during the 2008–2009 school year that looked at the preparedness of students for Advanced Math in Grade 5, and the pathways students took from Grade 5 to Algebra.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
A strong arithmetic foundation is essential for success in algebra		
a. Current body of research related to development of algebraic reasoning at the elementary school level emphasizes that arithmetic can be conceptualized in algebraic ways and that building an understanding of algebra begins within the learning of arithmetic. This emphasis can be capitalized on to encourage young students to make algebraic generalizations without necessarily using algebraic notations.	Kieran, 2007	• The math curriculum should provide students with a strong arithmetic foundation for success in algebra. This should not be confused with computational fluency. The foundation should include, but not be limited to, number operations, numeric equalities, change and pattern, and relationships between quantities.
b. Properties of number operations, numeric equalities, change and pattern, and relationships between quantities, although not introducing young students to conventional algebraic notation, relies on the use of language and other representations to express algebraic ideas.	Kieran, 2007	

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
Time needs to be taken to develop strong conceptual understanding prior to moving to the symbolic and more abstract levels of mathematics.		
a. Although going back and forth between patterns with geometric shapes and their numerical representation in tables can lead to general insights, too early a focus on the numeric values in tables can inhibit the richness of the process of generalization from the geometric data.	Kieran, 2007	• Students need to spend adequate time working with patterns and shapes and their numeric representations in tables, before moving solely to numeric values.
b. Rushing students to represent patterns with letter symbols can be counterproductive. Research on patterns suggests that it is generally more profitable for young students to remain for long periods of time in exploring aspects of the generality in their patterns than to be exposed too quickly to the symbolic representation of this generality—for these symbolic representations do not get used until much later when students begin work in symbolic manipulation.	Kieran, 2007	
c. The numbers of disjointed protocols a learner must control to form the rational number concept is extensive. Too often an algorithm has simply been taught, providing no connections for understanding, and leaving the student clinging to a prescribed set of steps—with no understanding.	Brown, 2007	• Prior to learning complex algorithms, students must understand the concepts and connections among the concepts involved in the algorithm.
d. Although learning to use algebra makes students powerful problem solver, these important concepts and skills take time to develop. Its development begins early and should be a focus of math instruction from Pre-K through Grade 12.	National Council of Teachers of Mathematics , 2008	• Algebra needs to continue to be a focus of the MCPS Math Curriculum from Pre-K through Grade 12.
e. At elementary level, teachers should help students develop and generalize patterns and solve equations.		

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
f. Secondary school teachers should help students move from verbal descriptions of relationships to proficiency to the language of function and skill in generalizing numerical relationships expressed by symbolic representation. g. Only when students exhibit demonstrable success in prerequisite skills should they focus explicitly and extensively on algebra, whether in a course title Algebra 1 or within an integrated math curriculum. h. Exposing students to such coursework before they are ready often leads to frustration, failure, and negative attitudes toward math and learning. Algebra is an important gateway to expanded opportunities. i. Because of the importance and power of algebra, all students should have the opportunity to learn it. With high-quality teaching and suitable support, all students can be successful in their development and the use of algebra. j. All students should have access to algebra and support for learning it. Algebraic concepts and skills should be a focus across the Pre-K–12 curriculum.	National Council of Teachers of Mathematics , 2008	• MCPS needs to establish consistent processes to determine readiness for advanced courses. These processes should include the finding of the National Math Panel calls **Critical Foundations of Algebra.** • Rather than a grade-level requirement, students need to demonstrate success in foundational skills prior to enrolling in algebra course. • Algebra is an important gateway to expanded opportunities. Because of the importance and power of algebra, ALL students should have the opportunities to learn it.
High achieving countries have similar focus in elementary and middle school a. Results of TIMSS and other international tests showing student achievement across participating counties have led to international comparisons of curricula and provided much information as to what high-achieving countries teach their students in elementary and middle school. b. Based on these considerations, the Panel proposed three	United States Department of Education, 2008 Schmidt, 2001	The MCPS K-8 curriculum should adequately focus students on what the National Math Panel called, Critical Foundations of Algebra. These include:

