Milwaukee Mathematics Partnership

Final Report

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MILWAUKEE MATHEMATICS PARTNERSHIP

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Part 1
Need for the Journey

The *Milwaukee Mathematics Partnership* (MMP) has seen significant improvement in mathematics achievement for students in the Milwaukee Public Schools, with a substantial gap reduction between the district and the state. The University of Wisconsin-Milwaukee (UWM), Milwaukee Public Schools (MPS), and Milwaukee Area Technical College (MATC) have shared in the leadership for this student success as core partners to this unique collaboration among a large urban district, a four-year urban university, and a two-year technical college.

The challenges in the Milwaukee Public Schools, and likely reflected in many urban districts across the country, included low student achievement in mathematics and issues associated with quality of mathematics instruction. However, we would identify the primary problem at the start of the MMP as one that treated the instruction of mathematics simplistically and superficially. Discussions on ways to improve mathematics learning focused on what textbook was used, viewing the solution to the district's problems as simply finding the "right" program. The hypothesis we advanced was that continuous growth in students' mathematics achievement is heavily dependent on quality and consistency across teachers within a school working toward a common vision of challenging mathematics.

We believed that a district-wide, consistent implementation could only be accomplished through a distributed leadership model that established teacher leadership for mathematics, and would require considerable professional development for teachers on both mathematics content knowledge and formative assessment. While there was an immediate need to work with teachers, it was also necessary to improve the mathematical preparation of the next generation of teachers. We believed this could be best accomplished in stronger connections between MATC and UWM through course revision and course development in collaboration with MPS teachers-in-residence. Hence, the work of the MMP was framed through the identification of four goals.

Goal 1. Comprehensive Mathematics Framework: Implement and utilize the Comprehensive Mathematics Framework to lead a collective vision of deep learning and quality teaching of challenging mathematics across the Milwaukee Partnership.

Goal 2. Distributed Leadership: Institute a distributed mathematics leadership model that engages all partners and is centered on school-based professional learning communities.

Goal 3. Teacher Learning Continuum: Build and sustain the capacity of teachers, from initial preparation through induction and professional growth, to understand mathematics deeply and use that knowledge to improve student learning.

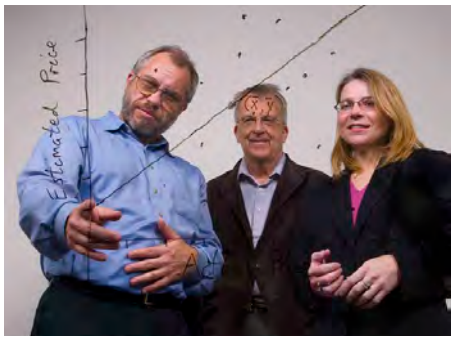
Goal 4. Student Learning Continuum: Ensure all students, PK-16, have access to, are prepared and supported for, and succeed in challenging mathematics.

Throughout its eight years of work, the MMP engaged thousands of individuals in its initiatives to improve the teaching and learning of mathematics. At the university and college level, a total of 17 mathematics faculty and instructors and 4 mathematics education faculty and instructors contributed substantial amounts of time to MMP activities. At the district level, a total of 20 individuals provided mathematics leadership as math curriculum specialists, math teaching specialists, math teachers-in-residence, and math instructional coaches. At the school level, about 450 individuals across the years have stepped forward to take on the challenges of being Math Teacher Leaders for their schools.

This resulted in the involvement of approximately 6000 teachers in MMP initiatives, including participation in university courses, district professional development, and school-based professional learning focused on mathematics. In addition, the MMP impacted approximately 2800 preservice teachers at UWM and another 600 preservice teachers at MATC through revised or new mathematics courses for teacher preparation. Furthermore, the MMP established an IHE Network for Mathematics and sponsored statewide networking meetings that engaged another 88 mathematics and 27 mathematics education faculty and instructors from university and colleges throughout Wisconsin.

Core Partners

The three core partners of the *Milwaukee Mathematics Partnership* (MMP) have collaborated in seeking solutions, implementing and evaluating strategies, and sharing in accomplishments. The key principal investigators from each institution remained consistent throughout our work while the contextual setting in regards to the school district organizational structures and student population have shifted.



The district leadership in 2003 supported a decentralized mode of operation. The prevailing assumption was that each school knew what was best for its students. This resulted in allowing individual schools to develop mathematics programs that ultimately trumped any recommendations from the central administration. Many teachers were too comfortable with viewing the mathematics taught as something that could be prepared in short order and delivered to students with minimal preparation by just teaching the next lesson in the textbook. As we began our work, the district joined the movement to create small high schools, as well as to break apart large middle schools to create K-8 elementary schools. Each year, the district moved further back to a centralized system of administration and curricular expectations. This was not met without resistance from schools. With the implementation of *No Child Left Behind* legislation, testing requirements changed and increased, many schools, as well as the district itself, were identified as in need of improvement and became subject to corrective actions. Nonetheless, the MMP continued, often with detours and bumps, on its journey to implement its core strategies.

Mr. Henry Kranendonk spearheaded the MMP work in the Milwaukee Public Schools (MPS) as its district Mathematics Curriculum Specialist. In 2010-2011, MPS had an enrollment of approximately 81,000 students. While this was a substantial decrease from approximately 97,000 students in 2003, MPS was still by far the largest school district in Wisconsin but had dropped from a ranking of 27 to 33 on the list of the largest school districts in the nation. The percent of low-income students in the district had increased from 72% to 82%, along with increased proportions of students with disabilities from 16% to 20% and English Language Learners from 9% to 10%. The student population was now comprised of 56% African-American, 23% Hispanic, 15% White, 5% Asian, and 1% Native American. This reflected a 4 percentage point decrease for African-American students and an increase of 7 percentage points for Hispanic students.

Dr. DeAnn Huinker, Professor of Mathematics Education, and Dr. Kevin McLeod, Associate Professor of Mathematical Sciences, directed the work for the University of Wisconsin-Milwaukee (UWM). UWM is considered Wisconsin's premier, public urban university, and is one of two public doctoral research universities in the state. In 2010-2011, UWM offered over 30,000 students a comprehensive liberal arts and professional education through 180 majors and degree programs compared. Students of color from targeted and non-targeted groups comprised nearly 20 percent of the UWM student body. UWM prepares more teachers who take positions in MPS than any other teacher preparation program.

Dr. Kimberly Farley, Associate Dean of Letters and Sciences, oversaw the work at the Milwaukee Area Technical College (MATC). MATC has distinguished itself as the Midwest's largest community-based technical college. The college served over 57,000 students in 2009-2010 and offered over 200 degree, diploma, certificate and apprentice programs in six academic divisions. Student demographics were 28% African American, 14% Hispanic, 4% Asian American, and 1% American Indian, with a median age of 27. Almost one-third of incoming students plan to pursue bachelor's degrees. About 500 students per year transfer to the University of Wisconsin-Milwaukee from MATC.

An important contributing partner has been the Milwaukee Partnership Academy (MPA). This urban PK-16 council of community and education leaders was formed to focus on improving the quality of teaching and learning in the Milwaukee Public Schools. The MPA has brought together key players from school, university, teachers' union, government, business, and community organizations. The MPA was crucial to both the establishment of the MMP and the early years of solidifying the partnership. It has been a conduit for communication and dissemination of our accomplishments, as well as a support in addressing struggles and overcoming obstacles. For example, the MPA has included updates on the work of the MMP in its regular reports to the Milwaukee Board of School Directors and to its executive partners.

Vision of Challenging Mathematics

The MMP Comprehensive Mathematics Framework (CMF), shown in Figure 1, has been at the center of our work. It has been discussed and dissected, and has served as our vision of what it means to be successful in challenging mathematics. It includes the five components of mathematical proficiency—understanding, computing, applying, reasoning, and engaging—as presented in the National Research Council (NRC) reports, *Helping Children Learn Mathematics* (NRC, 2002) and *Adding It Up (*NRC, 2001). The five components revolved around the Wisconsin content standards of number, algebra, statistics, probability, geometry, and measurement.

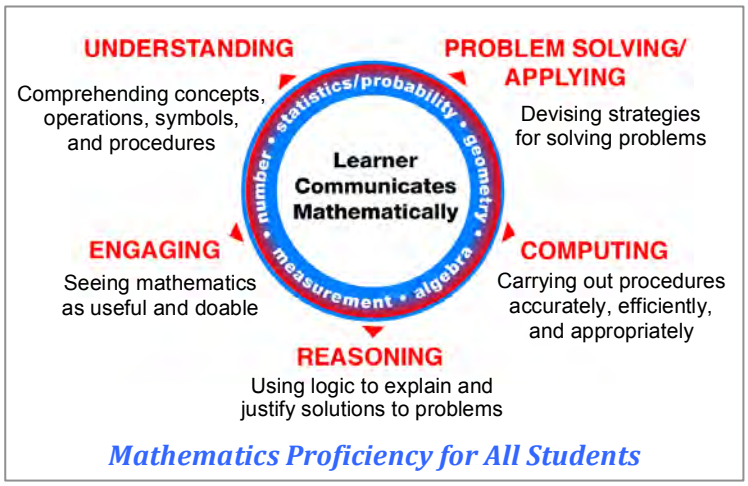


Figure 1. Comprehensive Mathematics Framework

Our vision, as shown through this simple, but powerful, graphic, was a constant reminder that proficiency in mathematics included student abilities to demonstrate their conceptual ***understanding*** of mathematics content, ***apply*** principles and strategies to solve problems, and ***reason*** logically, as well as use skills in ***computing*** accurately, flexibly, and efficiently. In addition, our vision included ***engagement*** in doing mathematics as the development of productive dispositions in which students viewed mathematics as useful and doable. These components were not to be addressed as isolated topics, but rather the expectation was to interweave these components into mathematics instruction and into assessments of mathematical knowledge.

Part 2
A Road Map for the Journey

The *Milwaukee Mathematics Partnership* (MMP) has been on a journey in moving the district toward improved teaching and learning of mathematics. The process began by developing grade-level learning targets for mathematics connected to the State standards, but grounded in the discipline of mathematics. MPS and UWM collaborated on writing the learning targets with prominent involvement of several UWM mathematics faculty and mathematics education faculty. Eight to ten statements were developed per grade that captured the important mathematical ideas for students to learn by the end of that grade and that showed the progression of ideas across the grades.

While the learning targets defined the mathematics students needed to learn, we felt strongly that performance assessments would focus teaching and define learning. Committees of teachers, at the elementary, middle, and high school levels, worked with UWM and MATC mathematics faculty to generate and pilot classroom assessments aligned to the targets that eventually became model assessments disseminated throughout the district. Next, we created a protocol for collaboratively looking at student work from these assessments (Bedford, Hollinger, & Huinker, 2006), along with a DVD training module (Huinker & Freckmann, 2005). District curriculum guides were also developed that showed the alignment of the learning targets to the curricular materials (i.e., textbooks) and to the classroom assessments. The guides also suggested a pacing schedule for the school year.

These resources were developed as tools for bringing consistency to mathematics throughout the district. However, unless teachers had opportunities to study the tools, understand their purpose, and have support in using them, we feared they would become yet another binder just sitting on a shelf (as has happened with previous projects) and not affect their instruction or student learning. This led to the development of the "MMP Continuum of Professional Work for Mathematics."

This section begins with the important role of the MMP Continuum as a roadmap for moving mathematics instruction through the collaborative efforts of teachers in a school. Then principles of formative assessment will be described in showing how they gave further detail to this map, along with a guy named "WALT" who joined us on the journey. The section ends with a summary of the MMP Math Action Plans that strategized the professional work in the schools. MMP funds associated with the plans financed a small part, yet provided leverage for a considerable part, of the journey in the schools

MMP Continuum: A Guide for School Reform

One of the most powerful unanticipated events involved the development of a "MMP Continuum of Professional Work for Mathematics." We knew from the start of the MMP that we wanted to promote formative assessment practices but struggled with how to articulate our vision. The continuum emerged as a response to this need for an organizing framework. It then grew into a central tool for our work, as well as a tool for school and individual self-assessment and for data collection to document the evolution of the overall project.

MMP Continuum of Professional Work for Mathematics

The "MMP Continuum of Professional Work for Mathematics" is comprised of five stages as shown in Table 1. Each of these stages reflects practices of formative assessment. Stage 1 began with the need for teachers to have a common understanding of the important mathematical ideas that students were to be learning, defined as the district grade-level learning targets. Stage 2 indicated the importance of knowing how the district learning targets align with state standards and with a the school mathematics curricular program. Stage 3 moved teachers to then consider the use of common classroom assessments at a grade level to tap into student understanding of the targets and standards. Stage 4 emphasized the importance of collaboratively examining student work on the common assessments to monitor progress and inform instruction. Stage 5 emphasized the importance of providing students with "descriptive" feedback related to the learning targets rather than the more common practice of merely providing evaluative feedback, a letter grade, or percent correct.

Table 1. MMP Continuum of Professional Work for Mathematics

Stage 1 Learning Targets	Stage 2 Align State Standards and Math Program	Stage 3 Common Classroom Assessments	Stage 4 Student Work on Common Assessments	Stage 5 Descriptive Feedback on Common Assessments
Understand importance of identifying and articulating big ideas in mathematics to bring consistency to a school's math program.	Develop meaning for the math embedded in targets and alignment to state standards and descriptors and the school's math program.	Provide a measure of consistency of student learning based on standards, descriptors, and targets.	Examine student work to monitor achievement and progress toward the targets and to inform instruction.	Use student work to inform instructional decisions, and to provide students with appropriate descriptive feedback.

The MMP continuum emerged in our second year of work and was further developed in subsequent years. An important elaboration was articulation of specific descriptors of the professional work that should occur at each stage. These descriptors, along with tools for each stage, are listed in Table 2. For example, in Stage 3 we indicated that teachers should not only use common assessments but that they should identify and discuss the math expectations being assessed and identify potential student misconceptions that might be revealed through the assessment. The articulation of these descriptors dramatically changed the conversations that were occurring among teachers in schools. The conversations became more focused on the specific mathematical ideas and how students would demonstrate their understanding through the common assessment. These Stage 3 conversations were critical as they became the basis for the conversations at Stage 4 in which teachers collaboratively examined the student work from the common assessments to inform instruction.

The MMP Continuum put order to the professional learning at a school level and gave focus to district professional development. These three components—the stages, the descriptors, and the tools—were then organized into a one-page document that was used extensively throughout the district. This document is included in Appendix A.

To support the school-based professional work, the MMP developed many tools over the years for math teacher leaders to use with the teachers in their schools. For example, the math teacher leaders would be introduced to the tools listed in the continuum during their monthly seminars and then as appropriate would use these tools with the teachers in their schools. These tools were also used with classroom teachers and administrators in district-wide professional development sessions. Appendix B provides a description of the tools listed in the continuum along with additional tools developed by the MMP over the years. Most of these tools have been posted to the project website (www.mmp.uwm.edu), including the grade-level learning targets, model classroom assessments, and various recording and reporting forms (e.g., CABS Assessment Overview, CABS Classroom Summary Report, and Class Feedback Summary).

Given that the continuum was developed to guide the professional work within a school, we developed a school self-assessment guide. The purpose of the guide was to help a learning team identify the school's current stage on the continuum and then use this data to plan ways to move their staff to the next stage. Learning teams used the descriptors to rate their schools on a four-point rubric (i.e., weak, emerging, moving forward, and strong) for each stage of the continuum. Some schools had each of their math teachers individually complete the self-assessment. This self-analysis and data formed the basis for the district math specialists to hold monitoring conferences with the principal and math teacher leader at each school and to set the direction for the work of the math teacher leader and the development of a school's math action plan.

Table 2. Continuum Descriptors and Tools

Stage	Descriptors of School Professional Work	Tools
Stage 1 Learning Targets	Teachers develop awareness of learning targets for each math strand. Teachers discuss what each learning target means and can articulate the math learning goals students are to reach. Teachers examine the development of mathematical ideas across grades.	Grade level learning targets (9-11 big ideas per grade). Progressions of learning targets across grades. Comprehensive Mathematics Framework (CMF).
Stage 2 Align State Standards and Math Program	Teachers examine alignment of state standards and state assessment descriptors to district learning targets. Teachers identify the depth of knowledge in the state assessment descriptors. Teachers study how the mathematical ideas in the descriptors are developed in the school's math program. For each lesson, teachers inform students of the math learning goals in terms that students understand.	Target-descriptor alignment worksheets. Depth of knowledge analysis. Curriculum pacing guides. Lesson planning with formative assessment principles (WALT).
Stage 3 Common Classroom Assessments	Teachers select and study common classroom assessments based on standards (CABS) to use for a grade level or course. Teachers identify math expectations of students on the assessments. Teachers identify potential student misconceptions revealed through the assessments. Learning team members and teachers examine student state test and district benchmark assessment data to identify areas of strengths and weaknesses for focusing teaching and learning.	Assessing an assessment guide. CABS assessment overview. District model CABS. Curriculum pacing guides. Depth of knowledge analysis. Student math test data reports.
Stage 4 Student Work on Common Assessments	Teachers collaborate in grade-level meetings to discuss student work and implications for instruction. Teachers meet in cross grade-level meetings to discuss common math expectations of student learning and implications for school-side practice. Learning team monitors and discusses student learning on CABS results from across the school, shares observations with staff, and uses data for the school improvement plan.	MMP protocol for collaborative analysis of student work. DVD of MMP protocol. CABS class summary report. School improvement plan.
Stage 5 Descriptive Feedback on Common Assessments	Teachers collaborate to write descriptive feedback to students on benchmark assessments and common CABS. Students use descriptive feedback to revise work and improve learning. Teachers use descriptive feedback to adjust and differentiate instruction. Learning Team monitors successes and challenges of writing descriptive feedback and identifies professional learning needs of teachers.	Types of feedback overview. Class feedback summary recording sheet. Student record of descriptive feedback.

PROGRESS ALONG THE MMP CONTINUUM

The Math Teacher Leaders (MTL) were asked to reflect on the work within their schools along the MMP continuum and indicate the placement of their schools at the end of each school year. The results for the K-8 schools are shown in Table 3. A progression can be seen across the eight years of our work, with more K-8 schools each year further along the continuum. At the end of the 2010-2011 school year, over half of the schools reported that teachers collaboratively examined the student work on common classroom assessments to monitor achievement and inform instruction (stage 4) or to provide students with descriptive feedback (stage 5).

Table 3. Percent of K–8 Schools at Each Stage of the MMP Continuum

	n	Stage 1 Learning Targets	Stage 2 Align Standards & Math Program	Stage 3 Common Assessments	Stage 4 Student Work on Assessments	Stage 5 Descriptive Feedback
Year 1, 2003-04	99	44%	47%	9%	0%	0%
Year 2, 2004-05	106	17%	29%	41%	13%	0%
Year 3, 2005-06	107	11%	28%	47%	12%	2%
Year 4, 2006-07	117	10%	27%	42%	18%	3%
Year 5, 2007-08	117	19%	29%	32%	18%	3%
Year 6, 2008-09	119	9%	25%	45%	16%	5%
Year 7, 2009-10	113	7%	14%	43%	25%	12%
Year 8, 2010-11	100	2%	7%	26%	35%	30%

Shown in Table 4, the high school MTLs reported on the work within their schools along this continuum since 2006-2007 (MMP Year 4). While the high schools were not as far along as the K-8 schools, a progression can be seen with more high schools further along the continuum each year. We acknowledged that the high schools were slow to get started in regards to buy-in of this focus on formative assessment practices. Thus, it was particularly encouraging to have high school teachers beginning to use common classroom assessments across all sections of a particular course and for the teachers to collaboratively examine student work from the assessments, as well as having some schools provide students with descriptive feedback. We attributed this movement largely to the released-time MTL position that began in 2008-2009 (MMP Year 6). The MTL now had the time to provide leadership for this work at the high school level.

Table 4. Percent of High Schools at Each Stage of the Continuum

	n	Stage 1 Learning Targets	Stage 2 Align Standards & Math Program	Stage 3 Common Assessments	Stage 4 Student Work on Assessments	Stage 5 Descriptive Feedback
Year 4, 2006-07	27	56%	30%	15%	0%	0%
Year 5, 2007-08	27	33%	33%	15%	15%	4%
Year 6, 2008-09	26	4%	46%	27%	15%	8%
Year 7, 2009-10	21	5%	29%	52%	10%	5%
Year 8, 2010-11	17	12%	12%	42%	18%	18%

The continuum grew in importance across the years of the MMP. It became an essential tool for engaging learning team members, teachers, and administrators in conversations and work focused on improving mathematics teaching and learning through implementation of formative assessment practices. The continuum moved teachers beyond just teaching the next lesson in their textbooks to a collaborative study of the mathematics they were teaching and its alignment to state standards. Furthermore, it prompted thousands of conversations across schools on selection of common classroom assessments and collaborative analysis of student work on those assessments. The continuum developed a framework and purpose for bringing teachers together in professional mathematics communities. As one math teacher leader reported,

> *The MMP Continuum has had a great impact on our school because all grade levels are doing the same thing. The continuum has given teachers the opportunity to work together to help their students succeed. It has let teachers really sit down and examine their students' work to see what areas are in need of more focus. Many of the teachers commented on how it is nice to compare their student results with other teachers at their grade level because then they can get support and share ideas that have been successful across classrooms.*

Stage 3 on common classroom assessments proved to be a critical stage for schools to reach. This stage required teachers to select and study common classroom assessments based on standards (CABS) using the model assessments developed by the MMP. These rich conversations engaged teachers in identification of the mathematical expectations of students on the task and of potential

student misconceptions. Moving beyond this stage to collaborative analysis of the student work (stage 4) and to use of descriptive feedback (stage 5) was more difficult for schools, but the continuum prompted them to keep progressing. As two of the math teacher leaders commented,

> *Having the MMP continuum as a major focus helped to keep our school working towards better implementing the use of CABS and in writing descriptive feedback. More teachers are finally beginning to see the impact of using descriptive feedback to help with instruction and planning.*

> *Throughout the years, I have focused on all of the stages of the continuum. My principal set aside meeting times for professional development on unpacking learning targets and aligning them to the state standards and to our curriculum. Using CABS and analyzing student work has also been a focus of my after-school professional development sessions including our collaborative planning sessions. This year I have spent much of my time working with individual and small groups of teachers to analyze student work and write descriptive feedback. Despite the MMP ending, I hope to continue the momentum my school has developed around the teaching and learning of math next year.*

The math teacher leaders were asked to report on the level of implementation of using the MMP Continuum to guide the professional work in their schools throughout the lifespan of the MMP. They were given a six-point scale (1=low, 6=high), ranging from "not even addressed" to becoming "institutionalized" as part of normal, school-wide practice. The elementary leaders reported a mean of 4.17 (SD=1.09, n=100 schools) indicating good to strong implementation of using the continuum to guide their work. The high school leaders reported a mean of 3.12 (SD=1.23, n=24 schools) indicating good implementation. The math teacher leaders at both levels were asked to report on the importance of the continuum for their work. On a five-point scale, (1=of little importance, 5=extremely important), the elementary leaders reported a mean of 3.89 (SD=0.74, n=99) and the high school leaders reported a mean of 3.43 (SD=0.78, n=23) indicating that the continuum was important in providing direction for their work in the schools.