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
clusters of concepts and skills —called **Critical Foundations of Algebra**—reflecting their judgment about the most essential mathematic for students to learn thoroughly prior to algebra course work. Whether part of a dedicated algebra course in Grade 7, 8, or 9, or within an integrated mathematics sequence in the middle and high school grades, the **Critical Foundations of Algebra** deserve ample time any mathematics curriculum. **(a) Fluency with Whole Numbers.** By the end of Grade 5 or 6, children should have a strong sense of number. Place value; basic operation; commutative, associate, and distribute properties; computational facility; ability to estimate results of computations and orders of magnitude **(b) Fluency with Fractions**. Before they begin algebra coursework, middle school student should have thorough understanding of positive as well as negative fractions; compare fractions, decimals and related percents. The most important foundational skill not presently developed appears to be proficiency with fractions (including decimals, percent, and negative fractions). The teaching of fractions must be acknowledged as critically important and improved before an increase in student achievement in algebra can be expected.	United States Department of Education, 2008 Brown, 2007	• **Fluency with Whole Numbers** including a strong number sense, place value, computational fluency, and the ability to estimate results of computation and orders of magnitude. • **Fluency with Fractions** including a thorough understanding of positive as well as negative fractions; compare fractions, decimals and related percents. • **Particular Aspects of Geometry and Measurement**. Middle grade experience with similar triangles is most directly relevant for the study of Algebra. Students should be able to analyze the properties of two- and three-dimensional shapes using formulas to determine perimeter, area, volume, and surface area. They should also be able to find unknown lengths, angles, and areas. • The teaching of fractions must be acknowledged as critically important and improved before an increase in student achievement in algebra can be expected.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
Only 46% of twelfth grade students demonstrated success with decimals, percents, and fractions as reported by the 1990 National Assessment of Educational Progress (NAEP). Similarly, the 1999 NAEP reports that twelfth grade students reported correctly to test items related to the operations of fraction numbers only fifty percent of the time. Effective methods for teaching understanding of fractional numbers must allow students time to construct their own understanding as teachers direct them toward accurate and meaningful student-invented algorithms. **(c) Particular Aspects of Geometry and Measurement**. Middle grade experience with similar triangles is most directly relevant for the study of Algebra. Students should be able to analyze the properties of two- and three-dimensional shapes using formulas to determine perimeter, area, volume, and surface area. They should also be able to find unknown lengths, angles, and areas.	United States Department of Education, 2008	
Too many students are unprepared for learning basics of algebra a. There are many gaps in the current understanding of how students learn algebra and the preparation that is needed before they enter Algebra. What is known indicates that too many students in middle or high school algebra classes are woefully unprepared for learning even the basics of algebra.	United States Department of Education, 2008	• If considered a gateway course to higher level mathematics and science, MCPS need to better understand how students learn and what preparation they need before they enter Algebra. • MCPS should consider conducting research that would determine the predictors of algebra, including specific mathematical

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Acceleration Practices: Mathematics Targets and Acceleration **Research Question 3:** What are the most essential math curriculum strands or topics to consider in determining whether or not a student is ready for acceleration? Specifically, what data points (qualitative and quantitative) should be considered in determining the most appropriate and challenging math course for a student?		
Key Findings	**Citation**	**Response to Key Findings**
b. Longitudinal research is needed to identify predictors of success or failure in algebra. These predictors may help to guide the design of interventions that will build foundational skills needed for success		concepts and skills.

Acceleration Practices: Mathematics Targets and Acceleration Research Question 3–Sources Cited:

Brown, George and Robert J. Quinn. Fraction proficiency and success in algebra: What does research say? Australian Association of Mathematics Teachers, 2007.

Fractions and algebra are critically important components of the mathematics education of children. Unfortunately, however, students have typically struggled in these areas. For this reason, teachers and researchers have focused their attention on these topics for at least the past century. This article discusses what research shows regarding fractions and algebra, particularly on issues related to when fractions should be taught, how fractions should be taught, and how competence with fractions affects the transition from arithmetic to algebra will be considered. Suggestions for teacher practice are included throughout the article.

Kieran, Carolyn. What do We Know about the Teaching and Learning of Algebra in Elementary Grades? National Council of Teachers of Mathematics, 2007.

This compendium of research addresses the questions: Which algebraic concepts might be stressed in elementary school to lay a foundation for later success in algebra?

National Council of Teachers of Mathematics. "Algebra: What, When, and for Whom A Position." Position Paper, September 2008.

This position paper suggests that although learning to use algebra makes students powerful problem solvers, these concepts and skills take time to develop. Preparation for algebra begins early and should be a focus of math instruction from Pre-K through grade 12. Exposing students to coursework before they are ready can promote negative attitudes toward math and learning. Researchers need to determine the key concepts and skills that can be used to assess readiness for Algebra.

Schmidt, William, Richard Houang, and Leland Cogan. A Coherent Curriculum. The Case of Mathematics American Educator. 2001.

This paper examines the U.S. mathematics content standards from an international perspective, as well as the implications for teacher quality from the Third International Mathematics and Science Study (TIMSS).

United States Department of Education. "Foundations for Success: The Final Report of the National Mathematics Advisory Panel." Washington, D.C., 2008.

In April 2006, President George W. Bush convened the National Mathematics Advisory Panel, with the responsibilities of relying upon the "best available scientific evidence" and recommending ways "…to foster greater knowledge of and improved performance in mathematics among American students."