Summary Comments

The continuum became an important tool at the school level to guide and monitor formative assessment practices and became an important tool at the district level to focus professional development of teacher leaders and learning teams. Two MTLs described the continuum as the backbone and the roadmap of the MMP, not only for their role as teacher leaders but for all of the teachers in their schools.

> *In my position as the school's MTL for every year of the program, I have found that all of the initiatives of the MMP have been extremely valuable. The one area that has helped me the most has been the MMP Continuum. This has been a guide and a road map to assist our school in moving forward through the work of the MMP. Every piece of the journey is written there and through this we were able to assess our mathematics teaching and learning every year. Even though we did not follow every step in order, we knew where we were headed and where we needed to make improvements. The continuum guided my work as an MTL and helped define what I needed to do to keep the strong focus on mathematics in my building.*

> *The MMP Continuum is the backbone and road map of our efforts. It outlines the MMP initiatives and connects those initiatives to formative assessment strategies, along with our school improvement plan. The strongest influence the Continuum has had on our math teachers is that it provides us with coherence in our approach to improving student achievement, beginning with alignment and ending with analyzing student work as a school. This helped to bring the issue of math achievement to a school level concern, not only one of math teachers alone.*

The MMP has learned that a developmental continuum such as the "MMP Continuum of Professional Work for Mathematics" is a powerful tool for guiding reform. It allows teachers and schools access and entry at various stages, and it clearly delineates a pathway for making incremental progress that supports student learning and classroom instruction.

Formative Assessment Practices

The MMP continuum was our foray into providing guidance for phasing in formative assessment practices. We realized our own understanding was naïve in the early years of the MMP. Early on, we had established assessment committees with the charge to develop model classroom assessments. As part of their regular meetings, we also studied the work of Black and Wiliam (1998; Black, Harrison, Lee, Marshall, & Wiliam, 2004), Clarke (2001), and Stiggins and colleagues (e.g., Chappuis, Stiggins, Arter, & Chappuis, 2005; Stiggins, 2006; Stiggins, Arter, Chappuis, & Chappuis, 2004). This deepened our knowledge of formative assessment and brought us to the realization that our initial work presented a limited view that merely equated giving classroom assessments with doing formative assessment.

Principles of Formative Assessment

We were struck that our perspective had been so narrow and altered our work to be more intentional and explicit by providing teachers with a set of ten principles of formative assessment (Huinker & Freckmann, 2009; Huinker, Kranendonk, & Freckmann, 2012). These principles, drawn heavily from the work of Stiggins and colleagues, are listed in Table 5. With the articulation of these principles, our journey became more focused on classroom practice, and we moved forward in viewing assessment as something that is not done *to students* but rather *with students*.

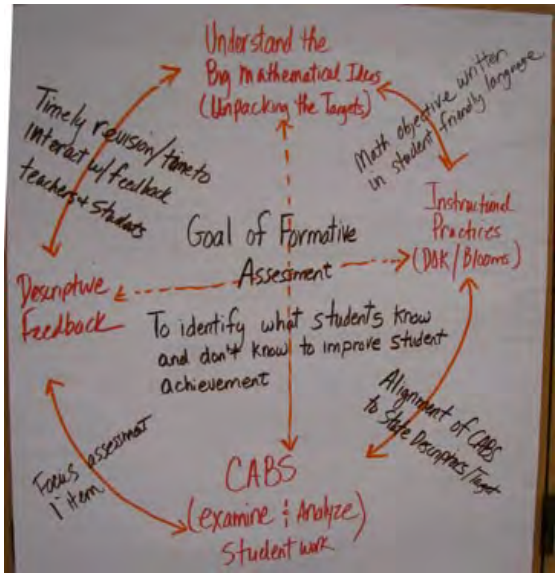
These ten principles were aligned to the MMP Continuum and became a focus of district and school-based professional development. This was an important step for the MMP as we were able to use these principles to more intently center our work on classroom instruction and student engagement and on the interactions of teachers and students in learning mathematics. An MTL commented on the importance of this focus for herself and her staff:

> *Formative assessment was a huge area of growth for me, beginning with watching a snippet of the Stiggins video at one of our MTL meetings. I showed the video to my staff, and we began a year-long journey studying assessments that could be used in the classroom and discussing the need for formative assessment to guide instruction. Teacher buy-in was significant.*

Table 5. MMP Principles of Formative Assessment

Teacher and Student Articulation of Learning Goals	Teacher Focus on Using Assessment Information to Guide Teaching	Student Focus on Using Assessment Information to Move Learning
• Prior to teaching, teachers study and can articulate the math concepts students will be learning. • Teachers use student-friendly language to inform students about the math objective they are expected to learn during the lesson. (W.A.L.T.) • Students can describe what mathematical ideas they are learning in the lesson. • Teachers can articulate how the math lesson is aligned to district learning targets, state standards, and classroom assessments, and fits within the progression of student learning.	• Teachers use classroom assessments that yield accurate information about student learning of math concepts and skills and use of math processes. • Teachers use assessment information to focus and guide teaching and motivate student learning.	• Feedback given to a student is descriptive, frequent, and timely. It provides insight on a current strength and focuses on one facet of learning for revision linked directly to the intended math objective. • Students actively and regularly use descriptive feedback to improve the quality of their work. • Students study the criteria by which their work will be evaluated by analyzing samples of strong and weak work. • Students keep track of their own learning over time (e.g., journals, portfolios) and communicate with others about what they understand and what areas need improvement.

In attempts to move toward formative assessment practices, we learned how difficult it was for teachers to recognize and articulate the important math concepts students need to be learning. It was easy to say students need to learn "multiplication," but not to articulate the important mathematical ideas that students need to understand about multiplication in its representations, its properties, its uses, and its connections to other mathematical ideas. This is where "WALT" joined us on our journey. The MTLs studied the work of Shirley Clarke (2001) on learning intentions and success criteria. She stated, "It is important to post, in writing, the daily goal as a focus for the lesson and to engage the students in considering the objective." Teachers were asked to begin posting their daily lesson goals using WALT, which is an acronym for the phrase, "We Are Learning To." This helped to clarify the purpose of the first four assessment principles on making the mathematics explicit to both teachers and students. At this juncture in our journey, we finally felt as though we had gotten to the heart of instruction, to making instruction intentional and explicit in regards to the important mathematics students should be learning. We had started to shift away from "how" to implement an activity to the critical conversations on the specific mathematical ideas students were to be learning and how teachers and students would know whether they were being learned. As an MTL reflected:



> *WALT has made a huge difference in the math instruction at our school. Who would have thought a guy named "WALT" would have such a profound impact on math instruction. Teachers were reluctant as first to post learning intentions. I had the opportunity to model a lesson in each classroom in the school using WALT. This gave teachers an opportunity to see how to begin the lesson and how to monitor students' participation in class related to the learning intentions and success criteria. As a result, there was a shift in thinking about WALT from something I have to do, to something I want to do. We also had student teachers from UWM in our building this year, who got on board using WALT.*
>
> *The journey began three years ago as I began my work as an MTL. I remember coming to an MTL meeting and hearing about "Learning Intentions" and "Success Criteria." I now post learning intentions and success criteria daily for my students in math, but the more remarkable success is that 58% of the time classrooms in my school have learning intentions and success criteria posted for their students. In my first grade team, the teachers post their learning intentions and success criteria close to 95% of the time. But even better, teachers refer to it throughout their lessons. And even better yet, students know where to look for it and can articulate the math they are learning in their daily lessons because of the posted learning intentions and success criteria. These are by far the most noticeable changes in our building… but we still have a long way to go.*

The focus on informing students about their daily learning goals in student-friendly language, or what has come to be referred to as "WALT," has taken the district by storm. In fact, a set of five universal expectations for all schools was deployed in fall 2011, led by district and regional administrators. One of these included posting learning intentions and success criteria in all schools for all subjects.

Implementation of Formative Assessment Practices

Each Math Teacher Leader (MTL) was asked to reflect upon the level of implementation of formative assessment practices in his or her school. They reported on the practices listed in Table 6 on a scale from "not even addressed" (value=1) to being "institutionalized" as a part of normal, school-wide practice (value=6). Both elementary and high schools demonstrated the highest ratings for the same three principles, which are highlighted in the table. The strong implementation of articulating learning

goals and using classroom assessment information mirrors the emphasis placed on these practices in professional development. Teachers providing students with descriptive feedback and students using that feedback was reported as moderate, indicating a need to involve students more as users of assessment information to guide their own learning.

Table 6. Implementation of Formative Assessment Principles (1=None, 6=Institutionalized)

	Elementary			High School		
Topic	n	Mean	SD	n	Mean	SD
Teachers understand and can articulate in advance of teaching the achievement targets students are to hit.	99	4.27	1.00	24	4.00	0.93
Students are informed daily about the targets in terms they can understand (i.e., student-friendly language) and which clarify what they are expected to learn. Students study the criteria by which their work will be evaluated by analyzing samples of strong and weak work. (W.A.L.T.)	99	4.01	1.08	24	3.75	1.11
Students can describe what targets they are to hit. Teachers can describe what comes next in student learning.	98	3.64	1.00	24	3.42	1.10
Classroom teachers transform those targets into assessments that yield accurate information about student learning of the content.	99	3.90	1.10	24	3.50	0.78
Teachers use classroom assessment information to revise and guide teaching and learning. Students use assessment information in ways that require them to think about their own progress.	99	4.02	1.04	24	3.75	0.79
Feedback given to a student is descriptive, frequent, and timely. Feedback provides insight on a current strength and focuses on one facet for revision linked directly to the intended learning.	99	3.67	1.19	24	3.10	1.06
Students actively and regularly practice using descriptive feedback to improve the quality of their work. Students develop skills of self-assessment to monitor their learning	99	3.16	1.18	24	2.67	0.96
Students keep track of their own learning over time (e.g., journals, portfolios) and communicate with others (e.g., students, teachers, parents) about what they understand and what they need to understand better.	99	2.72	1.20	24	2.75	1.07
Teachers understand the relation between assessment and student motivation and use assessment to build student success and confidence rather than failure and defeat.	99	3.56	1.26	24	3.29	0.91

While implementation was further along in the elementary schools in regards to formative assessment practices, implementation in high school was stronger than expected, particularly for the focus on learning intentions and success criteria. This suggested that the work of the MTLs and learning opportunities for high school teachers (e.g., pilot committees, learning labs, university courses) did influence instruction. This is reflected in the following statement from a high school teacher.

> *The WALT learning intentions and success criteria was something that I began learning at the Algebra and Geometry Labs. Using the WALT format has been helpful in guiding my lessons as I deliver them in the classroom. I have found that the more I use them, the easier they become. I have also learned, more clearly, over the last year how to write them and focus the students' attention on them. The WALT format is also a wonderful way to help the students know what we are doing and what it should look like when we get there. The students now check the board daily to see what we are learning!*

The sustainability of a focus on formative assessment was evident in the inclusion of the ten MMP principles of formative assessment in the *MPS Comprehensive Mathematics and Science Plan* implemented in fall 2011. The implementation of the district differentiation framework (i.e., Response to Intervention) further requires the continued practice of using assessment information formatively to adjust instruction to meet the needs of students.

Part 3
Leading the Way in the School District

Prior to the MMP, a single individual was responsible for oversight of mathematics throughout the Milwaukee Public Schools, namely the K-12 Mathematics Curriculum Supervisor. This person oversaw mathematics for about 200 schools, nearly 100,000 students, and some 6000 teachers. Needless to say, the position was daunting and the math supervisor was often mired in bureaucracy rather than in meaningful issues of improving the teaching and learning of mathematics. The MMP successfully established a model of distributed leadership for mathematics that expanded both district and school leadership for mathematics with important links to its higher education partners.

This section begins with a presentation of our distributed leadership model for mathematics, centered on the establishment of Math Teaching Specialists and Math Teacher Leaders. Then the work of the Math Teacher Leaders in their schools is discussed, along with the MMP Math Action Plans that financed a small part, but provided leverage for a considerable part, of the journey in the schools.

Distributed Leadership for Mathematics

This model acknowledged our belief that leadership practice stretched over organizational structures can be transformative in empowering others to lead school reforms (Spillane, Halverson, & Diamond, 2001) and that specific attention and strategies must be given to mathematics separate from literacy and other subject areas (Burch & Spillane, 2003; Spillane, 2005). Our model for distributive leadership is shown in Figure 2. This model addressed how the work of multiple school leaders is needed to mediate the progress of mathematics instructional reforms and must move beyond an exclusive preoccupation with the principal. Rather, a distributive perspective involves multiple leaders within a school who share in the work of improving the teaching and learning of mathematics.

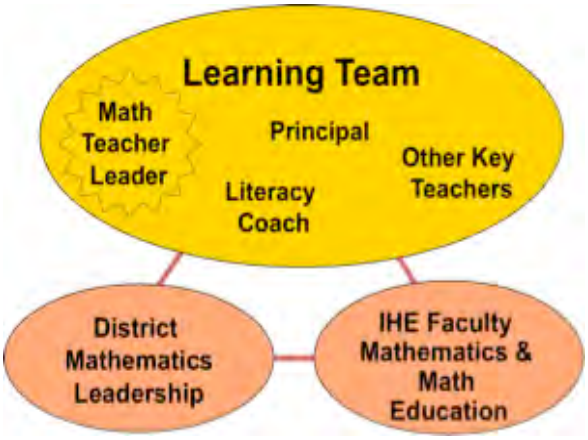


Figure 2. Distributed Leadership Model

A central component of the model was a learning team in each school focused on improving student achievement at its school. These teams were formed the year prior to the MMP with a focus on literacy. In the 2003-2004 school year, each team was expanded to include a Math Teacher Leader (MTL), which was a new position that originated with the MMP. From the start, we firmly believed that the MTL alone, as one single person, could not address all the needs for mathematics within a school. It was our vision and belief that it would be vital to connect the MTL to the structure of a learning team and to engage the entire learning team in bringing about change for mathematics within a school. The MTL focused the learning team on mathematics, ensured a link from the school to the district and to the university and college partners, and generated shared purpose and understanding of the MMP initiatives. The learning teams became key to fostering a school community that could work toward continuous improvement in mathematics teaching and learning.

The MMP also originated a Math Teaching Specialist position to provide additional district-wide teacher leadership for mathematics. These individuals worked under the direction of the Math Curriculum Supervisor. The MMP began with a cadre of six Math Teaching Specialists in 2003, which expanded to ten specialists in 2008. We maintained an essential core group of specialists that provided continuity and stability, even as we experienced change and struggles in regards to other district leadership. A total of 15 individuals served as Math Teaching Specialists throughout the MMP: 3 held the position for all eight years, 2 held it for five years, 7 held it for three years, and 2 held it for two years. Seven of the individuals also served in other teacher leadership roles (i.e., Math Teacher-in-Residence, Math Instructional Coach, Math Teacher Leader) before becoming an MTS.

The specialists provided a critical link from district and partner leadership to the schools through the learning teams and the Math Teacher Leaders. The specialists facilitated critical district-wide and school-based professional development, assisted with development of school improvement plans and math action plans, and guided the analysis of student mathematics performance on classroom assessments, district benchmark assessments, and state tests. The Math Teaching Specialists (MTS) were, without a doubt, an invaluable and necessary element of the MMP. The Math Teacher Leaders (MTL) often expressed their appreciation and admiration of the specialists as illustrated in the following MTL reflections.

The MTS support is a critical piece to the puzzle. A full day every month of training was unheard of in our district, but because of the MTSs, we have very thoughtfully planned training every month to help us do our jobs better so that we can help teachers do their jobs better so that students can learn and achieve.

I have gained so much through the MMP. One of the things is the tremendous network that has been formed. I have learned to ask questions, mentor people, lead people, but most importantly, I have learned leadership of self. I have learned to become a powerful voice in the area of mathematics. I had an awesome math teaching specialist who has been my cheerleader, my mentor, the voice in my head of ethical responsibility, and my friend. She has helped me become the leader I am. I don't know if I would have bloomed into the flower that I am without her.

The other component of our distributed leadership model was the connection to university and college mathematics and mathematics education faculty. We formed a leadership team of university and district leaders that remained essentially unchanged throughout the MMP. This leadership team met at least monthly for eight years to plan and implement MMP initiatives. In addition, higher education faculty worked in collaboration with the Math Teaching Specialists to plan and carry out professional development sessions for Math Teacher Leaders and classroom teachers, to develop classroom assessments and curriculum guides, and to provide direct supports to teachers and math teacher leaders in their schools.

Mathematics Teacher Leader Models

A central strategy of the MMP was the establishment of a mathematics teacher leader position in every school and the inclusion of this individual on the school's learning team. As the voice for mathematics on the learning team, the MTL was a liaison between the school and the district leadership and the higher education partners. The MMP began with our original model of non-released Math Teacher Leaders. As the MTL became a key person in changing the school culture for mathematics, the need to provide more time for the MTL to meet the expectations of this position grew. This resulted in an unprecedented level of support from the State of Wisconsin.

The opportunity arose for the MPS Superintendent, William Andrekopoulos, to discuss the work of the *Milwaukee Mathematics Partnership* with the Governor of Wisconsin, Jim Doyle. This resulted in a special allocation of $10 million in the 2007-2009 state budget to specifically support the work of the partnership by funding approximately 100 released-time Math Teacher Leader (MTL) positions in MPS. However, the passage of the state budget was delayed, thus delaying implementation.

Consequently, the Superintendent included a district budget item of $5 million to begin implementation of this new model in January 2008. State funds were then used to continue the positions during 2008-2009. The special allocation of funds was maintained in the 2009-2011 budget which provided approximately $20 million to continue the positions for two more years. Thus, $35 million was directly leveraged to establish released-time MTL positions in the Milwaukee Public Schools from 2008 through 2011. The state funding, coupled with Board funds, also allowed for the continuation of the district Math Teaching Specialist positions.

Initial Non-released Math Teacher Leader Model (2003-2007). At the beginning of the MMP, teachers were asked to consider stepping forward to provide mathematics leadership for his or her school as a "Mathematics Teacher Leader" or MTL as they became called. The MTL maintained full classroom responsibilities for mathematics instruction, but was released one day a month to attend a training seminar. This person became a member of the school-based learning team and participated in discussions and decisions that impacted the school. Based on the needs and resources of the school, the MTL facilitated grade level, subject area, and staff meetings during or after the school day. Stepping into this role meant that this person would be doing more and working harder. Nonetheless, in fall 2003, nearly 150 MPS teachers undertook this teacher leadership position and embarked on a journey with the MMP that resulted in major shifts of how mathematics was taught and valued in most schools across the district. The non-released MTL model continued through fall 2007, and thereafter, in some schools, as state funding was not sufficient to allow all MTLs to be released.

In general, the MTL would inform the learning team of MMP initiatives who would then decide how to proceed with the information within the culture of its school. This required the learning teams to shift from a focus on literacy to also include a focus on mathematics. At first, many MTLs found it difficult to get mathematics on the agenda. However, their voice became stronger as the MTLs grew in their knowledge of the MMP initiatives and as the district included mathematics on its agenda for learning team training. While we anticipated that the MTLs would focus learning teams on mathematics teaching and learning at their regular meetings, we did not anticipate the extent that learning teams would eventually come to expect and utilize the contributions of the MTL. In general, the MTLs attended MMP monthly seminars knowing they would be expected to report back on information and activities to their learning teams. A ripple effect occurred as the MMP trained the MTL, the MTL informed the learning team, and the learning team guided the work of the MTL in engaging the school staff on issues related to mathematics. While the extent of this flow varied from school to school over the years, it was actualized to some degree in almost all schools.

Released-time Math Teacher Leader Model (2008-2011). In the initial years of the MMP, the MTL was not a released-time position. However, the district literacy coach model was a fully released-time position. It was often asked whether the MTL should also be a full, or at least a partial, released-time position. With the funding from the Wisconsin Office of the Governor, the opportunity arose to redesign our math teacher leader model. The intent was to design a position that would build from the foundation established so far through the MMP and expand the role of the MTL at each school.

First of all, we continued our approach of school-based math teacher leaders; each individual MTL worked within one school and continued as a member of its learning team and part of the school community. Second, we acknowledged that a success from the non-released model was that each MTL was first and foremost a classroom teacher, and that keeping this connection to the classroom was important. Thus, we took a strong position and insisted that MTLs maintain direct and regular contact with students and be responsible for student learning of mathematics, thus practicing "Leadership of Self" while becoming skilled in "Leadership of Others" (NCSM, 2008). Third, it was recognized that is was difficult for the MTL to meet the needs of staff and the district and still maintain a fulltime role as a classroom teacher. This resulted in our released-time model which required the Math Teacher Leaders to remain engaged as teachers of mathematics for 20 percent of their day and to work with teachers and staff members in improving mathematics instruction for the remaining 80 percent of their day.

Stability of the Math Teacher Leader Cadre

The MMP has been extremely fortunate to have had such an amazing group of dedicated and passionate Math Teacher Leaders (MTL) who were willing to embark upon this journey with us. The road was often bumpy, the map was difficult to follow, and we encountered the occasional detour. Yet, despite changes in the MTL model and school organizational structures, we had many MTLs who remained in the position for several years, some even for all eight years.

Changes in school structures were particularly challenging over the years as teaching staffs shifted to accommodate organizational variations. Many small high schools were created in the early years of the MMP only to be reconstituted back into comprehensive high schools in the later years. Many elementary schools added middle grades and became K-8 schools, which resulted in many traditional middle schools being closed. Due to decreases in the student population, a number of elementary and high schools were also closed. Thus, the number of targeted MMP schools ranged from an initial high of 167 schools to a final count of 140 schools.