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Teacher Preparation and Development: Teaching for Mathematical Proficiency **Research Question 1:** What factors about teacher preparation programs and/or certification should be considered in recruiting teachers of mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
There seems to be no research-based relationship between the route to certification and student achievement as measured by student test scores. Findings about the impact of teacher certification on student achievement in mathematics have been mixed.	What Works Clearinghouse. 2009; National Mathematics Advisory Panel, 2008	Route to certification should not be a filter in recruiting MCPS teachers of mathematics.
Based on a National Council on Teacher Quality study that examined the relevance, breadth, and depth of coursework syllabi and textbooks, the University of Maryland, College Park meets the criteria for an exemplary program for elementary teachers of mathematics.	Greenberg, 2008	Continue to seek applicants from UMCP. Consider recruitment efforts from other undergraduate programs identified as exemplary. Use the criteria from the NCTQ study to examine other preservice programs. Use the criteria to backmap successful probationary teachers of mathematics to find commonalities in their preparation programs.
Teacher preparation program coursework should integrate content and pedagogy, including the use of technology.	Ferrini-Mundy, 2010; National Research Council, 2001	Encourage university partnership programs to incorporate more technology into preservice coursework. Consider recruiting from preservice programs with strong technology components.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Teacher Preparation and Development: Teaching for Mathematical Proficiency **Research Question 1:** What factors about teacher preparation programs and/or certification should be considered in recruiting teachers of mathematics?		
Key Findings	**Citation**	**Response to Key Findings**
Important learning takes place in field experiences as novices experience actual classrooms with experienced teachers. Field experience professional learning should be situated in models of practice we wish to encourage.	Ball, 1999; Putnam, 1999	Consider lead teacher status as a criterion for cooperating teachers of preservice teachers/student teachers. Examine the supervision, support and feedback provided in university partnership programs such as professional development schools. Continue the liaison between consulting teachers and content-focused instructional specialists.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 1–Sources Cited:

Ball, Deborah Loewenberg and David K. Cohen *Teaching as a Learning Profession: Handbook of Policy and Practice*. Edited by Linda and Gary Sykes Darling-Hammond. “Chapter One: Developing Practice, Developing Practitioners, Toward a Practice-Based Theory of Professional Education”. San Francisco: Jossey Bass, 1999.

The authors discuss ways teacher education can prepare teachers to learn to do more thoughtful and challenging work and how professional development can help teachers sustain such work. A central element of their thinking is that professional development should be grounded in practice and use the contexts of teachers’ ongoing work. It is important to recognize the frame of reference in which preservice and practicing teachers hone their skills. Teachers need to understand the subject matter they teach in ways different from those they learned as students.

Ferrini-Mundy, Joan, and Bradford Findell. "The Mathematical Education of Prospective Teachers of Secondary School Mathematics: Old Assumptions, New Challenges." *Committee on the Undergraduate Program in Mathematics Discussion Papers about Mathematics and the Mathematics Sciences in 2010*. Washington, D.C.: Mathematical Association of America.

This paper addresses the question of what mathematics prospective secondary school mathematics teachers need to know. The authors maintain that content and pedagogical content knowledge are both important. Although teachers need to know mathematics content in order to teach well in secondary schools, the authors’ review of research studies finds no convincing relationship between teacher content knowledge and student achievement.

Greenberg, Julie and Kate Walsh. "No Common Denominator: the Preparation of Elementary Teachers in Mathematics by American's Education Schools, Executive Summary." *National Council on Teacher Quality*, June 2008.

This study evaluated elementary teacher preparation programs in every state except Alaska through an examination of syllabi and texts. Ten schools, including the University of Maryland College Park, met the study's three criteria of relevance of coursework, breadth of mathematics topics covered, and depth or sufficient time devoted to essential topics.

Hiebert, James. "Presentation to MCPS Mathematics Work Group." Rockville, June 25, 2009.

In his presentation, Dr. Hiebert reviewed results of international comparisons and stressed that teaching matters. Teacher content knowledge alone is not enough, and a challenge is moving beyond the experiences teachers had as learners of mathematics and the ways of teaching that are passed from generation to generation.

National Mathematics Advisory Panel. *Foundations for Success: Reports of the Task Groups and Subcommittees*. "Chapter 5: Report of the Task Group on Teachers and Teacher Education." Washington, D.C.: United States Department of Education, 2008.

The Teachers and Teacher Education Task Group of the National Mathematics Advisory Panel reviewed the available research on the relationship between teacher knowledge and student achievement, and how effective teachers can best be recruited, prepared, supported, and rewarded. They also addressed questions about the effective models and impact of math specialists. In addition to making recommendations based on the best available evidence, the Task Group also highlighted the need for additional research.

National Research Council. *Adding it up: Helping children learn mathematics*. Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

The Committee on Mathematics Learning, established in 1998 by the National Research Council, reviewed and synthesized the rich and diverse research on mathematics teaching and learning. *Adding It Up* is the product of this project and provides research-based recommendations for teaching, teacher education, and curriculum for improving student learning. The report focuses on pre-kindergarten through eighth grade mathematics learning.

Putnam, Ralph T. and Hilda Borko. "What Do New Views of Knowledge and Thinking Have to Say About Research on Teacher Learning?" *Educational Researcher*, July 13, 1999: 4-15.

The authors apply the situative perspective (ideas about the nature of knowledge, thinking, and learning) to how teachers learn new ways of teaching. They explore issues of teacher learning and teacher education brought to light through this perspective, including the impact of discourse communities for experienced and preservice teachers. Examples of elementary and secondary professional development projects and models are discussed.

What Works Clearinghouse. "WWC Quick Review of the Report 'An Evaluation of Teachers Trained through Different Routes to Certification'." *National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences* (United States Department of Education), July 2009.