It was impressive to us to have a solid core of 27 MTLs who held the position for all eight years. Table 7 shows the number of years MTLs held the position. Our veterans, defined as those who held the position for four or more years, comprise 28 percent of the entire cadre. In fact, 42 percent of the high school MTLs and 41 percent of the K-8 MTLs held the position for three or more years. We expected some turnover in the MTL positions and even planned for it by developing opportunities to develop teacher leadership through other venues, such as assessment pilots, math committees, and even UWM courses. Over the lifespan of the MMP, a total of 457 individuals held an MTL position. To us, this represents an astounding number of teachers who developed leadership content knowledge for mathematics and whom the district can continue to count on for years to come.

Table 7. Number of Years Teachers held a Math Teacher Leaders Position

Number of Years in MTL Role	K-8 Math Teacher Leaders		High School Math Teacher Leaders		Total Math Teacher Leaders	
	n	Percent	n	Percent	n	Percent
1 year	135	35.1%	23	31.9%	158	34.6%
2 years	92	23.9%	19	26.4%	111	24.3%
3 years	48	12.5%	11	15.3%	59	12.9%
4 years	43	11.2%	9	12.5%	52	11.4%
5 years	20	5.2%	1	1.4%	21	4.6%
6 years	14	3.6%	4	5.6%	18	3.9%
7 years	9	2.3%	2	2.8%	11	2.4%
8 years	24	6.2%	3	4.2%	27	5.9%
Total	385		72		457	

With the approval of state funds and additional district funds for the MMP, the released-time MTL model was set into action during the 2007-2008 school year. An application process was established for schools to be considered for the new MTL model as funds were insufficient to include all schools. The school year began with strong continuity as many MTLs continued in their non-released position from the previous year. However, some MTLs did not want to leave their classrooms and chose not to continue under the new model. A total of 106 schools made the transition to the released-time MTL model in spring 2008. In 65 percent of these schools, the MTLs also made the transition to the released-time position. The other schools identified a new individual as its MTL. An additional eight schools were approved to begin the new model in fall 2008. For the final three years of the MMP from 2008 to 2011, approximately 110 of the targeted schools had a released-time MTL position and about 35 schools continued with a non-released MTL.

Evolution of Teacher Leadership for High School Mathematics

The MMP leadership model for high school mathematics evolved over the years. The initial model at high school was different than that at the K-8 level. At the elementary and middle school levels, one person was designated as the Math Teacher Leader (MTL) and became a member of the school learning team. These MTLs had monthly professional development seminars separate from the high school leaders. The eventual design of teacher leadership for high school mathematics resulted in a model that was essentially the same as that in elementary and middle schools, including joint K-12 seminars that brought all the MTLs together each month for professional learning.

Our goal at the high school level was to distribute leadership for mathematics among more teachers and move beyond the traditional model of the mathematics department chair being “the” leader. In our original model, the leaders at the high school level were the Department Chair, the Assessment leader, and the Foundational Level Network leader. While this increased the number of high school teachers involved, the role of each leader was not always clearly established. In addition, sometimes a teacher would assume more than one role. This was particularly problematic with the emergence of many small high schools and increased numbers of district charter schools and partnership schools which may have had just a few math teachers in the entire school.

By 2006-2007 (MMP Year 3), we had adjusted our model and now asked all schools to identify an individual as its Math Teacher Leader, using this title across all K-12 schools. This MTL role was sometimes a single individual in a school and sometimes it was shared between a teacher and the math department chair. This shared role sometimes still resulted in conflicting messages and responsibilities. Perhaps the greater challenge was the large variability of needs among the high school MTLs depending upon whether they were in a comprehensive high school or a small high school and our struggles in addressing their varied needs in joint professional development sessions.

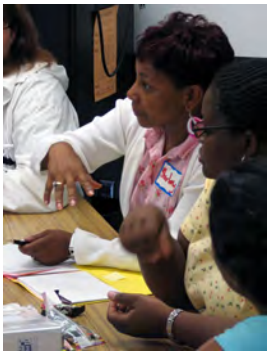
In 2007-2008, we had two major shifts. First, we identified grade 8 and 9 pilot leaders who had separate meetings and defined responsibilities to work on bridging the gaps across these two grades. Second, some high schools shifted to a released MTL model along with the K-8 schools during the spring semester. This released MTL was to be an individual other than the department chair. This allowed the MTL to focus on supporting instructional practice, while the department chair continued to carry out course scheduling and administrative duties. In some schools these separate roles conflicted, whereas in others it was not an issue as they either worked well together or the school no longer had a department chair position such as in the smaller schools. For the next two years (MMP Years 7 and 8), we continued with both released and non-released MTLs at the high school level, while further refining and guiding their work with a more district-wide K-12 vision for mathematics.

While the yearly MMP Kickoff in late August included all K-12 math leaders, the monthly MTL seminars had only involved the K-8 MTLs for many years. In general, the MTL seminars were comprised of three strands—leadership, assessment, and content. Some high school MTLs wondered why they did not continue to meet as a K-12 group during the school year and have similar focused professional development for their role. While we tried to replicate some of the sessions during after school meetings with the high school MTLs, the time was too limited. Finally, in 2009-2010 (MMP Year 7), we began holding monthly K-12 MTL seminars. This posed some organizational issues with the increased number of MTLs and the increased grade range, but overall it was a success to have elementary, middle, and high school MTLs working together each month. Sometimes we split the content sessions into a K-6 group and a Grades 7-12 group, and other times we kept them as combined groups depending upon the specific content topics.

We surveyed all the MTLs at the end of this year and the majority wanted to continue with combined K-12 monthly seminars. The MTLs said it was beneficial to hear the perspectives and questions of the teachers at the other grade levels. The high school teachers grew in their respect and appreciation of the work of elementary teachers, and vice versa. One MTL commented that the combined seminars "gave us a sense of unity across the district for mathematics." Another MTL noted, "It really felt like a K-12 district mathematics effort this year."

Summary Comments

Many MTLs reported that they finally had the time to truly promote the vision and work of the MMP with the shift to a released-time Math Teacher Leader (MTL) position. For example, they acknowledged that they could now work with other teachers regularly by meeting with grade-level groups or math committees and by modeling lessons in classrooms. However, it was still our perspective that it was valuable to begin with a non-released MTL model before transitioning to a released-time model. This provided time for the MTLs to build knowledge and skills as a teacher leader for mathematics. It also provided time to generate a willingness and acceptance on the part of school staffs to engage in more focused work on mathematics. In retrospect, we acknowledge it might have been beneficial to have made the transition to a released-time MTL model earlier in our program work. We asked the teacher leaders and principals to reflect, in writing, on the value of having an MTL that was released. Here were just a few of the many powerful and moving statements we received from two math teacher leaders and two principals.



The released MTL position has made a world of difference in our school. Prior to the MTL position being released, our math program and instruction were in shambles and our test scores reflected that. We have been able to devote time to data, analyzing student work, assessments, instructional practices, math knowledge for teaching, and so on. We have changed so much throughout the course of the past 2.5 years (since the MTL was released) and we are beginning to see the results in the data—our student scores went up 13 percentage points on our WKCE this year alone! Although changes have begun happening, there is still a LONG way to go and a LOT to continue working on and improving. We've only just begun our journey and without the released position, I fear that we would not be able to continue the work that we as a school have started. –MTL

As a released MTL, I am able to see the how math is being taught at all grade levels and identify problems as well as successes. I have the time to plan strategies for improving instruction and assessment. I am also able to work with teachers on creating lessons that engage students in the mathematics they are learning. This year, I have been able to facilitate math grade-level planning sessions during the school day. These sessions have been extremely successful because I have been able to provide professional development to all the math teachers in my school. This is something that I could never have done as a full-time classroom teacher. –MTL

As a released MTL, I have been able to devote time and effort in bringing together math teachers at different grade levels to discuss and implement our curriculum. Without the extra time made available, there would

have been very little communication between the "teachers in the trenches" and the research-based developments promoted by the MMP. I have been able to help teachers, not just getting this information, but also discussing and implementing the initiatives. My work as an MTL has also had a strong influence on my personal growth as a teacher, as I have been able to implement the various teaching strategies learned at the monthly meetings. This has then allowed me to model them for the other math teachers in my school. –MTL

I am fortunate to have the benefit of a released MTL. She has the flexibility to visit classrooms, observe instruction, and reflect with the teachers to improve instruction. She can watch the progression of the "Big Math Ideas" over the grade levels. She has planned and facilitated cross-grade level meetings which gave teachers the opportunity to see the math content their colleagues teach at prior and subsequent grade levels. Teachers have commented about the benefit of these discussions. They also are now teaching math concepts and big ideas rather than page numbers. My MTL was a driving force in getting teachers to post learning intentions which helps to focus the lesson for the teachers and the students. We are making progress in our math scores, but still have a long way to go. –Principal

The role of the MTL is key to the successful academic gains at the district level (and in my school). In just 2.5 years at my school with a released MTL, we experienced "double" digits gains in our WKCE scores. The MTL is in the classrooms every day. She conducts grade-level meetings. The math dialogues never cease. Every teacher seems to enjoy teaching math. The MTL has built a math culture in the building. The district must do whatever it takes to have an MTL in everyone of our schools. It is the very least we can do for all of our students. –Principal

Initially, fulltime classroom teachers willingly assumed extra responsibilities and assumed the Math Teacher Leader (MTL) positions. During the fourth year of the Partnership, additional funding from the State of Wisconsin allowed many of the MTL positions to be funded as a released-time position. The introduction of the released-time model presented challenges and opportunities for the teacher leaders. Their role shifted from being a classroom teacher with some leadership responsibility to being a school-wide teacher leader with a limited teaching assignment. This shift forced the MTLs to broaden their own understanding of the depth and breadth of the world of mathematics. Many MTLs had stark realizations, "I was asked to help out in an eighth grade classroom…I was scared to death! But, I took the lesson home and studied it and did the best I could. I realized that I can get eighth grade students to think effectively and showed the teacher how to manage it with eighth graders." With the shift in the role of the MTL, came a corresponding need to adjust the work of the Math Teaching Specialists and some of the initiatives of the MMP.

These positions, the Math Teacher Leader and the Math Teaching Specialist, continued to be valued and supported by the district beyond the eight years of the MMP, although the number of positions and the scope of their work has changed due to significant budget cuts. The MMP initiated these positions and supported the development of hundreds of individuals as teacher leaders for mathematics, and they remained a significant force within the current structure of the district to continue the improvement of mathematics instruction and student learning.

The Work of Math Teacher Leaders

The Math Teacher Leader (MTL) was designed to be the point person at each school for addressing mathematics instruction. The Partnership focused on providing extensive MTL training in the key pillars of mathematics content, leadership, and formative assessment. Resources were developed that provided the tools, guidelines, and models to support MTL work at their schools. The MTL cadre was an amazing group of teachers whose vision was focused on improving the quality of teaching at their schools that would lead to increased student achievement of mathematics.

TASKS AND RESPONSIBILITIES OF THE MTL POSITION

The Math Teacher Leaders (MTL) were asked to reflect on their daily work as an MTL, and then indicate how confident they were in carrying out the tasks and responsibilities listed in Table 8. The five highest rated tasks are highlighted in the table for each MTL group. In general, the elementary MTLs were more confident in their work than the high school MTLs, which reflects our stronger emphasis initially at the elementary level. Nonetheless, the fairly strong ratings at the high school level reveal a cadre of teachers leaders ready to continue the challenging work of improving student learning at this level.

Table 8. Confidence in Doing the Work of an MTL (1=Not at all confident, 6=Totally confident)

	Elementary MTLs			High School MTLs		
Topic	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Facilitating grade-level meetings, grade-band meetings, study groups, or staff development at your school.	99	5.21	0.94	24	4.00	1.47
Participating in school policy development designed to improve mathematics achievement.	99	5.10	1.06	23	4.61	1.16
Supporting the collaborative review of student assessment data in mathematics to identify math teaching and learning priorities.	99	5.08	1.01	24	4.33	1.05
Facilitating and supporting professional development in mathematics for the teachers in your school.	99	5.06	1.07	24	3.92	1.50
Supporting teachers to engage in collaborative analysis of student work samples in mathematics to inform their instructional decisions.	98	5.01	1.08	23	4.26	1.14
Communicating MMP activities, strategies, and priorities within your school.	98	4.88	0.94	23	4.17	1.27
Modeling effective math lessons in all grade levels in your school.	99	4.87	1.12	23	3.91	1.24
Assisting mathematics teachers in planning and reflecting on their math lessons.	99	4.87	1.12	23	4.22	1.00
Promoting a professional learning community in mathematics in your school.	98	4.83	0.93	24	4.29	1.27
Successfully fulfilling the roles and responsibilities as the Math Teacher Leader in your school.	99	4.80	1.06	24	3.83	1.27
Coaching teachers to improve their mathematics instruction.	97	4.39	1.07	23	3.70	1.15
Discussing and problem solving equity issues with colleagues in the school.	99	4.39	1.04	23	3.91	1.31
Coaching teachers in deepening their mathematics content knowledge.	99	4.23	1.06	23	3.65	1.11

The highest rating for elementary MTLs was facilitating the professional learning of teachers in their schools; this was also fairly high for high school MTLs. The second highest rating for elementary MTLs and the highest for high school MTLs was participating in the development of school policies to improve mathematics achievement. Both groups had strong confidence in working with teachers to collaboratively analyze student work and use it to inform instructional decisions.

These results showed that the MTLs had clearly evolved from their tentative stance in wondering what their work entailed to becoming leaders in their schools for mathematics and for establishing professional learning communities for mathematics. School principals have also repeatedly reported on their appreciation of the MTLs and have indicated how leadership for mathematics has been distributed across multiple leaders in their schools, as illustrated in the following comments:

> *I use my MTL as an instructional leader. We meet daily to discuss where each grade level needs support, how teachers are using data, and how we are impacting students' proficiency levels in math. As a principal, I couldn't survive without our MTL input and our students lives would be negatively impacted. –Principal*

The Math Teacher Leader has positively impacted students, teachers, and parents. She team-teaches with teachers, modeling and planning with them. This enables the teachers to learn appropriate strategies and techniques to increase student achievement, and while team-teaching, the students are being taught using best teaching strategies. The students also benefit by having two adults to help them. The MTL and teachers study student work from CABS to determine students' strengths and weaknesses and to plan their lessons accordingly. Test scores have improved; the students are excited and highly motivated. The MTL also offers professional development to all staff and is able to discuss student work with the students and teachers. The collaboration is invaluable and what truly brings change in teaching habits. –Principal

MMP Math Action Plans

An unanticipated, critical element of the MTL work was the MMP math action plans. These action plans provided a stronger than expected leverage for the MTLs in focusing their schools on mathematics. The action plans required learning teams to sit down and work together to develop a vision and plan for mathematics in their schools. Upon approval by the MMP, the school received additional funds to engage teachers in professional learning and support the work of the MTL. The guidelines and priorities for the action plans were established by the MMP leadership team each year. The plans became a driving force to focus the work of mathematics at school sites. Learning teams, along with their Math Teacher Leaders (MTL) and input from their Math Teaching Specialists, identified a focused set of strategies each year based on the needs of their individual schools. Then a timeline was developed to implement the strategies to move their staff forward in improving the teaching and learning of mathematics.

The enthusiastic reaction of learning teams to the action plan initiative was something of a surprise, given that the amount of funds available each year was relatively small, ranging from $1000 to $3500 per school or a total of approximately $150,000 per year. The money compensated teachers to meet before or after school, or was used to hire substitute teachers so staff members could be released from their regular classroom responsibilities to engage in professional learning sessions. The action plans, as leverage, influenced schools to use existing contracted staff meetings and professional development days for mathematics and to utilize their Title I funds for mathematics.

For many schools this money enabled them to influence important conversations among teachers. The first priority in using these funds was often to support the implementation of the MMP Continuum of Work for Mathematics as teachers studied the mathematics of the learning targets, held grade level meetings to discuss the mathematics embedded in classroom assessments, used the MMP protocol to examine student work, or to write descriptive feedback. In addition, the funds were used to ensure that the school learning teams were able to meet and discuss the mathematics work of the school (e.g., analysis of student performance on common classroom assessments, benchmark assessments, and on state tests). The importance of these plans over the years is best expressed by the MTLs themselves:

We [our Learning Team] have completed the first and important step and that is finishing our Action Plan! This has helped us to really get the ball rolling in the right direction. It is seeming to be more accepted that I am now a part of the learning team. Our biggest achievement seems a little simple, but means a lot! The administration is recognizing the importance of focusing on mathematics and is beginning to see how much work we have to do! At times, it seems as if we are turning our wheels doing a lot of talking and not a lot of working. I am excited to go ahead with our action plan and get people in our building really excited about teaching math! (MTL, Year 2)

Through the action plan we set aside time for teachers to get paid to examine student work, discuss the mathematics involved, and give good descriptive feedback to their students. This year our work became even more focused as we decided to concentrate on only one math strand. The strand we chose was measurement (including some geometry, naturally) which overall was our weakest strand according to our state test data. This conveniently aligned to the work we were doing at the district level [the MMP content focus for the year]. This continued work is proving to be effective. Classroom teachers have shared how well their students are doing on benchmark assessments, hopefully directly linked to the work we have been doing. (MTL, Year 4)

The action plan has given us the opportunity to share and conference with each other at different grade levels. That time has brought understanding among each other in ways that we see students work. It has given us the opportunity to get better at an "effective" way of telling the students what they are good at and how they can improve through descriptive feedback. (MTL, Year 5)

I would say that the most powerful example of MMP impact in our school has been an increase of over 10 percentage points in our state test scores for math, including an increase of 20 percentage points in the 8th grade. Without the support and resources provided by the MMP, this type of improvement would not have been possible. Although it would be impossible to single out only one reason for these improvements in student performance, there are numerous examples that are representative of the impact the MMP has had in our school. One focus at the monthly MTL meetings had been descriptive feedback on the constructed response (CR) items on the benchmark assessments. Over the past two years, our math department has been able (due to action plan money) to meet after school to analyze, score, and provide feedback on these assessments. This helped teachers to assess their students' needs and plan instruction. This year, our focus was on doing more to include students in this process. After attending the monthly MTL meetings at which the benchmark CR items were discussed, I was able to return to school, meet with the other math teachers to discuss the CR prompts, and then plan a lesson that would involve having the students assess their own work after looking at a scoring rubric as well as other student work samples. I feel that this alone has greatly improved our students' abilities to perform both on high stakes tests as well as embedded classroom assessments. (MTL, Year 6)

Action plan monies have been very valuable to me and my high school. This money allowed the math department to meet on a regular basis to discuss pacing, CABS, create common lessons, create common final exams, and just time to collaborate as a department. We are not given time during the day to collaborate with each other and we don't share a common prep so the meeting time after school was important to us. The conversations that take place are so important in improving math and moving forward. (MTL, Year 8)

Part 4
Fueling the Journey with Teacher Learning

The engagement of teachers in studying the mathematical knowledge needed for teaching fueled the MMP journey. The MMP developed and supported numerous opportunities to engage teachers and teacher leaders, as well as administrators, in professional learning centered on mathematics. Throughout all of these opportunities, we situated professional learning in the *practice of teaching* (Ball & Cohen, 1999). In this view, the everyday work of teaching became the object of on-going investigation and thoughtful inquiry. Rather than learning content and theories with the hope of applying them to instructional practice, teachers were developing an understanding of subject matter, of pedagogy, and of students through inquiry into and collaboration on tasks that were part of their mathematical teaching practice (Smith, 2001). The sites of practice that became prominent in deepening teachers' understanding of mathematics through the MMP were: (1) grade-level math learning targets for students; (2) learning intentions and success criteria; (3) alignment of curriculum to state standards and assessment descriptors; (4) classroom assessments based on standards; (5) levels of thinking, both domains of knowledge and cognitive demand; (6) big ideas in mathematics; (7) collaborative analysis of student work samples in math; and (8) descriptive feedback.

The MMP established three pillars of professional learning for the Math Teacher Leaders (MTL). Certainly the most critical pillar of their learning was developing content knowledge for leading through the sites of practice. A second important pillar of study were principles and practices of formative assessment. The third pillar was teacher leadership development and was vital in strengthening their understanding of working with and leading among peers. This included studying adult learning as a process (e.g., Concerns Based Adoption Model) and studying school change as focused on building relationships (Fullan, 2004). The MTLs also studied stages of leadership action (NCSM, 2009), which became part of our language and expectations. The first stage was particularly important, "Leadership of self." In other words, it was essential that the leader be respected for her or his own teaching and learning skills, which required the leader to be knowledgeable and to model the specific strategies being developed, prior to and in connection with stage two, "Leadership of Others."

The energy that powered the MMP journey arose from the synergy of the learning of classroom teachers and the learning of math teacher leaders. This section begins with a discussion of the development of mathematical content knowledge for leading of the Math Teacher Leaders. Next is a summary of the UWM-MMP professional development courses that enrolled approximately 1500 teachers and administrators in sustained study of mathematical knowledge for teaching, along with a summary of related UWM professional development projects that provided additional opportunities for sustained and intense professional learning. Then the momentum for high school mathematics is described through the evolution of professional development for high school teachers and the unified, district-wide textbook adoption.

Mathematical Knowledge for Leading

The theoretical perspective driving our work in deepening the mathematics content knowledge of teacher leaders has been that of the mathematical knowledge needed for teaching (Ball, 2003; Ball & Bass, 2003). We firmly believed that the MTL work would require not only knowing the mathematics, but knowing it in ways that makes it useful for teaching and for leading (Huinker, 2011). Our elementary leaders were generalists and needed to deepen their mathematics knowledge. Our high school leaders were mathematics teachers and needed to expand their instructional strategies. Both groups needed to better understand and make use of mathematical connections, representations, and explanations, and be more aware of students' developing conceptions and misconceptions.

Mathematics Content Strands of Study

We strategically selected strands for concentrated study each year by our cadre of Math Teacher Leaders (MTL) while continuing to address the proficiency areas in our Comprehensive Mathematics Framework. While the specific strands were selected to deepen the content knowledge of the teacher leaders, the strands also became a unifying theme for further learning by teachers throughout the district. For example, as the teacher leaders studied algebra, so did "the district" as numerous professional learning opportunities were reflective of the direction set in the teacher leader seminars. The strands of study were mathematical processes (MMP Year 1), rational numbers and operations with fractions (Year 2), algebraic relationships (Year 3), measurement and geometric reasoning (Year 4), probability and statistical reasoning (Year 5), foundations for algebraic thinking (Year 6), rational numbers and proportional relationships (Year 7), and Standards for Mathematical Practice (Year 8).