This study reported in this *What Works Clearinghouse Quick Review* examined whether teachers who choose to attend alternative certification programs are generally more or less effective than teachers who choose a traditional certification route. The study looked at 2,600 kindergarten and first grade students and 174 teachers in 63 schools in seven states. Variation in student achievement was not strongly linked to the teachers' chosen preparation route or other teacher characteristics, including SAT/ACT scores and levels of teacher training coursework.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Teacher Preparation and Development: Teaching for Mathematical Proficiency **Research Question 2:** What features of professional development are most effective to help teachers improve their content knowledge and content-specific pedagogy?		
Key Findings	**Citation**	**Response to Key Findings**
Effective professional development engages participants in active learning communities.	Blank, 2006; Cwikla, 2004; Holland, 2005; Hiebert, 2010; National Research Council, 2001; Putnam, 1999	Provide time and structure for teachers to engage in collaborative activities that address subject matter content that research has shown to be effective (e.g., case study, lesson study).
Effective professional development is coherent: differentiated to support teachers' knowledge and experiences; and aligned with content standards, curriculum, and assessments.	Blank, 2006); Cwikla, 2004; Ball, 1999; Garet 2001; Holland, 2005; Hiebert, 2010; Investing in STEM. 2009; National Research Council, 2001;	Align professional development with the relevant mathematics content. Provide a variety of professional development opportunities (e.g., lesson study, analysis of student work, peer visits with reflection) that can be

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Teacher Preparation and Development: Teaching for Mathematical Proficiency **Research Question 2:** What features of professional development are most effective to help teachers improve their content knowledge and content-specific pedagogy?		
Key Findings	**Citation**	**Response to Key Findings**
	Paek, 2008; Putnam, 1999	differentiated to meet teachers' needs.
Content knowledge and pedagogy are equally important in effective professional development.	Ball, 1999; Ball, 2005; Blank, 2006; Hiebert, 2010; Holland, 2005; Investing in STEM, 2005; Maina, 2008; National Mathematics Advisory Panel, 2008; National Research Council, 2001	Balance content knowledge and pedagogy in professional development at all levels. Examine the current state of MCPS teacher knowledge of content and pedagogy.
Ensure a reliable system for evaluating the impact of professional development on teacher practices and student learning.	Blank, 2008; Garet, 2001; Holland, 2005.	Consider evaluation plans that address Guskey's levels of evaluating professional development.
Effective professional development is sustained over time and in a variety of contexts.	Blank, 2006; Cwikla, 2004; Garet, 2001; Hiebert, 2010; Holland, 2005; National Research Council, 2001; Putnam, 1999; Report of the College Success Task Force, 2010	Follow up initial professional development with opportunities throughout the school year for teachers to directly apply what they learned and to reflect, reinforce, and revise instructional practices collaboratively. Consider strengthening collaboration with universities to provide job-embedded professional development opportunities.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 2–Sources Cited:

Ball, Deborah Loewenberg. "Research on Teaching Mathematics: Making Subject Matter Knowledge Part of the Equation." J. Brophy (Ed.), *Advances in research on teaching*, Vol. 2. *Teachers' subject matter knowledge and classroom instruction*. Greenwich, CT: JAI Press, 1999.

The thesis of this paper is that teachers' subject matter knowledge interacts with their assumptions and beliefs about teaching and learning, about students, and about context to shape the ways in which they teach mathematics to students. The author analyzes past

investigations of the role of teachers' content knowledge in teaching mathematics and discusses the concept of subject matter knowledge for teaching mathematics. The mathematical understanding of prospective elementary teachers and mathematics majors who were prospective secondary teachers was also examined

Ball, Deborah Loewenberg and David K. Cohen *Teaching as a Learning Profession: Handbook of Policy and Practice*. Edited by Linda and Gary Sykes Darling-Hammond. "Chapter One: Developing Practice, Developing Practitioners, Toward a Practice-Based Theory of Professional Education". San Francisco: Jossey Bass, 1999.

The authors discuss ways teacher education can prepare teachers to learn to do more thoughtful and challenging work and how professional development can help teachers sustain such work. A central element of their thinking is that professional development should be grounded in practice the contexts of teachers' ongoing work. It is important to recognize the frame of reference in which preservice and practicing teachers hone their skills. Teachers need to understand the subject matter they teach in ways different from those they learned as students.

Ball, Deborah Loewenberg, Heather C. Hill and Hyman Bass. "Knowing Mathematics for Teaching: Who Knows Mathematics Well Enough To Teach Third Grade, and How Can We Decide?" *American Educator*, Fall 2005: 14-17, 20-22, and 43-46.

The authors present a practice-based picture of mathematical knowledge for teaching, professional knowledge of mathematics different from that demanded by other mathematically intensive occupations. Their research shows that, using their measures of mathematical knowledge for teaching, teacher knowledge is a predictor of gains in student achievement. They emphasize the need for additional research about the knowledge and skills teachers need as well as the impact of professional development on such teaching learning.

Blank, Rolf K., John Smithson, Andrew Porter, and Eric Osthoff. "Improving Instruction through Schoolwide Professional Development: Effects of the Data-on-enacted-Curriculum Model." *ERS Spectrum*, Spring 2006: 9-23.