The MTL content sessions at their monthly seminars were developed and facilitated by a team that included university mathematics faculty and mathematics educators, teachers-in-residence, and district mathematics teaching specialists. The composition of our team allowed us to draw upon our expertise and experiences to develop sessions that connected the rigor of the mathematics with the practice-based needs of teacher leaders. In fact, we believed this connection between mathematical rigor and practice was essential for deepening the mathematical knowledge of our teacher leaders.

In addition, we chose to identify big ideas central to the learning of each mathematics strand that allowed for connections and commonalities across grade levels and topics (Charles, 2005). In this way, we were able to develop a sense of mathematical coherence and interconnections in order to have rich mathematical conversations with teachers at all grade levels. The following comments by the teacher leaders reflect the value they attributed to the deepening of their content knowledge and the importance it held as essential to their effectiveness as leaders.

As I develop my understanding of math content, especially the knowledge that reflects the focus of our MMP trainings, I find I am better able to field questions, provide strategies, and move my staff in a direction that reflects the core ideas and goals of the MMP.

I cannot find the right words to really express how much I have grown in my math knowledge in the past eight years. My ability to question students at a variety of levels regarding their understanding of fractions has improved greatly. I know where students need to be five or more years past their current grade level. I can push students forward in their individual thinking because I now know what is needed in the next grade or three grades ahead. I am no longer locked into the learning in my own grade.

When I was in school, I was taught procedures to follow for solving math problems. My teachers never taught me to think about the content behind the procedures. The MTL program made me step outside of my procedural comfort zone and really engage in the math. This happened at my first MTL meeting. We were comparing fractions, but we were not allowed to use a paper and pencil to do it! All of my math anxiety from grade school came back and I thought that I was not cut out to be an MTL. Now, however, after many years of learning new ways of looking at math, I feel confident and flexible in my mathematical thinking.

GROWTH IN MATHEMATICAL KNOWLEDGE FOR TEACHING

We administered pretests and posttests to study the impact of our professional development on the content knowledge for teaching of the MTLs. In MMP Years 2, 3, and 4, we selected items to construct scales specific to the content focus from the Learning Mathematics for Teaching (LMT) project at The University of Michigan (Hill & Ball, 2005; Hill, Rowan, & Ball, 2004). The test results were converted to ability estimates using a two-parameter item-response-theory (IRT) model. The results are shown in Table 9. The MTLs demonstrated significant gains in each area tested.

Table 9. Results on Mathematical Knowledge for Teaching Assessments

		Pretest	Posttest	Change	t-value	Sig
Topic	n	Mean (SD)	Mean (SD)	n	Mean	SD
Number and Operations (MMP Year 2)	78	0.17 (1.07)	0.59 (1.27)	0.42	4.14 (df=77)	0.001
Patterns, Functions, and Algebra (MMP Y3)	107	0.02 (0.78)	0.32 (0.81)	0.30	5.58 (df=106)	0.000
Geometry and Measurement (MMP Year 4)	79	-0.10 (0.78)	0.34 (0.81)	0.44	7.70 (df=78)	0.000

As items were not yet available in the area of statistics and probability from the Michigan project, we used an instrument from the diagnostic mathematics assessments developed at the University of Louisville in MMP Year 5. The assessment measured four types of knowledge in the domain of statistics and probability: (1) declarative knowledge, (2) conceptual understanding, (3) problem solving and reasoning, and (4) mathematical knowledge for teaching or pedagogical content knowledge. The MTLs made statistically significant ($p<0.000$) gains for each type of knowledge in the domain of statistics and probability with the greatest gain on mathematical knowledge for teaching.

The MTLs were also asked to reflect upon the impact of the MMP on deepening their content knowledge and on improving their instructional effectiveness. The results are shown in Table 10. Of the elementary MTLs, all but two percent agreed that their content knowledge had been deepened (mean=5.73) and that they improved their instructional practice (mean=5.74). Notably, 84% indicated strong agreement in both areas. Similarly, most of the high school MTLs reported that their content knowledge (mean=5.00) and instructional effectiveness (mean=5.05) had been strengthened. This unmistakably showed that the MTLs judged themselves as having grown in their knowledge of mathematics, as well as their effectiveness as a teacher of mathematics.

Table 10. Impact on MTL Mathematics Content Knowledge and Instruction

	n	Mean	SD	Level of Agreement					
				1 Strongly Disagree	2 Disagree	3 Somewhat Disagree	4 Somewhat Agree	5 Agree	6 Strongly Agree
To what extent do you agree with the following statement: I have deepened my mathematics content knowledge over the years of the MMP.									
Elementary	99	5.73	0.82	2%	0%	0%	3%	11%	84%
High School	22	5.00	1.23	5%	0%	5%	14%	36%	41%
Combined Total	121	5.60	0.95	3%	0%	1%	5%	16%	76%
To what extent do you agree with the following statement: I have become a more effective teacher of mathematics over the years of the MMP.									
Elementary	99	5.74	0.80	2%	0%	0%	2%	12%	84%
High School	22	5.05	1.21	5%	0%	0%	23%	27%	46%
Combined Total	121	5.61	0.93	3%	0%	0%	6%	15%	77%

SUMMARY COMMENTS

Throughout our work, the MMP has strived to build the capacity of schools for continuous improvement in mathematics. When we began our work with the teacher leaders in spring 2004, we met with some initial resistance to studying mathematics content as a discipline. We explicitly stated that the purpose of the content sessions was to deepen and extend their own knowledge of mathematics as learners. This resistance was short-lived as the "content sessions" soon became a highlight of our monthly teacher leader seminars.

We learned that the identification of a mathematics theme for each year of our partnership work was beneficial in several ways. First, it gave sustained focus over nine months to examining and deepening the teacher leaders' mathematical knowledge. Second, it gave focus to engaging teachers at school sites in examining the topic throughout the year. Third, it allowed time to examine this content area within the context of practice—curriculum, daily lessons, assessments, and student work.

The learning at school sites often flowed directly from the training of the math teacher leaders during their monthly seminars. Beyond the more obvious aspects of leadership practice such as conducting a workshop for other teachers, the teacher leaders also reported more subtle yet perhaps more powerful influences of their deepened content knowledge. These subtle changes were apparent in what they noticed in their conversations with other teachers, what they noticed as they visited classrooms or co-taught with other teachers, in their interactions with students, and in the analysis of student work. For example, several teacher leaders remarked that they now noticed when teachers implied that the equal sign means where to put the answer or when teachers strung together expressions that were not equivalent, and were able to have conversations with them and their students about viewing the equals sign as showing how two quantities have the same value. As the math teacher leaders were deepening their content knowledge, they were also utilizing this learning as part of their leadership practice in schools. The work of the MTLs has been embraced and applauded by teachers throughout the district, as exemplified in the following comment by a classroom teacher.

> *The impact that the MMP has had on my school is due to our MTL. She was a teacher in my building as well as the MTL. She loves math and everyone in our building knows it. Her second grade students were thrilled about learning math as she always made it meaningful and enjoyable for them. She has been our MTL for several years, attends their monthly training, and has taken several of the UWM classes offered by the MMP. She organizes all of our teacher professional development in regards to math in our school. Now that she is released, she models math lessons and works with us in our classrooms. She brings her excitement for math to our Learning Team meetings and spreads it throughout the building. –Classroom Teacher*

UWM Professional Development Courses and Projects

The sustained and ongoing professional learning of the Math Teacher Leaders was critical to their work as leaders in their schools. However, it was also vital that teachers have opportunities to learn and grow as professionals. While the school-based sessions contributed to the learning of teachers in important ways, these were often more limited in terms of time and depth. Thus, another important source of energy for the journey were university courses and related grant projects offered through the University of Wisconsin-Milwaukee (UWM).

UWM-MMP Courses

The MMP offered university courses each year through UWM for teachers and administrators in the Milwaukee Public Schools. These courses focused on deepening mathematical knowledge for teaching and strengthening mathematics instructional and formative assessment practices. The coursework ignited a fever of interest that spread from school to school over the years. Teachers would inquire about and anxiously await the course announcement each semester so that they could fax in their applications. Course sections often filled within a few days of the release of the applications. When possible, we added additional course sections or moved a course to a larger room to accommodate more teachers, while still having to turn some teachers away nearly every semester. Teachers embraced the opportunities to further their learning with colleagues and respected the contextualization of course content to MMP goals, district initiatives and needs, learning expectations for students, and opportunities to do mathematics. The target audience was, for the most part, classroom teachers of mathematics, but often our Math Teacher Leaders enrolled to further their own knowledge and practices or to work more closely with school colleagues. The value of the courses can not be overstated as emphasized in this reflection from a veteran math teacher leader.

The biggest change I saw in the knowledge of mathematics and the teaching of mathematics in my school was through those teachers who took advantage of the excellent UWM courses offered by the MMP. Once a teacher enrolled in one MMP course, that teacher usually continued trying to take at least one credit a semester. Teachers in those classes brought new ideas to me, the MTL. They were excited about what they were learning about their own students and about mathematics in general. They tracked me down and showed me student work, asked questions about implementation of the concepts in the class, and shared their learning. I found that this professional development, in the context of an earned university credit, had the strongest impact in changing teachers. They became more analytical of their lessons and of student responses. The sheer number of classes, the fact that they were usually only one or two credits, and the repeating of sessions throughout the years provided consistent training to a large number of teachers. The added incentive of no cost to the teachers taking the classes, encouraged some teachers who normally may not have chosen a math class to attend. Thank you so much for the outstanding credit program run through the MMP in partnership with UWM.

The UWM-MMP courses were, for the most part, developed and offered as special topic courses specifically to support the goals of the MMP. Figure 3 provides a sample of course topics. The courses ranged from one to three credits. The courses were often co-taught by a UWM faculty or staff member and a district classroom teacher. This ensured the course content was leading-edge and emphasized rigorous and challenging mathematics, yet was relevant, practice-based, and contextualized in the needs of urban schools.

Communication and Reasoning in Mathematics	Algebraic Relationships and Reasoning
Teaching Fraction Concepts and Computation	Making Sense of Statistical Studies
Number and Computation Development	Teaching Geometry and Spatial Reasoning
Standards-based Mathematics in Kindergarten	Lenses on Learning: Instructional Leadership in Mathematics
Number Development of Special Education Students	Teacher Leadership in Mathematics
Developing Mathematical Ideas: Working with Data	Common Core State Standards in Mathematics: Grades K-5, 6-8, and 9-12
Developing Mathematical Ideas: Measurement	
Mathematical Explorations for Teachers	

Figure 3. Sample of UWM-MMP Professional Development Course Topics

Over the eight years of the MMP, approximately 1500 different teachers and administrators enrolled in the UWM courses for a total of 3068 participations and collectively earned 4086 university credits, as shown in Table 11. This was a mean of 384 enrolled participations and a mean of 511 credits earned per year. The majority of teachers enrolled in one or two courses with some taking three or more courses for a mean of 1.9 courses (SD=1.32) per teacher. It was interesting to note that almost all schools in the district had teachers who participated in the courses. A total of 173 different schools were represented in the courses over the years with a mean of 8.4 (SD=6.02) teachers per school enrolling in at least one course.

Table 11. UWM-MMP Professional Development Courses

Year	Number of Courses	Number of Participations	Credits Earned	Number of Schools	Amount of Tuition Waived
2003-2004	8	157	212	74	$45,000
2004-2005	14	300	346	97	$73,000
2005-2006	17	399	505	103	$121,000
2006-2007	29	654	810	125	$208,000
2007-2008	28	603	875	127	$232,650
2008-2009	15	375	462	111	$128,000
2009-2010	13	273	451	107	$131,000
2010-2011	12	307	425	118	$133,000
Totals	136	3068	4086	---	$1,071,650

As mentioned, administrators as well as teachers enrolled in the MMP courses. Sometimes administrators enrolled in a course with their teachers or joined a course for their own learning. We also offered courses explicitly for administrators utilizing the *Lenses on Learning* course materials developed at the Education Development Center (EDC). The administrators usually met twice a month throughout the school year to study classroom practices that aligned with the MMP *Comprehensive Mathematics Framework* and to examine their role in providing math instructional leadership and supervision. Over 100 administrators enrolled over the eight years, most participants being principals and assistant principals, as well as some curriculum generalists and supervisors. As these administrators developed new lenses for observing math classrooms and rethought the nature of their mathematical conversations with teachers, they often became strong advocates of the MMP and were able to more fully utilize and support the work of the math teacher leaders within their schools.

Because of the MMP award and the partnership between the university and the district, MPS teachers and administrators were given tuition remission; in other words, they did not have to pay for the credit as it was waived. NSF funding was used to support these tuition remissions for six years of the MMP. In the final two years, MPS also contributed funds to support the continuation of these courses through a grant to UWM which was used in conjunction with remaining NSF funds. The tuition waivers were certainly an incentive for teachers, at least initially. Unquestionably, as the worth of the coursework became apparent it was clear that teachers and administrators valued the personal learning of mathematics, the relevance for improving their classroom practice, and the networking, as well as being part of mathematical learning communities.

A classroom teacher noted, “At a personal level, it was really sad news when you received the fax where you had been declined from a course. The good news, however, was that some other teacher was accepted.” She remarked that the momentum the MMP had created for mathematics “started like a ripple, and had become an incredible wave, a movement that took a life of its own, vibrant and active.” This same teacher reflected further on the impact of the courses on her teaching:

As a classroom teacher, it was really a privilege to have been accepted into these courses. All of them have contributed enormously to my development and improvement as a mathematics teacher. I only have myself to judge the place where I started teaching mathematics several years ago, and the place where I am now. There's a new mathematics culture in my classroom. I ask a lot of questions, better questions, and this has become a habit. Students also ask more questions. I have developed the habit of listening carefully, and it still amazes me how essential my students' questions are for their learning. It is as if, by nature, my students had a mathematical curiosity and restlessness that takes them to the very core of mathematical thought.

UWM Professional Development Projects

Prior to the MMP, UWM had a long history of obtaining grants to fund professional development projects for teachers in the area of mathematics. The funding for these programs was mainly from the Elementary and Secondary Education Act (ESEA) administered through the University of Wisconsin System. Previously known as the Title II Eisenhower Professional Development program, it is now known as the Wisconsin Improving Teacher Quality (WITQ) program funded by ESEA Title II, Part A. The strength in these prior projects was the opportunity they provided teachers to engage in sustained and intense professional learning with university faculty. The projects often lasted for a year, with some projects continuing for multiple years. These projects were usually directed by Dr. Henry Kepner or Dr. DeAnn Huinker. The projects always included teachers from the Milwaukee Public Schools along with other teachers from the Milwaukee area.

UWM, through the direction of Dr. Huinker and Dr. Kevin McLeod, continued to apply for and receive additional grant funding to support the professional learning of teachers in mathematics. This included grant awards from the WITQ (ESEA Title II, Part A) program and from the U.S. Department of Education, Math and Science Partnership Program (USDE MSP) funded by ESEA Title II, Part B and administered through Wisconsin Department of Public Instruction. The list of grant projects is shown in Table 12. The combined grants provided over $2 million of funds to establish additional professional learning opportunities for teachers from the Milwaukee Public Schools (MPS), as well as for teachers from other public and private schools in the Milwaukee area. In all the projects, though, the majority of participants were teachers from MPS.

Table 12. MMP Course Offerings from ESEA Funding

Year	Funding Source	Title of Collaborative Project
2003-2004	WITQ	Mathematics Mentoring and Leadership
2004-2005	WITQ	Coaching and Leadership in Mathematics
2005-2006	WITQ	Distributed Leadership for Mathematics
2005-2006	USDE MSP	Middle Grades Mathematics Fellowship Program
2006-2007	WITQ	Assessment Leadership in Mathematics
2007-2008	WITQ	Developing Geometric Knowledge for Teachers
2008-2009	WITQ	Geometry Knowledge for Teaching
2008-2011	WITQ	Mathematics Fellowships for Middle Grade Teachers
2009-2012	USDE MSP	Alliance for Teaching Mathematics to Special Education Learners
2010-2011	WITQ	Common Core Leadership in Mathematics

These grant projects and the MMP had a synergistic relationship. Some grant projects allowed us to develop specific topics, tools, and professional development sessions with teachers and then bring that knowledge to the MMP. On the other hand, some projects provided a means to disseminate the work of the MMP to more teachers within MPS and beyond. Regardless, the grant projects provided teachers with intense and sustained programs of study with a duration of one to three years. The goals of the projects were to develop mathematical knowledge for teaching, to improve instructional and assessment practices, or to develop skills as teacher leaders or coaches for mathematics.

The goal of improving mathematics content knowledge for middle grades (i.e., grades 5-8) teachers was recognized from the start of the MMP as critical for improving mathematics instruction and student learning in these grades. This led us to develop the Mathematics Fellowship Program (McLeod & Huinker, 2007). The participants enrolled in the new courses developed through the MMP for the UWM mathematics minor for elementary teachers, allowing us to disseminate our NSF-MSP work with a first cohort of Math Fellows with funding by the U.S. Department of Education Math and Science Partnership Program (2005-2006) and then again with a second cohort funded by the WITQ (2008-2011). The Math Fellows engaged in an extremely intense professional learning experience. Approximately 50 teachers completed from 4 to 7 mathematics content courses. The following statement from one of the Math Fellows illustrates not only her growth but reflects the views of many participants.

> *When deciding to enter Math Fellows program I was scared to death. I knew my math content knowledge was not as well defined as others. I had done fine as an elementary teacher but the thought of returning to college courses that I hadn't thought about for 20+ years was scary. The courses as promised have been rigorous and full of important content. But most of all, the courses have helped me to make connections within content areas and improved my understanding of mathematics…. In particular, the Problem Solving course offered me the opportunity to experience "struggle." Problem solving wasn't about finishing a story problem once a day, but it was about interacting in a mathematical situation that pushed my thinking and helped me connect many branches of mathematics.*

A highlight of the program was its role in increasing the number of "highly qualified" middle grades mathematics teachers according to the NCLB definition by adding a mathematics endorsement to their teaching license. To add the endorsement, a Math Fellow had to complete 22 credits of mathematics including a calculus course to obtain a mathematics minor, pass the state required content exam for middle grades teachers, and complete a professional portfolio. Through the Math Fellowship program, 15 teachers had received or applied for the mathematics endorsement at the time of this report, with another 15 teachers close to completion of the endorsement requirements.

Momentum for High School Mathematics

While high school teachers have always been involved in the MMP, we have never been satisfied with the level of involvement of high school teachers. While elementary teachers seemed to jump at the opportunities the MMP was starting to provide, high school teachers seemed hesitant, perhaps even a bit skeptical. This might have been the case for several possible reasons, such as the changing organizational structure with the move to smaller high schools, high numbers of provisionally licensed math teachers, entrenched role of the math department chair, lack of accountability for student learning, and a stance that each school made its own decisions and did not need outside assistance. In addition, high school teachers might have been experiencing "initiative fatigue" and were just going to ride out yet another fad making its way through the district.

While the aforementioned obstacles might be more obvious, another view on the situation looks a bit further under the surface. Student achievement in high school mathematics was abysmal with only 28 percent proficiency on the state test in fall 2002, but more devastating was that students did not seem engaged in learning mathematics, nor were many teachers enthused about teaching mathematics. Mathematics seemed more about a checklist of topics or series of lessons to get through rather than attention to high-quality instruction and learning of challenging mathematics. In some ways there was an aura of desperation or hopelessness, which resulted in very little motivation to become involved in the MMP. The initial journey was slow, but the MMP persisted, often adjusting its strategies to create opportunities that would draw in and re-energize high school teachers and their mathematics instruction. In the last few years of the MMP, finally, momentum grew at the high school level for mathematics.

This section begins with the evolution of professional development for teachers of high school mathematics progressing from rigor sessions to learning labs to fishbowl sessions. Then a summary is given of the critical step taken with a unified textbook adoption for high school mathematics.

Professional Learning for High School Mathematics

High school teachers prior to the MMP were isolated from each other. They rarely interacted, and when they did, it was generally around the more operational needs of a school. This changed over the years of the MMP as high school teachers grew into more of a district-wide community of teachers as learners. We begin with a summary of the rigor sessions that occurred in the early years of the MMP. Next, we describe the evolution and success of the math learning labs. Then we describe the transition of the labs into school-based math fishbowl sessions.

Bringing Back the Rigor Sessions. Our initial foray into bringing together high school teachers had the specific purpose of re-inspiring their passion for mathematics through learning mathematics that was new and interesting to them, without necessarily being concerned about immediate connections to their classroom teaching. Led by UWM mathematicians, the MMP offered a series of "Bringing Back the Rigor in Mathematics" sessions for high school teachers beginning in 2004-2005. These Saturday morning workshops were co-facilitated by mathematicians, a mathematics educator, and a teacher-in-residence. A total of 19 workshops were offered over three years (MMP Years 2-4), with approximately 20 teachers attending on a regular basis. The sessions focused on "big ideas" in mathematics. Some of the topics included the Descartes view on how algebra and geometry are intimately related, Fibonacci, matrices and geometry, matrices and statistics, the Poincaré conjecture, completing the square, square roots, volume, circumference and area of a circle, and sequences and series. The workshops were pitched at a challenging mathematical level in order to deepen the teachers' own mathematics knowledge. These rigor sessions began the journey of bringing together high school teachers to connect with their interest in mathematics and the challenges of learning mathematics in ways that were not often demonstrated in their own classes. Teachers completed these sessions with a sense of accomplishment and a sense of how their own struggles were similar to some of the struggles of their students—just at a very different level of mathematics learning.

Math Learning Labs. During 2007-2008 (MMP Year 5), we replaced the rigor sessions with a series of Algebra Learning Labs. These labs were designed for high school teachers to both deepen their mathematics content knowledge and improve their instruction of algebra. The labs were held during the school day and teachers were released using substitute teachers funded by the MMP. The labs were facilitated by UWM mathematics faculty and district math teaching specialists or teachers-in-residence. The general format of the labs involved teachers as participants in a lesson representing some aspect of linearity which could then be replicated with their students. The teachers were given a classroom assessment on the content of the lesson and were asked to bring back their student work to the next lab. In the subsequent lab, teachers shared their experiences in replicating the lesson with their students, including lesson adaptations, student misconceptions and needed background knowledge, and how their students received the lesson. They also collaboratively examined their student work samples, using a protocol developed through the MMP.

In the following year (MMP Year 6), we kept the general format of the labs, but focused the content topics tightly on the new textbooks adopted by the district. We ran two series of labs, one for algebra teachers and the other for geometry teachers. Each series met for six half-day sessions during the year. The facilitation teams were expanded to include more mathematics faculty from UWM, and, we were particularly pleased and appreciative, to include mathematics faculty from Marquette University. The algebra topics included solving equations by undoing and balancing, fitting a line to

real-life data, and definitions and properties of functions. The geometry topics included the van Hiele model of geometric thought, moving from experiments (induction) to conjecture to proof, rigid motions and congruence, and proofs of the Pythagorean theorem and its connections.

In 2009-2010 (MMP Year 7), we ran three series of labs—Algebra, Geometry, and Advanced Algebra. The facilitation teams included mathematics faculty from UWM and Marquette University working with district math teaching specialists. The labs were expanded to full-day sessions with each series meeting six times throughout the school year. This was partly for logistical reasons—it is inconvenient for teachers to be released from their schools for half days—but we valued having the extra time to support and provide time for teachers to collaboratively work on designing instructional lessons related to the session topic. The morning session included content activities that stemmed from the district adopted textbooks and were extended by the university mathematics faculty. During the afternoon, teachers were to articulate the big mathematical idea in the lesson they had just experienced and write a learning intention and success criteria in student-friendly language (i.e., WALT). Unexpectedly, this was very difficult for the teachers. Small groups would post their drafts of learning intentions and success criteria on chart paper. After taking considerable time to debrief and expound on these statements, the groups worked on lesson planning using our Launch-Explore-Summarize-Apply (LESA) instructional design. This is where many teachers exchanged tips on what worked in their classrooms and would demonstrate uses of technology for each other.

Participants in the labs uniformly indicated that the labs had been helpful to them in understanding the content and pedagogy in the new textbooks, and reported that their own students were showing an increased interest in and engagement with the mathematics they were learning. The participants were asked to reflect and comment on how attending the labs affected their classroom instruction. Some of their responses were:

I think the #1 value of the labs is the collaboration between teachers. I take much of what I discover here back to try with my students.

I've learned to slow down and anticipate common mistakes made by typical ninth grade students.

I didn't realize that perpendicular bisectors would show up throughout the entire book! I can now plan accordingly.

It has given me a variety of ideas for teaching in different ways. These labs have helped me focus my lesson planning on what the kids are learning, doing, and what the big math ideas are in each section.

It refreshed my motivation to be creative and to create higher level thinking activities and lesson plans that are interesting and engaging for my students. They have helped me be a better teacher!

The teachers indicated appreciation for the supportive environment and time to think and talk collaboratively with other teachers about their mathematics instruction. An unexpected outcome from the labs was that many participants facilitated afterschool sessions for other MPS teachers on some aspect of the textbook, strengthening the district-wide community of teachers as learners.

Math Fishbowl Lab Sessions. Despite the success of the math learning labs in familiarizing teachers with the content and pedagogy in the new high school mathematics textbooks, we began to feel we had reached the point of diminishing returns. We were largely reaching the same teachers, those early adopters who were willing to make the effort to attend the labs. This led to the next step as we decided to take the labs to the schools and work with the Math Teacher Leaders (MTL) to set up "fishbowl" sessions in their schools. In a fishbowl, a teacher would teach a lesson to a group of students while other teachers observed the lesson. The observers were involved in discussions both prior to and following the lesson. The following vignette gives a glimpse into one of these sessions.

Marissa, the MTL rearranged tables in the school library and created a poster of her learning intentions, as she prepared for the algebra fishbowl. The district Math Teaching Specialist prepared the approximately 20 algebra teachers attending the session by reviewing the lesson the MTL was going to develop with her students. The teachers discussed the details of the lessons, including alignment to the State Standards, descriptions of what would be expected of students during the lesson, possible misconceptions that the teacher planned to address, critical student responses or explanations that would be used to identify students' understanding, and sample questions and problems that would be used throughout the instruction to address the objectives.

The lesson included an investigation of coordinate points and whether or not they formed a line. Students were to determine the rate of change between selected points, define this change as slope, and make sense of the slopes as indications of whether or not the points would form a line. Recognition of slope as a rate of change, and the corresponding equation of a line, were key topics to be developed by this lesson.

Students soon assembled in the "lab" arranged by their teacher. They were obviously aware that this was not an ordinary day. However, it did not take long before the students were interacting with each other and with their teacher as if the observers were not in the room. Marissa presented examples, directed small group discussion, encouraged students to share their work and articulate their thinking, provided explanations to encourage responses, and redirected student thinking when ideas were not accurate. Teachers observing the class marked down responses from students that were key to the understanding of the material and also identified instructional strategies that were discussed in the overview of the lesson.

One obvious advantage of this "fishbowl" model was the direct connection to classroom instruction with the lesson actually taught to students, rather than to teachers. A less obvious advantage was the unanticipated support of the principal of the hosting school. The arrangement allowed the principal to more easily require all mathematics teachers to attend. This resulted in several teachers attending at least one lab for the first time, and while most appreciated the opportunity, some showed displeasure at being required to attend, yet they did observe the lesson and participate in the discussions.

Four math fishbowl sessions were developed during the 2010-2011 school year (MMP Year 8). Two sessions focused on algebra and two on geometry. Each session was presented twice at different schools, so eight fishbowls were held in eight different high schools throughout the school year. Each session was developed jointly by the hosting MTLs, the district high school Math Teaching Specialists, and a consultant from the textbook publisher. The hosting MTLs then taught the lesson at their respective school with their own students. The following comment from a hosting MTL showed the potential power of the fishbowl for the teachers in her school.

Our school was one of the sites picked to host an Algebra lab. The experience was wonderful for our teachers as an illustration that our students can shine and do well working on investigations in groups. Teachers had the chance to experience what a full lesson with real students looked like and then we were able to debrief how each of the elements we had been discussing as a department fit together in a real class. The lab gave teachers an opportunity to see students changing groups and getting up and presenting their group work. The teachers saw how to summarize a lesson and how to make adjustments when parts of the lesson go faster or slower then anticipated. Several of my teachers commented on how seeing the learning intentions and success criteria referred to several times was also helpful.

The willingness of the MTLs to be observed by their colleagues and have their teaching critiqued was very impressive. While most of the credit must be given to the MTLs themselves, it was reasonable to conceive that the sense of community built up over several years of the MMP professional develop was also a factor. This format incorporated professional development at several levels. Teachers were able to observe good instructional strategies, as well as receive training in content and formative assessment. The math fishbowls provided a way to reach more teachers and more schools, and became an important format for the professional development of high school mathematics teachers.

Unified Textbook Adoption

A significant development for the district was addressed through the selection of a unified textbook series for the high school foundation levels (grades 9 and 10), namely, algebra and geometry. For over eight years, the district had been using a series that was poorly aligned to the district learning targets and to the state standards. Therefore, the opportunity to impact the high school curriculum through adoption of new textbooks was a high priority for the MMP.

During 2007-2008 (MMP Year 5), approximately 20 teachers served on the textbook selection committee. This represented a larger committee than normally funded by the district and was only possible due to support from the MMP. This allowed for involvement of more schools and greater buy-in for the eventual adoption. The committee began their work by developing a rubric that examined alignment to learning expectations, pedagogical design, differentiation resources, technology resources and expectations, and other strengths and weaknesses of the programs. In May 2008, upon the committee's recommendation, the Milwaukee Board of School Directors approved the adoption of *Discovering Algebra* and *Discovering Geometry* published by Key Curriculum Press.

With these new, district-wide, textbook adoptions, it became possible—and indeed necessary—for the MMP to tie professional development work with high school teachers closely to the textbooks. As their titles suggest, the new curricula have a student-centered, exploratory approach that was very different from the previous curriculum. We wanted to make sure that teachers were not tempted to supplement the new curriculum with older material, just because they were more comfortable with it.

The MMP offered two UWM courses in August 2008 for high school teachers on the curricula. Each course was designed to address the development of the mathematical ideas in the curriculum along with a study of the philosophy, instructional strategies, and pedagogical approach. The courses included detailed examination of the alignment of the new textbooks to learning targets and state descriptors. Teacher applications exceeded capacity for both courses, with an overwhelming response for the *Discovering Algebra* course. Some of the MTLs were invited to participate in a special leadership program. This had a two-fold purpose. First, it allowed more teachers to be accepted into the courses and, second, it developed additional teachers as leaders to support the implementation of the curricula.

During the following year in 2008-2009 (MMP Year 6), a similar process was carried out to select a single, district-wide textbook for the advanced algebra (grade 11) course. The committee recommended the adoption of *Discovering Advanced Algebra,* again published by Key Curriculum Press. The MMP supported the adoption process and incorporated the new curricula into its professional development. For example, as discussed previously, the learning labs situated teachers' professional learning within the context of these three new curricula.

Summary Comments

With the increased efforts to develop the MTL model at the high school level, the participation of MTLs in monthly K-12 leadership seminars, the high school math labs, and the common textbook programs, a strong foundation was established for moving forward at the high school level. However, the challenges at the high school level are complex and have often involved more focus on structural and organizational changes and competing initiatives rather than substantial focus on mathematics teaching and learning. We are optimistic that the new administration will support a consistent, cohesive, and coordinated effort based on the work of the MMP and now focused on the *Common Core State Standards* in order to improve student learning of mathematics at the high school level.

Part 5
Leading the Way in Higher Education

Certainly a major focus of the Milwaukee Mathematics Partnership (MMP) centered on the Milwaukee Public Schools (MPS) in improving the teaching and learning of mathematics through the professional learning of teachers and the development of math teacher leaders. This work drew upon the expertise of university mathematics and mathematics education faculty and deeply engaged them in work with teachers and teacher leaders.

A second important focus of the MMP addressed the mathematical preparation of teachers at the University of Wisconsin-Milwaukee (UWM) and at the Milwaukee Area Technical College (MATC), as well as teacher recruitment at MATC. In this work, the higher education faculty drew upon the expertise and experiences of teachers, particularly Teachers-In-Residence (TIR). The TIRs were district teachers placed on special assignment at UWM or at MATC for two years. The TIRs grounded the teacher preparation efforts in the real needs of teachers and served as a critical bridge between higher education and the district.

The third main focus of the MMP involved the transition of students to post-secondary mathematics. In other words, the MMP put forth concerted effort into both studying the problem of the need for non-credit, remedial mathematics courses at MATC and UWM, and in piloting strategies to address the issues. This involved collaboration among all three core partners in developing pilot initiatives for high school mathematics to strengthen preparation for college and in developing pilot programs and practices at UWM to more accurately place students into courses or to accelerate students through remedial mathematics courses.

This section begins by summarizing the efforts to improve the mathematical preparation of teachers at UWM and MATC. Next is a discussion of the efforts on teacher recruitment at MATC. Then the work across the partners related to transitioning students to college mathematics is described.

Mathematical Preparation of Teachers

The MMP concentrated on preparing prospective teachers with a deep understanding of the mathematical content needed for teaching. Our work addressed the mathematical preparation of teachers at both UWM and at MATC. At UWM, we focused on the early childhood (Birth to age 8), elementary (Grades 1-8), and secondary (Grades 6-12) teacher education programs. At MATC, the work addressed the teacher education track which allows individuals to begin coursework at the technical college and then transfer to a four-year college, including UWM, to complete a degree in education.

Our approach involved the use of “design teams” to revise existing mathematics courses and to develop new mathematics courses for prospective teachers in our teacher education programs. Our intent was to design courses in alignment with the recommendations of *The Mathematical Education of Teachers* (MET) report (Conference Board of Mathematical Sciences [CBMS], 2001).

Design Team Model

The purpose of design teams was to bring together mathematics faculty, mathematics education faculty, and classroom teachers in order to develop courses that truly developed the mathematical knowledge needed for teaching in urban districts. Mathematics faculty brought a deep knowledge of mathematics, mathematics education faculty brought knowledge of ways to connect those mathematical ideas with learners, and the classroom teachers grounded our work in the practice of teaching in urban schools.

Key to this collaboration was the Teachers-In-Residence (TIR) program. Four outstanding teachers of mathematics were selected and placed on special assignment at UWM to link mathematics teacher preparation and urban classroom practice. These teachers worked closely with mathematics and mathematics education faculty as members of the design teams to develop the courses, including co-teaching the initial offerings of the course with a mathematics faculty member.

University faculty were accustomed to working in isolation in developing and teaching courses. It was not common practice to collaborate on course development with faculty within one's own department, even less common to work with faculty from other departments, and nearly unheard of to solicit the advice and input of public school teachers. Similarly, co-teaching sections of university mathematics courses was a rare practice.

Foundational Mathematics Courses for Prospective PK-8 Teachers

All UWM elementary education and early childhood majors complete two foundational mathematics content courses specifically designed for prospective teachers and offered through the Department of Mathematical Sciences. Through the School of Education, elementary education majors then complete two mathematics methods courses, and the early childhood majors complete one mathematics methods course. In the Milwaukee area, some prospective teachers begin their initial course work at MATC and then transfer to a four-year institution to complete degree requirements. However, MATC did not have specific mathematics courses for these individuals. The prospective teachers would have to wait to take their foundational mathematics content courses once they transferred, which put them behind in their coursework and at risk for not completing their degree requirements nor obtaining their teaching certification. This was particularly salient because MATC had potential to be a major source of increased diversity of teacher candidates in the area.

Through the MMP, two foundational mathematics courses for prospective teachers were established at MATC and are now permanent and regular course offerings. These courses parallel those at UWM and were developed collaboratively across the institutions through the design team model. The amount of coursework in the UWM courses in their previously-existing form was consistent with the MET report recommendations (CBMS, 2001), but the presentation of topics was not satisfactory. The content did not focus sufficiently on a careful development leading to profound understanding of fundamental ideas (Ma, 1999), nor had much effort been made to connect it to teachers' future classroom practice with a perspective of developing the mathematical knowledge needed for teaching (Ball & Bass, 2003). The establishment of these courses at MATC was an important accomplishment of the MMP. Offering these courses at MATC resulted in better-prepared prospective teachers who could then move on to complete a four-year degree in education. Additionally, for those with a math focus, they had the opportunity to take more mathematics courses and improve their skills and range of knowledge. On an

anecdotal level, one MATC graduate was asked to come back to speak at the recognition ceremony that the teacher education program holds for its graduates each semester. That individual had moved on to UWM to continue his degree in education. When he described his experiences there, he remarked that the classes that had best prepared him to succeed at UWM were the new foundational mathematics courses (Math 275 and 276) at MATC. That student is now a teacher in MPS. As an African-American male, he also has helped to fulfill one of the goals of the grant to get more teachers of color into MPS classrooms.

A design team was established with mathematics faculty from both institutions and a mathematics educator from UWM. As the course was redesigned, MATC faculty observed the courses being taught at UWM. When the first sections were offered at MATC in fall 2004, UWM faculty would, on occasion, team-teach with the MATC instructors. This activity not only further developed bonds between MATC and UWM, but also helped to insure coordination and consistency between the same courses being offered at both institutions. Table 13 shows the course sections and enrollments over the years. Given that many students take both courses at an institution, approximately 500 students benefited from this collaboration at MATC and about 3000 students at UWM.

Table 13. Course Sections and Enrollments for Foundational Mathematics Courses

	MATC Math Explorations for Elementary Teachers 1		MATC Math Explorations for Elementary Teachers 2		UWM Math Explorations for Elementary Teachers I		UWM Math Explorations for Elementary Teachers II	
Year	Sections	Enrolled	Sections	Enrolled	Sections	Enrolled	Sections	Enrolled
2003-2004	2	33	0	0	15	430	14	317
2004-2005	2	75	1	19	15	372	12	276
2005-2006	2	55	1	33	14	391	11	259
2006-2007	2	69	1	29	14	369	10	241
2007-2008	2	68	1	34	13	323	10	240
2008-2009	2	45	1	26	12	330	10	254
2009-2010	2	66	1	33	10	285	9	243
2010-2011	2	51	1	35	11	316	9	227
Totals	16	462	8	209	104	2816	85	2057

As MATC began offering the courses in 2004-2005, the next step was to help ensure student success when they took the courses. This was done by hiring tutors to work with the students when assistance was needed. Space was made available at MATC for the tutors and students to meet during a set schedule each semester. This activity was another tie between MATC and UWM as many of the tutors were elementary education majors at UWM who were pursuing a minor in mathematics. Later, as MATC students completed the foundational content courses, some of them also returned to MATC and became tutors in the program. These tutoring sessions ended when MMP funding was no longer available as MATC was not able to continue paying for tutors outside of what was currently done in its academic support center.

Mathematics Minor Courses for Elementary Teachers

UWM revised its teacher education program in 2002 and took an extraordinary step to require elementary education majors to choose a minor in mathematics or science, along with a second minor in social studies or English and language arts. The state of Wisconsin only required one content area minor from among an array of choices. At UWM, when only one minor was required, most prospective elementary teachers chose social studies or language arts with only about 10 percent electing mathematics. UWM took an unprecedented stand on the importance of preparing elementary (Grades 1-8) teachers with strong knowledge of mathematics or science and when we changed our program requirements. In 2011, about 33 percent of our elementary education graduates had mathematics as a content area minor and 43 percent of our pre-admission elementary majors had declared a minor in mathematics.

Nevertheless, the requirement had changed, but not the curriculum. Much work remained to ensure that courses for the minor built and deepened the content knowledge needed to teach challenging mathematics. The mathematics minor required students to take 18 credits in mathematics beyond the two foundational content courses for a total of 24 credits in mathematics content, in addition to six credits of mathematics methods. Prior to the MMP, these prospective teachers took existing mathematics courses designed for general education or other majors to fulfill their minor requirements. The MMP developed four new courses in mathematics specifically for prospective elementary teachers electing a minor in mathematics, taking into consideration the recommendations of the MET report. The new courses included (1) problem solving and critical thinking, (2) geometry, (3) discrete probability and statistics, and (4) algebraic structures. Currently, the minor also includes an existing course in calculus concepts. As our knowledge of the unique needs of prospective teachers has grown, a specific calculus course for prospective elementary teachers was drafted with the intent to pilot the course. However, due to retirements and funding issues, we have not yet been able to move forward with further development of the calculus course.

Design teams were established for each of the four new courses. Each team spent about a year developing the course before offering it for the first time. The course was then revised, based on the experience gained from its initial offering. Each design team prepared a course package to be sent out for external review, and the course was again revised based on this feedback.

The first year that UWM offered all four courses was 2005-2006, and they have been offered each year since then, as shown in Table 14. The problem solving and geometry courses have been offered twice every year starting in 2008-2009. Moreover, the courses have now been taught by several mathematics faculty beyond those in the original design teams, and may be considered as firmly institutionalized within the department's suite of permanent undergraduate courses.

Table 14. Course Sections and Enrollments for Elementary Education Mathematics Minor Courses

	Mathematical Problem Solving for Elementary Education Majors		Geometry for Elementary Education Majors		Discrete Probability and Statistics for Elementary Education Majors		Algebraic Structures for Elementary Education Majors	
Year	Sections	Enrolled	Sections	Enrolled	Sections	Enrolled	Sections	Enrolled
2003-2004	1	13	1	14	1	5	0	0
2004-2005	1	22	1	26	0	0	0	0
2005-2006	1	32	1	30	1	18	1	29
2006-2007	1	28	1	25	2	15	1	15
2007-2008	1	30	2	56	2	20	1	13
2008-2009	2	40	2	59	2	19	1	30
2009-2010	2	53	2	48	1	23	1	31
2010-2011	2	45	2	47	1	8	1	33
Totals	11	263	12	305	10	108	6	151

What follows is a brief overview of each of the courses. We describe briefly the aims and content of each of the courses, in the order of their development. As stated earlier, the overall design of our program relied heavily on the MET report recommendations (CBMS, 2001), and also took into consideration the Wisconsin standards for mathematics and the MPS grade-level learning targets in mathematics. However, a major factor in the final selection of course content was the mathematicians' judgment as to which topics constituted important mathematics. A beneficial consequence of this decision process was that our courses remain relevant in the framework of the *Common Core State Standards*. Indeed, some of our chosen topics (for example, the emphasis on transformations in the geometry course) are arguably more closely aligned to the Common Core than to the earlier state standards.

Problem Solving and Critical Thinking Course. The course seeks to build a strong foundation for the teaching of challenging mathematics. The course was conceived partly in response to the MET report statement, "Prospective teachers at all levels need experience justifying conjectures with informal but valid arguments if they are to make mathematical reasoning and proof part of their teaching" (CBMS, 2001, p. 14). Through problems that are truly problems for the prospective teachers, the course leads them to become more conversant mathematically, and to learn what is considered acceptable evidence in mathematical arguments. The guiding philosophy is that it should be the students who make sense of problems, make conjectures, construct arguments to justify their conjectures, evaluate the evidence and arguments proposed, and adapt them recursively until the evidence can be accepted by all. In brief, students are expected to think as mathematicians would, and engage in the habits of mathematical reasoning as described in the Standards for Mathematical Practice articulated in the *Common Core State Standards*.

The course has a general flow that is repeated throughout the semester as new problems are presented for investigation. Students are usually shown, and then discuss, a new problem in the last few minutes of a class period. Before the next class, they are expected to make an effort to solve the problem. The discussion begins with first impressions, and then moves to possible solution strategies. Solutions are not discussed until a later class, so that students can take advantage of the sharing of strategies to try and make further progress on a solution of their own. The class may be working on two or three problems at the same time, in different stages of solution. A recurring theme is that solving the initial problem is often only the first step to real understanding. The course emphasizes reflection on the process of problem solving. To this end, students maintain a journal with entries for each problem on first impressions, initial solution attempt, reflections on the class discussion of strategies, solution attempts following this discussion, and a write-up of a final solution.

Geometry Course. The design team developed four modules to comprise the geometry course, and then experimented with teaching these modules in different orders. The current order is measurement, transformations, proofs and deduction, and spherical geometry. The measurement module begins with a discussion of error and reported accuracy and then moves into using right triangle trigonometry to determine indirect measurements. The transformations module addresses the four basic types of rigid motion in the plane and the results of composing rigid motions, leading to the conclusion that the set of rigid motions under composition forms a group. The proofs and deduction module explores the need for and value of deductive proofs, and has students construct short proofs or fill in justifications in more complicated proofs. The module on spherical geometry introduces students to an example of non-Euclidean geometry through the discussion of geometry on the surface of the Earth. It includes Eratosthenes's measurement of the size of the Earth and makes strong connections to science by discussing the meaning of the equator, tropics, and Arctic and Antarctic circles.

Discrete Probability and Statistics Course. The primary aim of this course is to develop knowledge of and facility with the mathematical modeling of randomness, and the ability to draw inferences based on appropriate models. It emphases understanding probabilistic concepts in discrete situations, where students carry out experiments and count the number of times a given outcome occurs. The course begins with simple probability models where the counting can be done directly, including conditional probabilities, and then moves into a discussion of advanced counting techniques before returning to more complex probability models. The course concludes with a discussion of statistical inference and maximum-likelihood estimates, including applications to models of real-world situations.