The authors report results from a longitudinal study of the Data on Enacted Curriculum (DEC) model for teacher professional development and instructional improvement. The model was tested in 50 middle schools in five large urban districts, with random assignment to treatment. Research-based features of the model included focusing professional development on curriculum content being taught and involving teachers as colleagues working together to improve their skills.

Blank, Rolf K., Nina de las Alas and Carlise Smith. *Does Teacher Professional Development Have Effects on Teaching and Learning? Analysis of Evaluation Findings from Programs for Mathematics and Science Teachers in 14 States.* Washington, D. C.: Council of Chief State School Officers, February 2008.

The Council of Chief State School Officers (CCSSO) study reviewed evaluation studies of 25 professional development programs for teachers of mathematics and science from programs nominated by 14 states. Analysis addressed questions about the quality of the professional development as well as program characteristics contributing to high ratings for quality that can be identified and replicated in future program design and development.

Cwikla, Julie. "Show Me the Evidence: Mathematics Professional Development for Elementary Teachers." *Teaching Children Mathematics*, February 2004: 321-326.

This article reviews the features of mathematics professional development for elementary teachers that have been supported by recent research. Professional development is defined as teachers' ongoing learning and their development in the profession, not simply one day workshops or trainings. Four features of effective professional development are identified: focusing on teachers' thinking and learning on students' thinking and learning; collegial environments based on teacher collaboration; narrow and intense focus over time and; the use of the classroom as a laboratory to investigate practice.

Garet, Michael S., Andrew AC. Porter, Laura Desimone, Beatrice F. Birman, and Kwang Suk Yoon. "What Makes Professional Development Effective? Results From a National Sample of Teachers." *American Educational Research Journal* 38, no. 4 (Winter 2001): 915-945.

This study used a national sample of over 1,000 teachers to provide comparison of effects of different characteristics of professional development on teachers' learning. Core features of professional development that have significant positive effects on teachers' knowledge, skills, and changes in classroom practice were identified.

Hiebert, James. "Presentation to MCPS Mathematics Work Group." Rockville, June 25, 2009.

In his presentation, Dr. Hiebert reviewed results of international comparisons and stressed that teaching matters. Teacher content knowledge alone is not enough, and a challenge is moving beyond the experiences teachers had as learners of mathematics and the ways of teaching that are passed from generation to generation.

Holland, Holly. "Teaching Teachers: Professional Development to Improve Student Achievement." *Research Points* (American Educational Research Association), Summer 2005.

The American Educational Research Association's quarterly series, *Research Points*, connects current research to education policy. This issue's review of research about professional development opportunities for teachers that are explicitly aimed at increasing student achievement discusses findings about the impact of teacher professional development and links findings to suggested actions for policymakers.

"Investing in STEM to Secure Maryland's Future. Final Report of the Governor's STEM Task Force Presented to Governor Martin O'Malley." August 2009.

This report is a response to Governor O'Malley's charge to address Maryland's challenges and move the state on a leadership path for STEM (Science Technology Engineering Mathematics) education and economic growth. The Task Force recommendations included preparation, recruitment, and retention of STEM teachers Pre-K through grade 12.

Maina, Nyambura Susan. *Impact of the Math Content Coach on Student Achievement in Title I Schools*. Evaluation Brief, Rockville, MD: Montgomery County Public Schools, September 2008.

The purpose of this evaluation was to examine effects of math content coaches on student achievement and the provision of a rigorous mathematics program in MCPS Title I schools. Measures of student achievement were Grades 1-5 end of unit assessments, 2006 and 2007 *TerraNova* scores, and 2005-2007 Grades 3-5 MSA scores. Completion of accelerated mathematics instruction was used as evidence of a rigorous mathematics program.

National Mathematics Advisory Panel. *Foundations for Success: Reports of the Task Groups and Subcommittees*. "Chapter 5: Report of the Task Group on Teachers and Teacher Education." Washington, D.C.: United States Department of Education, 2008.

The Teachers and Teacher Education Task Group of the National Mathematics Advisory Panel reviewed the available research on the relationship between teacher knowledge and student achievement, and how effective teachers can best be recruited, prepared, supported, and rewarded. They also addressed questions about the effective models and impact of math specialists. In addition to making recommendations based on the best available evidence, the Task Group also highlighted the need for additional research.

National Research Council. *Adding it up: Helping children learn mathematics.* Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

The Committee on Mathematics Learning, established in 1998 by the National Research Council, reviewed and synthesized the rich and diverse research on mathematics teaching and learning. *Adding It Up* is the product of this project and provides research-based recommendations for teaching, teacher education, and curriculum for improving student learning. The report focuses on pre-kindergarten through eighth grade mathematics learning.

Paek, P. L. *Building Teacher Capacity. Cross-Case Analysis From Practices Worthy Of Attention: Local Innovations In Strengthening Secondary Mathematics*. Austin, Texas: Charles A. Dana Center at The University of Texas at Austin, January 2008.

The author led a national search in over 30 schools and districts, conducted by the Dana Center, to identify practices in urban schools that showed promise of increasing student learning in secondary mathematics. This report describes their findings of innovative aspects of practices that increased student achievement and student learning or increased teacher capacity.

Putnam, Ralph T. and Hilda Borko. "What Do New Views of Knowledge and Thinking Have to Say About Research on Teacher Learning?" *Educational Researcher*, July 13, 1999: 4-15.

The authors apply the situative perspective (ideas about the nature of knowledge, thinking, and learning) to how teachers learn new ways of teaching. They explore issues of teacher learning and teacher education brought to light through this perspective, including the impact of discourse communities for experienced and preservice teachers. Examples of elementary and secondary professional development projects and models are discussed.

Report of the College Success Task Force. First Working Draft of the Governor's College Success Task Force, Maryland State Department of Education, February 16, 2010.

The College Success Task Force examined current Pre-K–12 and higher education policies and practices in the State of Maryland as they relate to college readiness and college success. Close attention was paid to mathematics and language arts. Recommendations included changes to teacher preparation and professional development.

K-12 Mathematics Work Group - Report of Research on Identified Questions		
Teacher Preparation and Development: Teaching for Mathematical Proficiency **Research Question 3:** What does research say about the impact of school-based math content support (e.g., math content coaches, algebra lead teachers, resource teachers) in building teacher capacity and increasing student achievement?		
Key Findings	**Citation**	**Response to Key Findings**
It is difficult to isolate the impact of math specialists from other factors, but results of studies are encouraging. Math specialists are needed to ensure that students receive math instruction from teachers who have a deep understanding of math content and pedagogy.	Fennell (2); Haver, 2008; McDaniel College, 2009-2010; McGatha, 2009; Maina, 2008; National Mathematics Advisory Panel (2); National Research Council, 2001; Saphier, 2009	Consider multiple models for providing school-based math specialist support for all schools at the elementary, middle, and high school levels.
Participation in professional learning communities optimizes professional development. Collaboration with colleagues provides the support for inquiry needed to develop proficiency.	National Research Council, 2001	Provide professional development to build professional learning communities for math specialists, by level and vertically across levels. Use resource teacher meetings as ongoing, job-embedded opportunities for math teacher-leaders' professional development.
The Office of Shared Accountability evaluation examined effects of math content coaches on student achievement and the provision of a rigorous mathematics program in Title I schools. Analyses of TN/2 scores showed differences large enough to be "educationally meaningful, suggesting the initiative had the desired result."	Maina, 2008	Continue to fund the math content coach positions. Allocate math content coaches for all elementary schools.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Research Question 3–Sources Cited:

Fennell, Francis. "Elementary Mathematics Specialists—We Need them Now! Follow Virginia's Lead!" *The Journal of Mathematics and Science* 9. Collaborative Explorations (2007): 1-4.

In this forward to the journal volume, the author explains why math specialists are needed and what they do. He recognizes Virginia as the model for a statewide initiative for elementary mathematics leadership and advocates for similar needs for teacher leaders/specialists at the middle and high school levels.

Fennell, Francis. "We Need Elementary School Mathematics Specialists NOW." *NCTM News Bulletin* (National Council of Teachers of Mathematics), November 2006.

The author, NCTM President 2006-2008, describes various models of the work of math specialists and explains why they are needed. Although focused on the need at the elementary level, Fennell also advocates for support for middle and high school mathematics teachers.

Haver, William. *The Impact of Mathematics Specialists in Virginia*. United States House of Representatives Committee on Education and Labor, May 21, 2008.

The Virginia Mathematics and Science Coalition identified Mathematics Specialists as "the most promising" means to improve K-12 student achievement. This testimony by Dr. William Haver, Professor in the Department of Mathematics at Virginia Commonwealth University, considered the impact of Mathematics Specialists in Virginia on instructional practice and student achievement as reported by mathematics supervisors, principals and teachers and student performance on standardized tests. Support and capacity building from multiple sources were described.

Maina, Nyambura Susan. *Impact of the Math Content Coach on Student Achievement in Title I Schools*. Evaluation Brief, Rockville, MD: Montgomery County Public Schools, September 2008.

The purpose of this evaluation was to examine effects of math content coaches on student achievement and the provision of a rigorous mathematics program in MCPS Title I schools. Measures of student achievement were Grades 1-5 end of unit assessments, 2006 and 2007 *TerraNova* scores, and 2005-2007 Grades 3-5 MSA scores. Completion of accelerated mathematics instruction was used as evidence of a rigorous mathematics program.

McDaniel College. *School District Models: Mathematics Specialists, Coaches & Resource Teachers*. 2009-2010. http://www2.mcdaniel.edu/emstl/district_models.html.

The McDaniel College Elementary Mathematics Specialists and Teacher Leaders Project established a web-based clearinghouse on issues of importance for elementary mathematics specialists and their supervisors. A variety of existing school district models for using mathematics coaches/specialists are documented, including information about program impact and research.

McGatha, Maggie. *Mathematics Specialists and Mathematics Coaches: What Does the Research Say?* Professional Development Research Brief, Reston, VA.: National Council of Teachers of Mathematics, March 17, 2009.