Algebraic Structures Course. The intent of this course is to develop a deep understanding of the structure of algebra—not just what algebraic steps to take when solving a problem. The emphasis is on *why* it makes sense to take specific steps, what is the underlying algebraic reasoning, and where in mathematics do the same structures appear. Course topics included language and mathematical logic, set theory, functions, operations, structures (e.g., groups, rings, and fields) and number theory.

MATHEMATICS CAPSTONE COURSE FOR HIGH SCHOOL TEACHERS

The MET report recommends a capstone course for prospective high school teachers that connects the advanced mathematics they are learning at the university with the high school mathematics that they would be expected to teach. Such a course did not exist at UWM. Through the MMP, we continued our approach of using a design team comprised of a mathematician, a mathematics educator, and a teacher-in-residence, to develop and offer a capstone course for our prospective high school teachers. We learned that a capstone course was particularly well suited for our program given that the majority of individuals were post-baccalaureate students returning for a second professional career. The capstone course allowed them to revisit important mathematical topics, their mathematical connections, and their connections to instructional practice.

The high school capstone course has been offered every Spring since 2005, but the small number of prospective high school mathematics teachers at UWM means that it invariably has low enrollment and is often in danger of being cancelled. Even though the course has the support of both the Department of Mathematical Sciences and the College of Letters and Sciences administrators, our ability to continue offering it every year remains uncertain. Over the six years the course has been offered, it has had a mean enrollment of 12.6 students with a total enrollment of 76 students.

One major theme of the course was the importance of clear definitions of mathematical concepts, emphasizing the historical development of definitions and concepts, and the possibility of alternative definitions of a given concept. A related theme was the exploration of proof. Overall, there was an attempt to present mathematics as a unified whole, and to make connections between the isolated topics that the students had met in prior college-level mathematics courses, and between those topics and the mathematics they will teach in high school.

The list of topics has varied slightly from year to year, depending on the perceived needs of the students. The following topics, however, can be considered typical: number systems, including the Peano Axioms and induction; function concept and its historical development; the Binomial Theorem, counting, combinations, and why 0! = 1; the role of axioms, definitions, and proofs in mathematics; Descartes' big idea that geometry and algebra are intimately connected; and essential trigonometry and connections between trigonometry and calculus.

Finally, as with all of our courses, we emphasized the processes, or practices, of mathematics. In the most recent offering of the course, this was made explicit by introducing the students to the Standards for Mathematical Practice from the *Common Core State Standards*.

We benefited from discussing our ideas with people working on similar courses at other institutions. This has included presentations on the capstone course at the annual meeting of the National Council of Teachers of Mathematics (NCTM), in a symposium at the Association of Mathematics Teacher Educators (AMTE) conference, at the American Mathematical Society and Mathematical Association of America (AMS/MAA) joint meetings, and at the annual conference of the Wisconsin Mathematics Council.

MATC Teacher Education Pathway

The Milwaukee Area Technical College (MATC) has been the postsecondary institution of choice for many students in the Milwaukee metropolitan area. As a public, two-year comprehensive college, students can earn the first two years of a bachelor's degree and then transfer to most Wisconsin four-year colleges and universities, as well as to other institutions across the nation. Its teacher education track, in particular, provided an important option to students who were considering a career in teaching. It is a sign of success when the name of a MATC student appears on the Wisconsin list of licensed teachers, and particularly when that license includes a mathematics endorsement.

The MMP provided the vision, resources, and cross-institutional support for MATC to create a stronger presence and focus on mathematics in its teacher education track and provide a clearer pathway for prospective teachers. In addition to the establishment of foundational mathematics courses for prospective teachers discussed earlier, the MMP supported changes in advising practices and provided mathematics internship experiences in MPS classrooms. Through these efforts led by key mathematics faculty, more individuals considered a mathematics focus at either the elementary or secondary levels or were better prepared and on track to transfer to a four-year teacher education program to complete their degree requirements and obtain their teaching license.

Pathway from MATC to UWM to MPS

A major accomplishment of the MMP was the establishment of the foundational mathematics courses for prospective teachers at MATC to parallel those taught at UWM. The purpose of this work was to create a stronger pathway for students to stay on track upon transfer to a four-year teacher education program. In the past, these transfer students would be behind in their program of studies because they still had to be complete these courses upon transfer as prerequisites for other program requirements.

To examine this pathway from MATC to UWM to MPS, we studied a sample of 269 students in the teacher education track at MATC. This was the first step into teacher education for these individuals. All of these students had completed one or both of the foundational math courses at MATC. We were able to track 104 individuals in this sample by examining UWM enrollment records, the state educator license database, and the MPS staff directory. It was very difficult to track individuals across institutions of higher education, and even more difficult to track them into a teaching position, as individuals were tracked by name and names can change for several reasons.

The second phase of the pathway examined was transfer to UWM. We identified 80 individuals who transferred to UWM, approximately 30% of the sample. This clearly indicated that UWM was a destination of choice for many of the MATC students. Of these individuals, 65 pursued a degree in education. This included 27 prospective elementary (Grades 1-8) teachers, with *14 electing a mathematics minor*. It was quite remarkable that over half of these prospective elementary teachers elected mathematics as their minor, which is above the rate when considering all prospective elementary teachers at UWM. This was likely reflective of the strong mathematics foundation that began at MATC. Another 19 individuals chose to pursue early childhood education. Of the remaining 19 who pursued education related degrees, seven were still classified as pre-education, nine were in education studies, and the other three were in various teacher education programs.

The third phase of the pathway was completing a program of studies and earning a bachelor's degree. Of the 80 individuals at UWM, 29 individuals had completed their program of studies as of this report (26 in education, 3 in non-education fields). Another 37 individuals were still active in their program of studies, and 14 were no longer active students.

The fourth phase was obtaining teacher certification in Wisconsin. To date, 15 individuals that had passed through UWM had been certified as teachers in Wisconsin, *five with a mathematics endorsement*. Another four individuals had received certification as special education aides which does not require completion of a bachelor's degree. We also examined the state educator license database for individuals in the sample that had not transferred to UWM. This led to the identification of 13 more certified teachers, *six with a mathematics endorsement*, and nine more individuals with certification as special education aides. Thus 10% (n=28) of the individuals in the sample had been certified as teachers in Wisconsin; 11 of them with a mathematics endorsement. We anticipate this percent of certified teachers to increase as more individuals complete their program of studies.

The fifth, and final, step in the pathway for the MMP was obtaining a teaching position in the Milwaukee Public Schools. From the UWM transfers, we identified 14 individuals employed by MPS. Eight were employed as teachers, three were employed as aides or paraprofessionals, and three were in other support staff positions. Among the non-UWM transfers, we identified five teachers, six paraprofessionals or aides, and one support staff. Thus, a total of 26 individuals in the sample were employed by MPS; 13 teachers, 9 paraprofessionals or aids, and 4 support staff. Overall, the MATC teacher education track has had a positive impact on supporting prospective educators on their pathway to the teaching profession.

RECRUITMENT AND ADVISEMENT

MATC made several changes in its recruitment of students into the teacher education program and advisement of these students. Recruitment now occurs at a variety of levels, starting with the recruiting staff who visit high schools and continuing with the teacher education counselor and student services specialist at MATC. Faculty also identify students in their classes who have potential as teachers and attempt to recruit them into the program. For example, mathematics faculty keep a lookout for math students who show promise as teachers. A similar lookout is maintained at the associate dean level. In an impressive case, a graduate of the Milwaukee Public Schools and a graduate of the MATC teacher education program went on to complete a B.S., M.S., and Ph.D. in mathematics. While this individual may not teach mathematics in a K-12 classroom, as an African-American, she is a role model to MPS students and will likely encourage students to pursue mathematics teaching as a career.

A continuing challenge in supporting students has been the importance of good advising. At MATC, students were encouraged, but not required, to see an advisor before registering for classes. Through new student orientation sessions, the teacher education students are now assigned an advisor specific to this program track. These orientations have given mathematics faculty advisors the opportunity to meet new students and inform them of tutoring services, as well as to recruit potential mathematics focus students. Mathematics faculty now advise students to ensure that they are appropriately placed in mathematics courses that will allow continued development as future teachers of mathematics. Similarly, they identify strong math students in their courses and suggest them as possible tutors and supplemental instruction leaders in the academic support centers at MATC. This has established a more coordinated and sound support team available to help prospective teachers succeed in their program of studies, particularly in mathematics.

Internships in Milwaukee Public Schools

MATC had a goal to give their students more exposure to the mathematics being taught in K-12 classrooms. With support from the MMP, MATC established an internship program in mathematics for its teacher education track students. The interns were placed in Milwaukee Public School (MPS) classrooms. The interns served as teaching assistants during mathematics instruction, working up to 10 hours per week with elementary or secondary students. The MATC mathematics faculty or teacher-in-residence conducted site school visits to work with the interns and their sponsoring teachers in mathematics instruction. They held meetings with the interns, both individually and in groups. Through the internships, and the group and individual support, the intent was to nurture prospective teachers in pursuing mathematics as their content area of concentration.

The initial goal was to place 15 interns per year in MPS classrooms for 10 hours per week and 10 months per year. This goal was overambitious on many levels. First, it was difficult to find enough students who met the requirement of having completed at least elementary algebra with a grade of C or better and with an overall GPA of 2.5. Next, the goal of 10 hours per week and 10 months per year was unrealistic. Most students could not commit to more than one semester, nor could they commit to 10 hours per week when they were going to school fulltime and most likely working fulltime or part-time. Consequently, most interns were only in the classrooms a couple of days per week for one semester. Finally, finding schools and teachers willing to take one or more interns was a time-consuming process, particularly at the beginning of the MMP when MATC was working to develop ties with MPS. This became easier once a teacher-in-residence was placed at MATC because she had the contacts and knowledge of the MPS system to find internship opportunities for students.

The placement of interns in MPS math classrooms was a highlight of the work at MATC. For those individuals placed as interns, they had the invaluable opportunity to get first-hand experience in MPS mathematics classrooms and to envision themselves as future teachers working in a similar situation with students. While we were not able to recruit as many interns as planned, those who did participate got a better sense of how mathematics was taught to students and gained experience in helping them learn. Whether those students were preparing to take their foundational math content courses, or were enrolled in the courses while interning, the intern experience provided classroom examples to which they could relate as they learned the mathematics they would need for teaching.

Transitioning to College Mathematics

In Milwaukee, as nationally, far too many students graduate from high school without having acquired a level of understanding of mathematics sufficient for subsequent success in their post-secondary lives, whether they intend to proceed to some form of higher education or directly into the workforce. At UWM, for example, 43% of all incoming freshmen tested into a non-credit bearing mathematics course in 2010-2011; the corresponding percentage at MATC was 77%. It is important to note that these dispiriting figures were for all freshmen, and not just MPS graduates, but the figures for MPS were more severe with 70% and 93%, respectively, placing into non-credit mathematics courses. Faced with this situation, the MMP put considerable effort into working with MPS high school teachers to raise awareness of college expectations and to improve their the college placement of their students.

Analysis of Mathematics Credits on College Course Placement

Just before prior to receiving the MMP award, the MPS Board of School Directors reduced the mathematics requirement for graduation from 3 to 2 course units, the minimum required by the state of Wisconsin. Since UWM had a three-year admission requirement, we did not expect much effect on incoming UWM students, but the same could not be said at MATC, which required only a high school diploma.

In 2006, MATC conducted an extensive analysis of MATC placement data to examine whether a difference existed between students who had two years versus those who had three years of high school mathematics (Ruszkiewicz, 2006). The results are shown in Table 15. A statistically significant difference was found with graduates having only two years of high school mathematics more likely to place into non-credit college mathematics courses than graduates with three years of mathematics. This finding was an important factor contributing to the school board's subsequent decision in 2008 to reinstate the three-year graduation requirement.

Table 15. Relationship of Years of Mathematics to Placement Level at MATC in Fall 2005

MATC Course Level	2 Years HS Math		3 Years HS Math		Total	
	n	Percent	n	Percent	n	Percent
Basic Skills (Remedial)	254	71%	253	59%	507	65%
Math Fundamentals (Remedial)	72	20%	103	24%	175	22%
Applied Algebra (Remedial)	29	8%	60	14%	89	11%
Intermediate Algebra (Low Level)	3	1%	11	3%	14	2%
Total	358		427		785	

MPS Transition Pilot Committee

A major goal of the MMP was to increase the number of students who made a successful transition from high school to postsecondary mathematics. A committee of MPS high school teachers and mathematics faculty from MATC and UWM sought to establish a common understanding of the issues and to pilot initiatives to address them. For example, the committee examined college expectations through study of math placement exams, specifically the University of Wisconsin (UW) System mathematics placement test used at UWM and the Accuplacer test used at MATC. One outcome of this study was a revision of the district learning targets for advanced mathematics courses that better aligned with the placement exams.

A major initiative of the committee was the distribution of two math resource books, one for algebra and one for geometry, that were developed jointly by faculty at MATC and UWM (Key, Osman, & Ruszkiewicz, 2005; Key & Ruszkiewicz, 2005). These resource books contained practice problems that were aligned with postsecondary math placement tests at these two institutions. After an initial pilot of the materials, the books were distributed to all high schools and placed on the MMP website (www4.uwm.edu/Org/mmp/_activities/transition.html).

Another important committee initiative was the development of a MPS Postsecondary Mathematics Readiness Test. The mathematics achievement of high school students in Wisconsin was, unfortunately, based on the state test administered at the beginning of grade 10. Thus, the test only reflected learning through ninth grade. It also represented the only and last measure of mathematics achievement while in high school for all students. The MMP transition committee developed the postsecondary math readiness test as a means to convey to district high school students and to high school teachers that enrollment in mathematics courses and achievement in mathematics was important throughout high school.

The test was modeled on the UW-System math placement test and the Accuplacer test. We also added one constructed response item to expand its usefulness to inform instruction, modeled on what the MMP had done for the district benchmark assessments in grades 3-9. The first district-wide administration of the math readiness test occurred in January 2008, the second was in January 2009,

and the third (and last) was in January 2010. This test was given to all students in grades 10, 11, and 12. The MMP sponsored a scoring session each year for the constructed response item, again modeled on the process used in grades 3-9. Teachers discussed expectations for student work, scored anchor papers for the constructed response item, scored their own students papers, and then discussed potential next steps for their schools.

The mathematics readiness test is no longer administered, because the district has now moved to requiring all students in Grade 11 to take the ACT which serves a similar purpose. On the positive side, the MMP-developed readiness test did appear to serve as a catalyst for beginning a district-wide conversation about students' preparedness for postsecondary mathematics. On the other hand, it was never used to the extent we had hoped to inform instruction or as a counseling tool. Analysis of the data from individual schools showed that students made little or no improvement on the test as they moved through the grades. We hope the ACT test, given its importance as an indicator of college success and its use as a college entrance requirement, will be used in the formative and counseling capacities that were not achieved with the readiness test.

UWM Transition Support

The MMP piloted two major initiatives related to college mathematics placement at UWM that resulted in providing students with options and supports. Both of these had sufficient success and were institutionalized as a part of the UWM *Access to Success* program.

Retesting Initiative and Summer Bridge Program. All incoming freshmen at UWM must take the UW-System Math Placement Test and freshman placement into UWM math courses is determined solely by this test. For students to be placed appropriately, students and their teachers, as well as guidance counselors, must have access to appropriate and timely information about the test including not only the content of the test, but also testing policies and how to interpret the scores. Prior to the MMP, this latter information was not generally available. As an example, new freshmen are allowed to take the placement test twice, but this fact was not widely known. In addition, UWM did not have a policy of releasing test scores in a sufficiently timely fashion for freshmen to even consider this option and prepare for a retake before signing up for classes.

Through the efforts of the MMP, UWM changed its policy on notifying students of their test results in Spring 2005. Criteria were developed to identify students whose placements were lower than their high school and ACT records would predict, and they were sent letters inviting them to retest over the summer. In the first year, 1052 students were contacted and 220 chose to retest. Of those who retested, 70 percent had higher placements (Key & O'Malley, 2005). The gains were particularly impressive for those 83 students who originally tested into remedial math courses. Of these, 63 percent moved from a remedial to a credit course in mathematics. Now any student who tests into a non-credit math course at UWM is encouraged to be retested.

Unfortunately, the program had minimal effect on MPS students. In that first year, only 17 of them met the criteria for misplacement. On the positive side, seven MPS students chose to retest, with 4 of them obtaining higher placement scores. Realizing the need to make a more concerted effort, the MMP piloted a bridge program in Summer 2006 for MPS students identified by the teachers involved in the transition committee. Students worked with instructors and the computer-adaptive learning software ALEKS for four weeks. Of the 29 students in the program, 21 enrolled in UWM with 14 earning placement in a course higher than their initial placement. UWM has continued to offer the bridge program each year with similar results. Even though enrollment is never as large as we would

like, the results were sufficiently positive for UWM to justify institutionalizing the program, and has taken on the responsibility of supporting it, starting in summer 2009.

Course Acceleration Pilot. The purpose of the acceleration pilot was to provide students with options for moving through remedial courses faster. Students were given the opportunity to use the computer-adaptive learning software ALEKS in conjunction with regular class sessions to potentially complete two courses in one semester. At UWM, the two remedial, non-credit courses are Math 090 Basic Mathematics and Math 095 Essentials of Algebra. Math 105 Intermediate Algebra does carry credit, but is considered low level. The acceleration pilot started in fall 2005 (MMP Year 3) with combined sections of Math 090/095. Over 90 percent of these students completed both courses during the semester. Table 16 shows that participants with remedial placement who participated in the acceleration pilot had a higher success rate (defined as maintaining a C average) in spring 2006 and a higher enrollment rate in fall 2006 as compared to non-participants. A successful pilot of combined Math 095/105 courses was conducted in spring 2006. Students met twice daily and essentially completed Math 095 in the first half of the semester and Math 105 in the second half of the semester.

The pilot of these combined courses continued for three more years in collaboration with the UWM *Access to Success* program, with results similar to those in the first year. The combined Math 090/095 version of the pilot was officially institutionalized in fall 2010 as a permanent course offering (Math 094). The combined Math 095/105 has also been institutionalized and continues to be offered as combined courses with concurrent registration.

Table 16. Effects of Math Acceleration Pilot for Math 090/095 in Fall 2005

	Math Pilot participants			Math Pilot non-participants		
	n	Satisfactory Spring 2006	Enrolled Fall 2006	n	Satisfactory Spring 2006	Enrolled Fall 2006
All students						
All students with remedial placement in any subject	44	65.9%	72.7%	1515	57.0%	61.1%
All students with MATH 090 placement	24	75.0%	66.7%	396	48.2%	56.6%
Targeted minorities total						
Targeted minorities with remedial placement in any subject	6	50.0%	50.0%	434	42.2%	52.3%
Targeted minorities with MATH 090 placement	3	66.7%	66.7%	167	37.1%	46.1%

Analysis of Math Placement Scores at UWM and MATC

The MMP, at both UWM and MATC, studied the transition of MPS high school graduates to college mathematics. Our hope was to increase the number of MPS graduates who, as freshman, placed into mathematics credit courses at the postsecondary level, thus reducing the number of students in remedial math courses. It must be admitted that we have not been successful in this area. We do have a better understanding of the situation for both MPS and non-MPS graduates and the analysis of this data led to our efforts to implement supports and initiatives as described above, as well as the MATC study on course credits.

The collection and analysis of placement test scores has been an ongoing activity of the MMP. Each year faculty compiled information from databases on the number of MPS and non-MPS graduates who would require remedial mathematics courses in order to complete their program requirements. Accuplacer scores were analyzed at MATC and the UW-System Math Placement Test at UWM. Table 17 shows this data from 2005 to 2010.

Table 17. UWM and MATC Results on Remedial Math Placement from 2005 to 2010

Placement	Fall 2005		Fall 2006		Fall 2007		Fall 2008		Fall 2009		Fall 2010	
	MPS	Non-MPS	MPS	Non-MPS	MPS	Non-MPS	MPS	Non-MPS	MPS	Non-MPS	MPS	Non-MPS
UWM Total	309	3465	269	3729	330	4180	299	3751	375	3667	373	3324
Basic Math	52%	11%	47%	11%	42%	11%	40%	10%	44%	13%	37%	13%
Essentials of Algebra	20%	14%	22%	19%	31%	25%	27%	29%	27%	26%	33%	27%
UWM Remedial	72%	25%	69%	30%	73%	36%	68%	39%	71%	39%	70%	40%
MATC Total	798	528	709	594	690	658	721	637	699	860	743	801
Basic Math	72%	26%	74%	29%	75%	25%	73%	27%	66%	24%	70%	28%
Essentials of Algebra	20%	21%	20%	24%	19%	41%	20%	37%	23%	28%	23%	34%
MATC Remedial	92%	47%	94%	53%	94%	66%	93%	64%	89%	52%	93%	62%

In fall 2010, 70% of MPS graduates entering UWM placed into remedial mathematics courses as compared to 40% of non-MPS graduates. At MATC, 93% of potential freshman from MPS schools placed into remedial mathematics courses as compared to 62% of non-MPS graduates. Although substantially higher proportions of MPS graduates required remedial mathematics courses compared with non-MPS graduates, a substantial proportion of the latter also required remediation. The gap between MPS and non-MPS graduates has actually narrowed from 2005 to 2010, but this decline is due to an increased need for remediation of non-MPS graduates and not to improved placement of MPS graduates. Needless to say, these numbers indicate much work still needs to be done in preparing high school students to move into college level mathematics.

Part 6
The Destination

The *Milwaukee Mathematics Partnership* (MMP) journey began, officially, in 2003 with an award from the National Science Foundation (NSF) for a Comprehensive Mathematics and Science Partnership in the amount of $20 million. Now eight years later as the NSF funding has come to a close, we have paused to look back at the journey we have traveled—the successes, highlights, and challenges—and the destination we have reached.

Even though we discuss "the destination" we know our journey is not over. Our aim was to improve student performance in mathematics in the Milwaukee Public Schools, and students have demonstrated significant progress along their journey of learning challenging mathematics. However, much work remains in order to reach the goal of mathematical proficiency for all students. Herein, we examine the progress of student mathematics proficiency from the early years of the MMP and compare it to their performance at the end of our eight-year journey. We also compare the gains of MPS to those made by students throughout the state of Wisconsin, and examine trends across the years by grade level.

The MMP brought together its core partners—Milwaukee Public Schools (MPS), University of Wisconsin-Milwaukee (UWM), and Milwaukee Area Technical College (MATC)—in seeking solutions to address the challenges of mathematics achievement in a large, diverse, and complex school district. Our work has included designing and implementing new policies and practices, as well as redirecting resources, within each of the core partner institutions. Not only has this included focused work on PK-12 mathematics, but also substantial work related to the mathematical preparation of teachers and the transition of students from high school to postsecondary mathematics. Herein, we reflect back on the journey and the destination reached within each core partner and summarize the institutional changes for sustainability of the work of the MMP.

Student Achievement in Mathematics

Students in the Milwaukee Public Schools (MPS) increased their mathematics achievement on the Wisconsin Knowledge and Concepts Examination (WKCE), and also narrowed the achievement gap between the district and the state. Even though the MMP began its work in the 2003-2004 school year, we have chosen 2005 as our baseline, since changes in the state test in response to *No Child Left Behind* (NCLB) legislation make comparisons with earlier data problematic. Because testing occurs in the fall, the most recent data available were from November 2010, reflective of seven years of MMP impact.

Mathematics Proficiency of MPS Students

The 2005 test results provide a reasonable baseline for our work and allow us to view changes and trends over five years. Figure 4 shows the increase in proficiency in mathematics from 2005 to 2010 for all students in grades tested, which included grades 3-8 and grade 10. In November 2005, 39.6% of MPS students were proficient on the state test. In November 2010, 50% of MPS students were proficient. These results showed that MPS students improved at a higher rate than the state of Wisconsin, increasing the proportion of students proficient or advanced by 10.4 percentage points compared with 4.4 percentage points for the state. This increase for MPS was statistically significant ($z=28.38$, $p=0.00$).

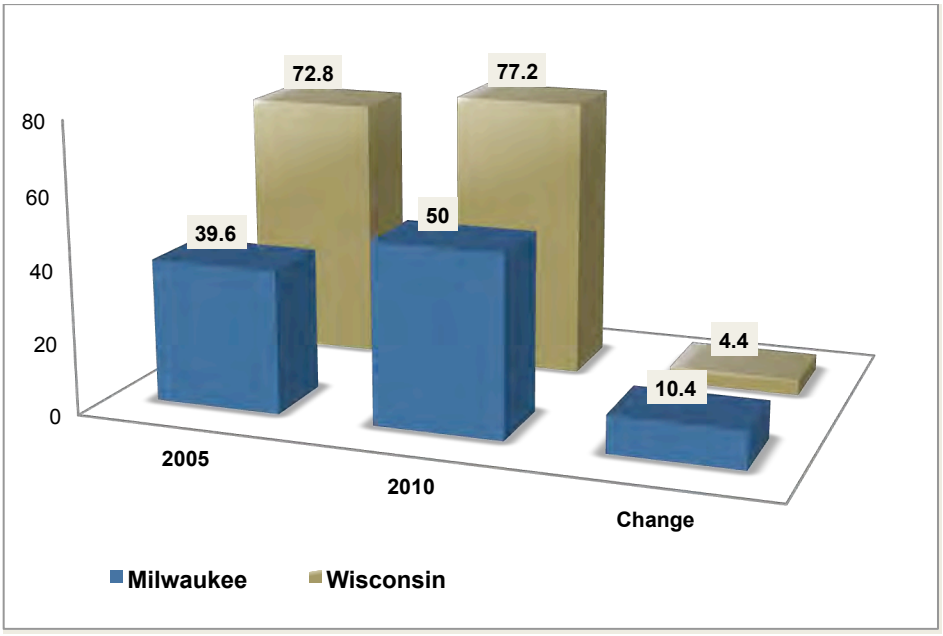


Figure 4. Percent of Student Proficiency on the WKCE in Mathematics for Milwaukee Public Schools and the State of Wisconsin

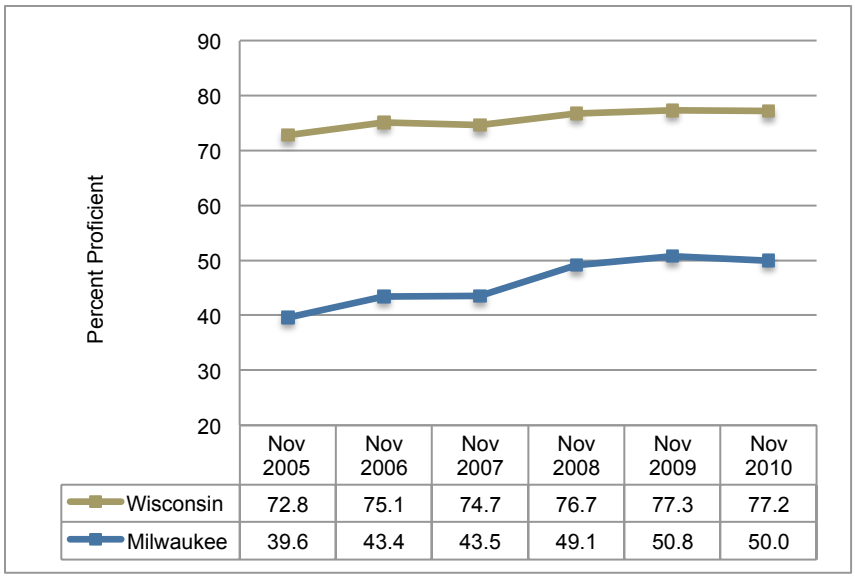
We readily acknowledge that MPS achievement was still too low and that the gap between the district and the state at 27.2 percentage points was still too large. Nevertheless, the district has made remarkable growth in mathematics, especially taking into account its challenging and changing student demographics. While the MPS student population has decreased from 2005 to 2010, the percent of students with disabilities has increased to 21%, compared to 14% in the state; the percent of students who are English Language Learners increased to 12%, compared to 6% in the state; and the percent of students in poverty increased to 81%, compared to 41% in the state.

Even with these changing demographics, all MPS subgroups demonstrated increased achievement on the state test from 2005 to 2010 as shown in Table 18. All subgroups, except Asian, either narrowed the achievement gap or had essentially the same rates of growth as the comparable state subgroup. The within district gaps narrowed slightly between African American and Hispanic students compared to White students. However substantial gaps still exist between African American and White students and between students with and without disabilities.

Table 18. Student Subgroup Results on the Wisconsin Knowledge and Concepts Examination

	Milwaukee Public Schools			Wisconsin		
	November 2005	November 2010	Change	November 2005	November 2010	Change
Economically Disadvantaged	35.3	46.0	10.7	53.5	63.2	9.7
Not Economically Disadvantaged	52.8	67.5	14.7	81.5	86.8	5.3
Limited English Proficient	35.7	46.1	10.4	50.1	55.6	5.5
English Proficient	40.0	50.5	10.5	74.0	78.6	4.6
Students with Disabilities	19.5	25.6	6.1	39.2	44.5	5.3
Students without Disabilities	44.1	56.5	12.4	78.3	82.6	4.3
Asian	58.7	65.6	6.9	69.3	78.4	9.1
African American	29.7	40.1	10.4	35.7	46.2	10.5
Hispanic	45.7	55.2	9.5	53.2	62.6	9.4
White	63.6	71.6	8.0	80.0	83.7	3.7

Change in student mathematics proficiency on a year-by-year basis is shown in Figure 5. While there was a steady improvement, the most notable change was from November 2007 to November 2008. Our data does not allow us to claim a rigorous explanation for this effect, but there were two plausible hypotheses. First, the initial implementation of the released MTL model occurred in the Spring of 2008, and this may well have had an effect on test scores in the fall. Second, the movement of K-8 schools along the MMP Continuum of Work for Mathematics shows that by Fall 2008 most schools were firmly at Stage 3 (Common Classroom Assessments) and many had moved on to Stage 4 (Examine and Use Student Work). We had always felt that we would see progress when schools were consistently looking at student work and using it for formative assessment purposes, and it may be that a turning point was reached. Probably some combination of these two effects was responsible as our prior work on the continuum and formative assessment practices established a culture in which the released MTL could work to maximum effect.



	Nov 2005	Nov 2006	Nov 2007	Nov 2008	Nov 2009	Nov 2010
Wisconsin	72.8	75.1	74.7	76.7	77.3	77.2
Milwaukee	39.6	43.4	43.5	49.1	50.8	50.0

Figure 5. WKCE Mathematics Proficiency for MPS Students from 2005 to 2010

Grade Level Trends in Mathematics Proficiency

The proficiency of MPS students by grade level for November 2005 and November 2010 is shown in Figure 6. Using a status-based comparison, the proportion of students proficient or advanced in 2005 was compared to the proportion of students proficient or advanced in 2010. The results, displayed in Table 19, showed that statistically significant increases were seen at grades 3-8, but not at grade 10, which had a slight non-significant decrease. The largest changes were at grades 5 and 6, with percentage point increases of 14.7 and 16.8, respectively. Strong improvements were also made at grades 4 and 7 with respective changes of 11.9 and 13.0 percentage points.

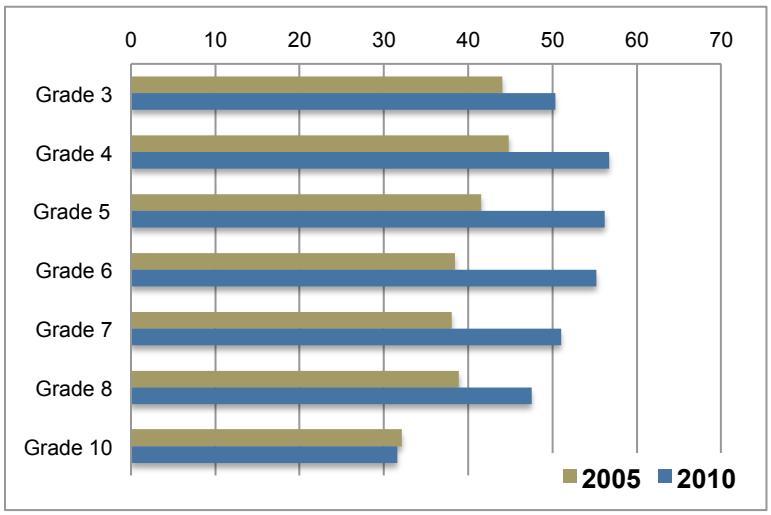


Figure 6. Percent Proficiency MPS Students WKCE Math 2005 and 2010

A comparison of the percentage point change in proficiency of MPS students to that of all students in the state of Wisconsin is also shown in Table 19. The results show that the district demonstrated larger increases in proficiency than that of students throughout Wisconsin. In other words, the achievement gap between the district and the state narrowed in all grades tested. The largest gap reductions are highlighted in the table. The greatest reduction was 9.9 percentage points at grade 6, followed by grades 5 and 7. While MPS grade 10 students had a small decrease in proficiency from 2005 to 2010, so did the state of Wisconsin. In other words, the district changes at Grade 10 mirrored the state.

Table 19. Milwaukee Public School Students Scoring Proficient or Advanced on the WKCE

Grade	MPS November 2005		MPS November 2010		Analysis of MPS Change		Percentage Point Change in Proficiency from 2005 to 2010		
	Enrolled	Percent Proficiency	Enrolled	Percent Proficiency	z	p	MPS	Wisconsin	Difference
Grade 3	5,567	44.0%	5,077	50.3%	6.50	0.00	6.3	2.1	4.2
Grade 4	5,808	44.8%	5,073	56.7%	12.39	0.00	11.9	6.7	5.2
Grade 5	5,715	41.5%	4,970	56.2%	15.17	0.00	14.7	6.8	7.9
Grade 6	5,966	38.4%	4,760	55.2%	17.35	0.00	16.8	6.9	9.9
Grade 7	5,923	38.0%	4,560	51.0%	13.30	0.00	13.0	5.4	7.6
Grade 8	6,084	38.9%	4,399	47.5%	8.79	0.00	8.6	4.1	4.5
Grade 10	5,718	32.1%	4,597	31.6%	-0.54	0.71	-0.5	-0.8	0.3

Trends on the state test by grade level for each year are shown in Figure 7. These are status-based comparisons of students tested at the respective grade level each year. Students at grades 3-8, in general, demonstrated trends of improved mathematics proficiency across the years. Most notable were the steady increases observed for grades 5 and 6, in which the percent of students proficient or advanced on the state test improved each year. These grades reflect the culmination of learning at the elementary school level—the level at which we perceived the MMP had the most impact.

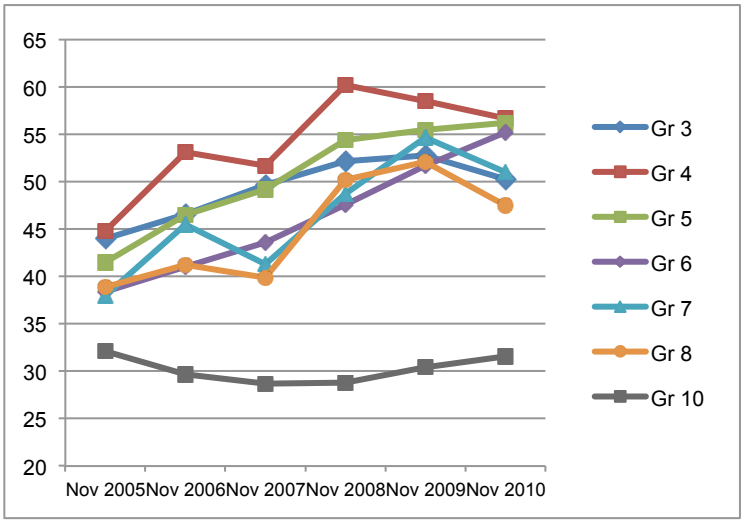


Figure 7. WKCE Grade Level Trends for MPS Students from 2005 to 2010

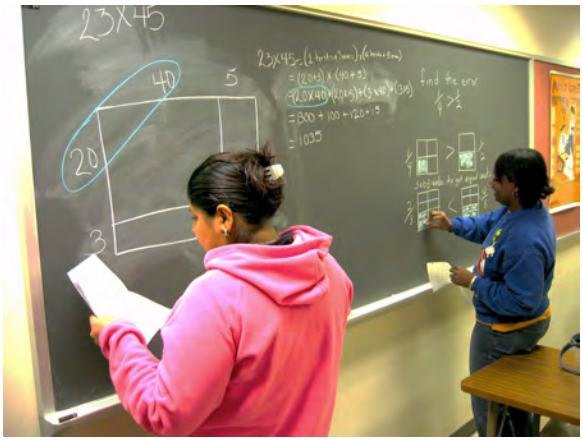
The high school trend showed that the percent proficient at grade 10 dropped from 2005 to 2010, but also showed that the level of proficiency had actually been increasing since 2007. The high schools had a slower start than the K-8 schools in working consistently and earnestly toward the MMP goals, partly due to conflicting district initiatives and changes in school organizational structures as well as school cultures. MMP involvement at the high school level was finally taking hold during the 2007-

2008 school year, particularly with the shift to a released-time MTL. In addition, the unified, district-wide textbook adoption was first used in high school classrooms in fall 2008 with implementation support through the MMP. This allowed for more cohesive and focused professional development and collaboration within and across schools that most likely also contributed to the trend toward increased proficiency. Nevertheless, the mathematics proficiency of MPS high school students remained alarmingly low and in great need of continued focus and attention. Through the MMP, a shift in the culture of high school mathematics was emerging with more collaboration among teachers and a renewed interest toward engaging students in more challenging mathematics. We anticipate that this foundation will be strengthened in subsequent years and will support further improvement in student learning in mathematics.

Linking Student Mathematics Achievement and MMP Involvement

The growth in state test results from 2005 to 2010 was encouraging and revealed that MPS student mathematics achievement was on the right trajectory. Yet, the test scores overall were still too low and the gap in comparison to the state was still too wide. Another view on student achievement is to consider changes at the school level. We know that student achievement in mathematics varied greatly across schools in the district. Some schools were high performing and were comparable to state levels of proficiency. Other schools had extremely low student proficiency in mathematics. Here we take a look at schools as the unit of analysis and examine changes in student mathematics proficiency on the state test from November 2005 to November 2010.

At the elementary and middle school level, a total of 114 target schools had test results for students in grades 3-8 range at both time points. Of these schools, 78% (n=89) demonstrated an increase in the percent of students proficient or advanced in mathematics, with 48 schools having more than 10 percentage point increases. The other 22% (n=25) of these schools had a decrease in student proficiency in mathematics.



At the high school level, 24 target schools had test results for students in grade 10 at both time points. Of these high schools, 33% (n=8) demonstrated an increase in the percent of students proficient or advanced in mathematics, with four schools having more than 9 percentage point increases. On the other hand, 63% (n=15) of these high schools had a decrease in student mathematics proficiency, and one school had no change in the level of proficiency.

The goal of the MMP was to help all schools across the district improve student performance in mathematics. However, we know that some schools were highly involved in MMP initiatives and other schools had low involvement. Similarly, some schools demonstrated remarkable increases in student mathematics proficiency and some did not. An evaluation challenge has been to link school involvement in the MMP to the student mathematics achievement in the respective schools. The MMP evaluation team made progress in finding approaches to explain variability in student mathematics achievement (Hanssen & Walker, 2011). They utilized different modeling approaches over the years based on their growing understanding of hierarchical linear modeling. Some models used schools within the district as the unit of analysis, while others used students within schools.

Across these models, the variables most commonly found to predict higher student achievement were those that, in some way or another, quantified how much effort a school put into improving mathematics teaching and learning guided by the MMP initiatives. Schools that reported greater focus on improving student achievement and greater collaboration among teachers for mathematics were more likely to have greater gains and higher proficiency rates in mathematics. More importantly, the results of the evaluation demonstrated that, at the elementary and middle school levels, MMP involvement was related to growth in student achievement in mathematics.

Teacher involvement in the MMP, as a school level variable, and student test scores, were only part of the story and still provided a limited view of the engagement of students on our journey. The more important trajectory, and the one which is harder to document, has been the change within classrooms, in the mathematical interactions of teachers and students. The following reflection by a Math Teacher Leader offers a glimpse into the real impact of the MMP on student learning and the trajectory established.

One very powerful example of the impact of the MMP in my school is that students seem to enjoy and understand math better. I am observing, as a sixth grade teacher, the results of the students who have been learning math in a different and more comprehensive manner for several years. They seem to better remember concepts from previous years and are using different strategies then in the past. I feel they have an overall better understanding of the concepts. Along with this, the teachers of those students are seeing math in a different way, feeling more comfortable with teaching "outside of the box" where they are actually utilizing the Comprehensive Mathematics Framework and seeing first hand the importance of students being able to use hands-on materials, developing and sharing strategies, and being engaged, not just practicing a worksheet after being given a lecture. The MMP has definitely made a difference in the way mathematics is being taught in MPS and it is truly helping our students to become better mathematicians.

Institutional Change and Sustainability

The *Milwaukee Mathematics Partnership* (MMP) brought together its core partners in seeking solutions to address the challenges of mathematics achievement in a large, diverse and complex district—the Milwaukee Public Schools (MPS), and to address the challenges of the mathematical preparation of prospective teachers at the University of Wisconsin-Milwaukee (UWM) and the Milwaukee Area Technical College (MATC). At the conclusion of the MMP, the changes in the schools and the district and at UWM and MATC, are, to a great extent, what we had hoped would happen.

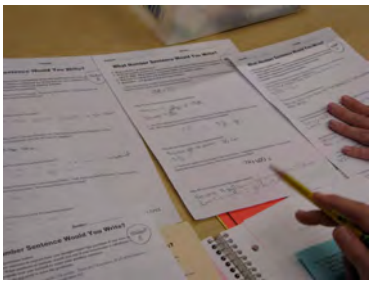
The Partnership remained strong. We saw more new teachers graduating from UWM and MATC with stronger mathematical knowledge for teaching. We saw classroom teachers placing value on collaborating with each other to improve the teaching and learning of mathematics. We saw principals placing value on the study and discussion of mathematics as a priority in their school leadership roles. We saw teachers sharing the "big ideas" of their teaching with students through learning intentions, and articulating what would be learned if these big ideas were accomplished. We saw students working with purpose and enthusiasm as they heard and read descriptive feedback from their teachers and were given the opportunity to improve their work and continue their learning.

In this section, we summarize the institutionalization of policies and practices among the core partners. In general, the basic principles and design of our work have been largely justified. Our vision of mathematics, as exemplified in the *Comprehensive Mathematics Framework*, has guided much of the mathematics instruction in the district and the mathematical preparation and professional development of teachers. Our vision has led to positive changes in the culture of schools for mathematics teaching and learning and has resulted in improved student performance in mathematics. More discussion of the work and impact of the MMP can be found through the publications listed in Appendix C which contains a listing of articles, book chapters, a dissertation, papers, reports, and news articles and feature stories.

MILWAUKEE PUBLIC SCHOOLS (MPS)

MPS has institutionalized and sustained several components of the Partnership. Some of these components were more obvious and tangible, whereas other aspects were more intangible but, perhaps, reflect more valuable and lasting impacts of our work.

Teacher Leadership. The district leadership for mathematics was expanded through the MMP with the establishment of the Math Teaching Specialist (MTS) positions. These six to ten individuals were critical as district-wide teacher leaders who worked tirelessly to move the district. In particular, they were the vital link from the district to the learning teams and the Math Teacher Leaders (MTL) across approximately 150 schools. The MTLs began their work as fulltime teachers in non-released MTL positions. Additional funding from the state of Wisconsin and the district allowed the majority of the MTLs to shift to a released-time position during its fifth year. The MTS and MTL positions originated with the MMP and have continued to exist and be valued and supported by the district, even though the structure and scope of their work has changed over the years.



School Culture. An elusive quality of the MMP that may well escape data analysis emerged as the driving force of the MMP as it matured, and as it survives in some form in the current environment of the Milwaukee Public Schools (MPS). That quality is what many of us refer to as a "cultural change" in the way mathematics is taught and learned in schools throughout the district. A change in culture is not easy–it requires changing attitudes of administrators, of teachers, and ultimately, of students. A change in the culture is more than just specific "compliance" to new practices or policies; it is more than just new ways of teaching or new ways of assessing, although each could be major contributors to the change in this culture.

How do you know and feel this culture? You see it in the way teachers interact with their colleagues regarding the mathematics their students are doing. You see it in the way they value student work (the real treasure of what happens as a result of our instruction). You see it in the way they expect (and demand) quality professional development regarding mathematics. You see it in the way teachers value good problems and good assessments. You see it in the way schools continue to address mathematics in teacher discussions, in the way schools address their special population of students with disabilities, or in the way they make sure that mathematics is appropriately part of school improvement plans. This cultural shift was most apparent in the words of our Math Teacher Leaders (MTL) as mirrored in the following reflections.