Insights from seven studies are discussed in this research review. The research discussed includes published studies and paper presentations since 1990. Studies about math coaches, those who work directly with teachers, focused on the design of coaching programs, improving instructional practices, and improving student achievement.

National Mathematics Advisory Panel. *Foundations for Success: Reports of the Task Groups and Subcommittees*. "Chapter 5: Report of the Task Group on Teachers and Teacher Education." Washington, D.C.: United States Department of Education, 2008.

The Teachers and Teacher Education Task Group of the National Mathematics Advisory Panel reviewed the available research on the relationship between teacher knowledge and student achievement, and how effective teachers can best be recruited, prepared, supported, and rewarded. They also addressed questions about the effective models and impact of math specialists. In addition to making recommendations based on the best available evidence, the Task Group also highlighted the need for additional research.

National Mathematics Advisory Panel. *Foundations for Success: the Final Report of the National Mathematics Advisory Panel*. Executive Summary, Washington, D.C.: United States Department of Education, 2008.

The National Mathematics Advisory Panel was charged with using the best available scientific research to advise and make recommendations for continuous improvement of mathematics education. This Final Report draws together the Panel's main findings and recommendations.

National Research Council. *Adding it up: Helping children learn mathematics.* Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Edited by J. Swafford, and B. Findell J. Kilpatrick. Washington, D.C.: National Academy Press, 2001.

The Committee on Mathematics Learning, established in 1998 by the National Research Council, reviewed and synthesized the rich and diverse research on mathematics teaching and learning. *Adding It Up* is the product of this project and provides research-based recommendations for teaching, teacher education, and curriculum for improving student learning. The report focuses on pre-kindergarten through eighth grade mathematics learning.

Saphier, Jon and Lucy West. "How Coaches Can Maximize Student Learning." *Phi Delta Kappan* 91, no. 4 (December 2009/January 2010): 46–50.

Schools throughout the nation are hiring coaches and deploying them in schools in a multitude of ways. The authors propose a definition for a school-based instructional coach and roles and responsibilities that will enhance the likelihood that coaches will be able to influence school culture, professional learning, and, ultimately, student achievement.

Attachment K

K–12 Mathematics Work Group Recommendations

Curriculum: Written Curriculum Recommendations

1. Revise and align the MCPS written curriculum to the rigorous Common Core State Standards, resulting in—
   - a streamlined curriculum with more in-depth study of content at each grade level,
   - a focus on mastery of number concepts in elementary school,
   - mastery in algebraic concepts by the end of middle school,
   - mathematical proficiency with geometric principles and Algebra 2 concepts, and
   - equitable preparation and opportunities for higher level mathematics courses in high school.

2. Investigate the adoption of the integrated secondary school mathematics pathway as articulated in the Common Core State Standards.

3. Provide curriculum resources that are aligned with the Common Core State Standards and support equitable access to learning by—
   - addressing content, pedagogy, assessment, and instructional practices,
   - offering tasks that allow for multiple places to begin a problem, multiple solution strategies or multiple solutions, and
   - presenting mathematics in contexts that include the use of culturally responsive practices and universal design principles.

4. Integrate a variety of technologies into the written curriculum to affect how mathematics is taught—to encourage critical thinking skills, to increase student motivation, and to facilitate access to mathematics content for all students, including those with disabilities and English Language Learners.

5. Create an online forum that allows instructional staff members to contribute to an evolving curriculum.

Classroom/Instructional Practices: Implemented Curriculum Recommendations

1. Support the improvement of mathematics teaching through the development and use of an instructional practices rubric that includes but is not limited to fidelity of curriculum implementation, equitable practices, inquiry-based instruction, mathematics discourse, metacognitive strategies, and differentiation.

2. Develop and implement a self-assessment, incorporating the instructional practices rubric, for instructional staff members to identify content and pedagogical strengths and needs so that instructional staff members have data to guide their professional development.

3. Identify school structures and strategies that promote success for all students and work to support their replication in multiple locations.

    - Implement school schedules that promote effective instruction and provide all students, including students receiving special education services and English Language Learners, with the math instruction and support they need to succeed.
    - Support instructional staff members as they work in collaborative teams to review curriculum, plan instruction, discuss student progress, review student data, and make adjustments in teaching.

4. Monitor implementation of MCPS Regulation IHB-RA, *School Academic Grouping Practices*, that establishes standards for ongoing, flexible grouping and regrouping of students to provide instruction differentiated to meet the needs of all learners.

5. Provide research-based guidance on the appropriate use of calculators.

Curriculum: Assessed Curriculum Recommendations

1. Revise the MCPS mathematics assessment program to ensure it is aligned with the Common Core State Standards and measures a student's growth and achievement over time in all content standards, across all strands of mathematical proficiency (understanding, computing, applying, reasoning, and engaging), and at all levels of mathematical thinking (reproduction, connection, analysis).

2. Provide formative and summative assessments at each grade level/course that make students' thinking visible to the teacher and inform teaching and learning.

3. Build time into the school schedule for mathematics teachers to collaboratively plan ongoing formative assessments, examine assessment data, reteach, reassess, and provide effective individual student feedback.

4. Provide professional development on formative assessment practices including item development, data analysis, and individual student feedback.

5. Create an online forum that will enable instructional staff members to share their formative assessment items and practices.

6. Ensure the overall assessment program includes appropriate national and international norm-referenced assessments that provide useful national and international comparison data.

Acceleration Practices: Mathematics Targets and Acceleration Recommendations

1. Eliminate the practice of large numbers of students skipping grade levels in mathematics. Ensure that all students have access to in-depth content knowledge at each grade level or course as reflected in the Common Core State Standards.

2. Continue programs and acceleration for students who demonstrate exceptionally strong and consistent proficiency of all mathematical strands (understanding, computing, applying, reasoning, and engaging) represented in the Common Core State Standards.

3. Monitor, at the school and district level, secondary course placement decisions to ensure equitable preparation and opportunities for advancement for all students, including those groups who have been underserved in the past: African American, Hispanic, special education, and English Language Learners.

4. Assess the impact of the implemented Common Core State Standards on the instructional program, including acceleration and targets.

5. Refocus the elementary mathematics target and Key 3 of the Seven Keys to College Readiness (Complete Advanced Math in Grade 5) to reflect the implementation of the Common Core State Standards.

Teacher Preparation and Development: Teaching for Mathematical Proficiency Recommendations

1. Provide time and structures for instructional staff members to engage in collaborative, job-embedded professional development; apply what they learn and reflect, reinforce, or revise instructional practices. Develop a plan to evaluate the impact of professional development on student learning.

2. Offer online, face-to-face, and hybrid (combination of online and face-to-face) professional development opportunities that align with the written curriculum and balance content knowledge and pedagogy.

3. Designate a school-based mathematics specialist position in every elementary, middle, and high school with allocated release time whose primary role is to support the professional growth of mathematics instructional staff.

4. Expand and strengthen university program partnerships to—
    - provide teacher preparation aligned with MCPS goals for the teaching and learning of mathematics, and

- place student teachers and interns in classrooms that provide models of effective mathematics teaching.

5. Continue to recruit and hire mathematics teachers with content expertise from a variety of professional backgrounds, including those who have pursued alternate routes to teacher certification. Involve content experts in the hiring process.

Attachment L

K–12 Mathematics Work Group

Definition of Terms

Acceleration

A term used to describe many instructional practices and interpreted in different ways by different users. Acceleration can mean compacting curriculum, skipping units, grade levels or courses to reach an adequate level of instructional challenge for the student, and helping underperforming students master foundational knowledge to quickly reach grade-level or above grade-level standards. Acceleration advances students through a given curriculum more rapidly than the standard pace.

Advanced in terms of mathematics achievement

A phrase used to describe students who are working on content from a course higher than their grade of enrollment. Advancement may occur within a course using the enrichment/acceleration provided in the instructional guide.

Common Core State Standards (CCSS)

A set of focused, coherent expectations for student knowledge and skills intended to develop high school graduates who are prepared for success in college and careers. These national standards, released in 2010, were developed by a multistakeholder group and produced by the Council of Chief State School Officers (SSDDO) and the National Governors Association for Best Practices (NGA Center).

Foundational Math Skills

Foundational skills include proficiency in arithmetic operations, including adding, subtracting, multiplying, and dividing whole numbers, fractions, and decimals; and measurement of lengths, distances, areas, and volumes. These skills provide the basis for success in advanced courses in mathematics. Foundational skills include both skills and concepts.

Grouping

A structure for instruction used to place students for instruction based on achievement or areas of need. Students may be grouped within or across classrooms or grade-levels. Heterogeneous grouping refers to placing students with diverse achievement together, while homogeneous grouping places students with similar achievement together.

Mathematical Proficiency (Proficient in terms of mathematics achievement)

A description of the components needed to be successful in mathematics. As defined in 2001 by the National Research Council (*Adding It Up: Helping Children Learn Mathematics*), a mathematically proficient individual is able to understand mathematical concepts, operations, and relationships; compute flexibly, accurately, and efficiently; apply concepts and

procedures appropriately to solve problems; reason to explain and justify answers; and see mathematics as sensible, useful, and doable.

National Mathematics Advisory Panel (NMP)

A multistakeholder group formed in 2006 by President Bush, and charged with using the best available scientific evidence to recommend ways to improve American students' mathematics knowledge and performance. These recommendations, released in 2008, included the charge to develop focused, coherent progressions mathematics learning.

Proficiency Scores

Within Montgomery County Public Schools (MCPS), proficiency has been determined for Math 1–Algebra 1 by the attainment of specific total scores on the end-of-unit assessments. The scores are intended to represent the minimum amount of knowledge of a course needed for success in the next course. These proficiency scores were determined by groups of teachers, principals, and central office staff in order to assist in the appropriate placement of students.

Targets

The percentage of students expected to meet or exceed a specified level of performance. Targets reflect the requirements of national, state, and local accountability mandates and take into consideration where MCPS wants our students to be each year. These achievement levels established are designed to raise expectations and standards for student and school performance and reinforce a commitment to eliminating the gap in student performance by race and ethnicity and other student groups.

Attachment M

K–12 Mathematics Work Group

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