> *I have been the MTL at my school since the beginning of the MMP and the changes I have experienced have been amazing. In the past, teachers worked in isolation with little opportunity to collaborate about mathematics topics or concerns. The approach was to just use the textbook and get as far as you could. We had no idea what was happening in other grades or even next door. There was no coherent vision and good ideas were not being developed into common practices. Teaching mathematics was not really a priority.*

Not only did I become the "voice" for mathematics in my school, but my staff wanted to learn to teach more effectively. I was able to help build the knowledge of my staff through more professional development and common school-wide practices. Many pieces of the MMP continuum became more institutionalized within my school, such as using common grade-level CABS that coordinated with the unit focus, better understanding and use of the learning targets and standards, and using more formative assessment practices.

As the MTL, I feel like I have been able to help staff and students "see" math concepts in deeper ways—trying to promote more student engagement while connecting concepts and real-world applications. All classroom teachers in my building are now using portfolios, have mathematics word walls, use W.A.L.T. on a daily basis, and use math journals with their students. This coordinated effort helped to guide our students from one year to the next with our expectations about their mathematics success. My school finally has a focus for math instruction and teaching mathematics has become a priority.

Mathematics Instructional Practice. The Math Teacher Leader (MTL) in each school was asked to reflect upon the level of implementation of some MMP initiatives related to instructional practice. The level of implementation was reported on a range from "not even addressed" (value=1) to being "institutionalized" as a part of normal, school-wide practice (value=6). The results are shown in Table 20 for elementary schools and for high schools. The implementation at the elementary school level, in general, was further along than at the high school level. These practices did not exist prior to the MMP and were developed and implemented as a result of the partnership.

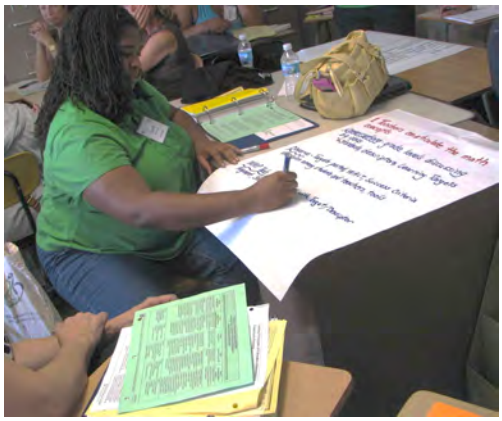
Table 20. Impact on Mathematics Instructional Practices

	n	Mean	SD	Level of Implementation					
				1 None	2 Weak	3 Some	4 Good	5 Strong	6 Instituted
Elementary Schools									
Math CABS: Use district model classroom assessments with students.	100	4.60	1.20	1%	3%	14%	29%	23%	30%
Curriculum Guides: Using the district mathematics curriculum pacing guides.	99	4.43	1.26	3%	3%	17%	22%	33%	21%
Constructed Response Problems on district math benchmarks: Teachers collaboratively examine student work and discuss next instructional steps.	100	4.11	1.30	2%	7%	29%	19%	26%	17%
WALT: Teachers state and post math lesson goals and learning intentions in student-friendly language.	100	4.08	1.25	1%	10%	22%	30%	21%	16%
Descriptive Feedback: Teachers give students written descriptive feedback on math assessments.	100	3.70	1.23	1%	14%	36%	22%	17%	10%
High Schools									
WALT: Teachers state and post math lesson goals and learning intentions in student-friendly language.	24	4.21	1.22	4%	4%	17%	25%	42%	8%
Curriculum Guides: Using the district mathematics curriculum pacing guides.	23	3.65	1.27	4%	13%	30%	22%	26%	4%
Math CABS: Use district model classroom assessments with students.	24	3.37	1.25	8%	13%	33%	29%	13%	4%
Descriptive Feedback: Teachers give students written descriptive feedback on math assessments.	23	3.04	1.11	4%	30%	35%	17%	13%	0%
Constructed Response Problems on district math benchmarks: Teachers collaboratively examine student work, and discuss next instructional steps.	24	2.87	1.04	13%	21%	33%	33%	0%	0%

At the elementary level, schools showed strongest implementation of the district model classroom assessments (CABS) with 53 percent indicating that they had been institutionalized or had strong implementation. Similarly, the math curriculum guides were highly implemented. Additionally, over 25 percent of the schools reported high implementation of using student work from benchmark assessments to inform instruction, of posting daily math learning intentions, and of providing students with descriptive feedback on assessments.

At the high school level, the strongest practice was in posting learning intentions in student-friendly language. This practice was modeled in the algebra and geometry learning labs and clearly resonated with high school teachers. The next strongest practice was the use of the district curriculum guides, which provided consistency and focus in implementing the newly adopted unified textbook program at the high school level. Even though the level of implementation was lower for use of classroom assessments, constructed response items, and descriptive feedback, it was encouraging that high school teachers were beginning to collaborate on the analysis and use of student work in mathematics.

Focused Expectations for Mathematics Learning. The MMP began with the development of its Comprehensive Mathematics Framework (CMF) and grade-level learning targets for mathematics. This began our journey to establish focused expectations for student learning of mathematics. The CMF broadened the view of mathematical proficiency to include understanding, computation, application/problem-solving, reasoning, and engagement. The math learning targets articulated the "big ideas" of what students were to learn. At the school level, significant evidence of this impact can be observed by simply walking into a typical mathematics classroom. Posted in the classrooms are the daily "learning intentions" for a mathematics class. Generally, these intentions are clearly stated goals for students to read and discuss as the mathematics class is started. In addition, the "success criteria" is stated and used to monitor whether or not the instruction is on target. These strategies were introduced, supported, and continually modeled by the MMP through its professional development. It is now a district "universal expectation" that all classrooms post their daily learning intentions not only for mathematics, but for all subject areas. This focused attention on the mathematical knowledge of students was further strengthened through grade-level selection of common assessments, collaborative analysis of student work, and descriptive feedback.



The institutionalization of our work on focused and articulated mathematical expectations was inherent in the *MPS Comprehensive Mathematics and Science Plan* that was implemented in fall 2011. The math plan was developed by the Math Teaching Specialists with strong involvement of the MMP. It included grade-level curriculum guides that articulated the mathematics content to be taught at each grade level. It included the MMP model classroom assessments and constructed response item prompts. It reflected the MMP focus on mathematical knowledge for teaching through its inclusion of common student misconceptions and challenges, instructional practices, and differentiation. It included an instructional design framework utilized by the MMP. It also included the ten principles of formative assessment established by the MMP. This plan, in essence, brought together the work of the MMP and set the stage for its sustainability under new administration, new organizational structures, and new Wisconsin standards. Because of the MMP, the district is well-positioned to embrace these new "learning targets," the *Common Core State Standards* adopted as the Wisconsin State standards, and the expectations they hold for teachers and administrators in developing focused, coherent, and deep understanding of mathematics by all its students.

MILWAUKEE AREA TECHNICAL COLLEGE (MATC)

The MMP was responsible for a number of activities that were initiated and accomplished at MATC. While some activities related only to MATC and its students, most of them had effects that extended beyond the college to UWM and other institutions of higher education, as well as to MPS. Each of these activities developed and strengthened the relationship of MATC with the other core partners, both serving to their immediate mutual advantage and speaking to the success of future partnerships, articulations, and activities.

True Partnership. An initial challenge was that of building a genuine partnership with the other core partners. Although MATC was an important conduit between MPS and UWM, the college was not always recognized as such. The first activity was to hire a Math Coordinator to spearhead the MMP work. This position and person, David Ruszkiewicz, became key to the success of the work done at MATC and with the partners, particularly UWM. The impact of this hire cannot be overemphasized. It was vital to MATC's role in becoming a full partner, rather than an afterthought, and in the accomplishments that were achieved by MATC, as well as by UWM and MPS. Finding an individual who could serve as a bridge between institutions was our solution to some of the obstacles that others have encountered. The Math Coordinator received his master's degree in mathematics from UWM and had been an adjunct faculty member at UWM. His experience and relationships were exactly what were needed by MATC to jumpstart, continue, and even expand its activities through the MMP. His hire demonstrated the importance of building bridges between the partners as quickly as possible. Subsequently, a UWM professor nominated Mr. Ruszkiewicz who then received the STEM Award in Education (the STEMMY), presented by the Engineers and Scientists of Milwaukee at its annual conference in 2009.

New MATC Courses for Prospective Teachers. MATC established two foundational mathematics courses specifically designed for the preparation of elementary teachers—Mathematics for Elementary Education Teachers 1 and 2 (Math 275 and 276). The course development and initial teaching was the group effort of faculty and staff from both MATC and UWM. This activity not only further developed bonds between MATC and UWM, but ensured coordination and consistency between the same courses offered at both institutions. These courses were first offered at MATC in the 2005-2006 academic year. Since then, two sections of the first course, Math 275, and one section of the second course, Math 276, have been offered each fall and spring semester. This has been a critical accomplishment for students in the MATC teacher education track. Offering these courses at MATC has resulted in a better-prepared prospective teacher as they move on to complete their four-year education degree and, for those intending to have a mathematics focus, has allowed them to stay on track in taking more mathematics courses.

Change in Mathematics Graduation Requirements. The graduation requirements for prospective teachers have changed as a result of the MMP. Prior to the grant, teacher education students were required to take college algebra in order to graduate with an A.A. degree. The requirement was an obstacle to graduation for many students both within and outside of the teacher education program and caused many students not to graduate before leaving MATC. In 2005, the math requirement was changed to intermediate algebra as a means of staying consistent with requirements of other transfer colleges in the Wisconsin Technical College System, as well as with its main transfer partner, UWM. Now teacher education students focused on grades K-8 take Math 275 and 276 while students planning to teach high school mathematics take college algebra. These changes have increased the number of MATC graduates from its teacher education track.

Recruitment and Advisement of Prospective Teachers. The MMP increased institutional awareness at MATC of the need to recruit students into its teacher education track program, appropriately advise them while they were at MATC, and track them after they graduated or moved on to a four-year college. Mathematics faculty now advise teacher education students to ensure that they are appropriately advised and placed in mathematics courses that will allow continued development as future teachers of mathematics. They also identify and recruit potential teacher education students from the courses they teach. This has established a sound support team available to help prospective teachers succeed. Once the teacher education students transfer to pursue their education degrees, MATC now maintains a database to track their progress.

Enforcement of Course Prerequisites. A long overdue action institutionalized during the tenure of the MMP has been the enforcement of prerequisites at MATC. This was primarily brought about because of the analysis of Accuplacer scores indicating the need for placement into remedial mathematics courses due to students' lack of preparedness for their program courses in mathematics. Without enforcement of prerequisites, the typical action of many students had simply been to sign up for their program math course regardless of their preparation. While prerequisites were listed for courses, they were often ignored. The result of doing this was predictable. What was not predictable was that, after failing the course, a student would just sign up for it again—sometimes multiple times—ostensibly on the premise that they had gained at least some knowledge that might help them to succeed the next time. MATC started prerequisite enforcement in fall 2008 with mathematics and English courses because students placed into these courses through the Accuplacer placement test and non-qualifying students could more easily be blocked from registering. Since that time, prerequisite enforcement has become institutionalized and has extended to many other courses and programs. Course instructors have commented that students are now better prepared to be in their classes. The system will continue to be modified and improved over time in order to ensure proper student placement in mathematics courses, as well as other courses, in a more accurate and streamlined manner.

UNIVERSITY OF WISCONSIN-MILWAUKEE (UWM)

The University of Wisconsin-Milwaukee (UWM) has exhibited a strong commitment to partnership-driven efforts aimed at improving the teaching and learning of mathematics in our community. UWM, in collaboration with our core partners, the Milwaukee Public Schools (MPS) and the Milwaukee Area Technical College (MATC), has established a reciprocal and mutually beneficial partnership through our work in envisioning, developing, and implementing the MMP initiatives. Herein, we summarize the institutionalization of policies and practices at UWM realizing that these would not have been possible without our collaborators at MATC and MPS.

New UWM Courses for Prospective Teachers. Using a design team comprised of mathematics faculty, mathematics educators, and teachers-in-residence, we developed courses based on the recommendations of *The Mathematical Education of Teachers* report (CBMS, 2001). We created four courses in mathematics specifically for prospective elementary teachers electing a minor in mathematics. The new courses included (1) problem solving and critical thinking, (2) geometry, (3) discrete probability and statistics, and (4) algebraic structures. All four courses have been offered each year since the 2005-2006 academic year, some with multiple sections. We also developed a mathematics capstone course for our prospective high school teachers, which has been offered each spring since 2006. These five courses have

become well established at UWM and are offered each year. Moreover, the courses have now been taught by several mathematics faculty beyond those in the original design teams, and may be considered as firmly institutionalized within the department's suite of undergraduate courses.

Acceleration Options for Transitioning to College Mathematics. The work of the MMP led to changes at both UWM and MATC in terms of student transition to college-level mathematics. At UWM, a successful summer bridge program run by the MMP for three years became institutionalized as part of the university's *Access to Success* program. The summer bridge program identifies incoming UWM freshmen whose mathematics course placement appears to conflict with their high school record, and invites them to strengthen their mathematics skills over the summer by working with university tutors and the computer-adaptive software ALEKS. At the end of the summer, they may re-take the placement test, or are sometimes given direct placement into a higher course. Approximately half of all students in the program improve their placement level, and the retention rate for these students has been consistently higher than for comparable students not in the summer bridge program.

UWM also piloted combined courses allowing students to essentially complete two courses in one semester, thus accelerating their progress through non-credit mathematics courses. The combined Math 090/095 (both non-credit courses) was officially institutionalized in fall 2010 as a permanent course offering, Math 094. The combined Math 095/105 (a non-credit course combined with Intermediate Algebra) has also been institutionalized and continues to be offered as combined courses with concurrent registration.

Collaboration of Mathematicians and Mathematics Educators. Strengthened by the MMP, the commitment to partnership-driven efforts has been evident in the relationship between the UWM College of Letters and Sciences and the School of Education. This administrative commitment has been apparent in the support for the collaborative work of mathematics and mathematics education faculty and staff who have worked diligently together with the aim of improving the teaching and learning of mathematics both at the university and in our community. This collaboration is best exemplified in the steadfastness and intensity of the work in regards to the MMP for over eight years, which has nurtured and confirmed this commitment. It was also apparent in the many collaborative grant projects of these faculty over these years aimed at improving the teaching of mathematics in MPS as well as the Milwaukee area, such as those funded by the Wisconsin Improving Teacher Quality program ESEA Title II, Part A) and the Math and Science Partnership Program (ESEA Title II, Part B) administered through the Wisconsin Department of Public Instruction).

This collaborative work was certainly strengthened by the attention to the depth, rigor, and coherence of mathematics that was embedded in our work by the involvement and engagement of mathematics faculty. Furthermore, we have every intention of continuing this collaboration of mathematicians and mathematics educators to support not only improved teacher preparation at UWM, but also continued work with MATC and other institutions of higher education and with MPS and other school districts. In addition, due to the strength of our work through the MMP, UWM mathematics and mathematics education faculty have been regularly sought out and invited to serve on state-level education committees and have been intensely involved in Wisconsin's adoption and implementation of the *Common Core State Standards for Mathematics*.

Part 7
Reflections of the Journey

The collaborative efforts of mathematicians, mathematics educators, teacher leaders, teachers, and administrators through the *Milwaukee Mathematics Partnership* (MMP) have guided improved PK-12 mathematics teaching and learning in the Milwaukee Public Schools (MPS) and stronger mathematical preparation of prospective teachers at the Milwaukee Area Technical College (MATC) and the University of Wisconsin-Milwaukee (UWM). The MMP began with the development of its *Comprehensive Mathematics Framework* and district grade-level learning targets for mathematics. It initiated the positions of Math Teacher Leader (MTL) and Math Teaching Specialist (MTS). We developed, modified, and revised model classroom assessments based on standards (CABS). We developed the *MMP Continuum of Professional Work for Mathematics* as a roadmap to guide the developmental progression of schools in movement toward formative assessment practices. As a result of these efforts, we have seen significant increases in student achievement in mathematics, strengthened teacher leadership for mathematics, and improved teachers' mathematical knowledge for teaching.

The Math Teacher Leaders and Math Teaching Specialists have built a strong foundation within each school centered on mathematical understanding as the core of quality instruction. The intense and sustained focus on one district has offered us the immense opportunity to create a culture and expectations for the work of teachers and the learning of students in mathematics. When the Math Teacher Leaders were asked to use one word to describe the MMP, some of their responses were: transformational, purposeful, collaborative, consistent, supportive, engaging, deep, inspirational, and life-changing. These words were indicative of the genuine, meaningful, and lasting influence of the MMP. We share here three illustrations of success as evidence of this transformative impact.

The first illustration involves an elementary school whose students made a *22 percentage point gain* in mathematics proficiency on the state test from 2005 to 2010 through a steady and incremental gain each year. The school reflected the challenging student population of the district with 76 percent of its students in poverty and 26 percent with disabilities. The Math Teacher Leader, who had been in the position since the beginning of the MMP, reflected on the importance of the formative assessment focus, the MTL monthly seminars, and the UWM courses.

> *The MMP has had a great influence on how I teach math and also on how the other teachers in my school teach math. The MMP has given our school opportunities to become aware of instructional practices that are research-based and beneficial in improving teaching for learning. All the work through the years on assessment has especially helped me to better understand the importance of formative assessment and how it plays an essential part of daily classroom practice.*
>
> *The monthly content sessions given to the MTLs and then shared with staff at my school have helped in promoting better understanding of math content, and therefore have been reflected in how content is taught to our students. The availability of the UWM-MMP courses on various content areas has given more teachers an opportunity to strengthen their math knowledge and to use strategies to help improve math understanding for our students. Quite a few of our teachers have taken part in these courses and have found them very beneficial.*

The monthly MTL sessions on leadership have helped me to become more aware of how what I do and say have an influence on how to help the teachers in my school. I am more conscious of my approach to my staff and try harder to help the teachers who are struggling with teaching math. I see enthusiasm from the majority of the staff to at least try new approaches. The teachers in my school have become more open to try new ways to improve math teaching because the MMP has been so organized and has been in the forefront of promoting best practices for the district.

The second illustration involves an elementary school whose students made an astounding *40 percentage point gain* in mathematics proficiency on the state test from 2005 to 2010, one of the largest gains in the district. The student population was comprised of 98 percent students in poverty, 38 percent with limited English proficiency and 17 percent with disabilities. The Math Teacher Leader, who had been in the position for seven years, reflected on the value of the released-time MTL position allowing her time to model, team teach, and provide teachers with more professional learning opportunities.

As a released MTL (I love my job), I believe my school has benefited tremendously as shown in the increase in our state test scores. I was available to work with teachers and share all the information I had learned in our monthly MTL meetings, as well as the UWM courses. When we were not released, it was very hard to find time to help teachers and students. I now could guide teachers and help them to have a deeper understanding of the big math ideas through modeling and team teaching, as well as providing math professional development in staff meetings, grade level meetings, and on a one-to-one basis, which helped promote student achievement. Being released also helped me to continue to grow as a leader in my school, and allowed me to help the staff and students achieve our math vision and goals.

The third illustration involves a middle school and the importance of the MMP Continuum for guiding professional work. From 2005 to 2010, the students made a *10 percentage point gain* in mathematics proficiency on the state test. The student population was comprised of 80 percent students in poverty, 17 percent with limited English proficiency, and 18 percent with disabilities The Math Teacher Leader who had been in the position for the last four years reflected on the transformative impact of the MMP.

The initiatives of the MMP have transformed the way we approach math instruction in my school. While we (teachers at my school) were at various stages on the MMP Continuum, we were given many opportunities to collaborate with our colleagues and be reflective about our instructional practices. Through more frequent committee and grade-level meetings we began the process of analyzing math instruction and learning, both within and across grade levels. This process has supported our understanding and vision of the big ideas students should be learning at each grade level. Additionally, we were able to identify gaps in grade-level content, giving us a chance to address those gaps and develop a comprehensive approach, relative to our math curriculum. This collaboration has also given us a chance to discuss student achievement through the use of common classroom based assessments. In our grade level groups, we analyzed student work samples to develop strategies and next steps to support student learning.

The MMP Continuum has been the backbone and roadmap of our efforts. This document outlines the MMP initiatives and connects those initiatives to formative assessment strategies, along with our school improvement plan. The strongest influence the MMP Continuum has had on our math teachers was that it provided us with coherence in our approach to improving student achievement, beginning with alignment and ending with analyzing student work as a school. This helped to bring the issue of math achievement to a school level concern, not only one of math teachers alone.

Finally, the MMP has linked our practice with institutes of higher education to provide our teachers ongoing learning and professional development opportunities, year after year. We have participated in UWM course work that focused on both the mathematical knowledge required to be effective teachers, as well as instructional practices such as differentiation in our classrooms.

Teachers and administrators have a clearer and deeper understanding of the mathematics students need to learn and of high-quality instructional and assessment practices in mathematics. Obviously, these observations are not evident in every school or every teacher, nor has student achievement increased in every school. New teachers, new schools, new administrators, and new students make the culture we nurtured a continual challenge to sustain. Yet, because it was a genuine cultural change that the MMP nurtured, changes will be challenged and evaluated by a high standard of respect and value for what the MMP has accomplished.

The MMP has been embraced among the partners and, in particular, embraced by the dedicated teachers in the Milwaukee Public Schools who have striven to make a difference in the mathematical learning of their students. Our work has been respected for its high level of quality, for our steadfast vision of the *Comprehensive Mathematics Framework*, and more importantly because it valued and supported the work of teachers who have seen improvements and gains in students' mathematical knowledge and engagement. We close with one final comment from a dedicated Math Teacher Leader as she reflected upon the journey of her elementary school, which by the way made a *22 percentage point gain* on the WKCE from 2005 to 2010 with 90% of its students in poverty, 28 percent with limited English proficiency, and 18 percent of students with disabilities.

> *The journey to get to this point has been a winding and bumpy road and my car broke down a few times. But as I arrived at this rest stop, I have to say that my greatest successes have been creating positive relationships with teachers and students and bringing math into our collective consciousness. Teachers TALK about math. They teach math and they are more willing to take risks in teaching math. They know that there is someone who has their back and will help them understand how to teach a concept or help give them that content knowledge. Kids want to do math. They look forward to being a part of something that makes them feel successful. Parents see their children making progress in mathematics. Because of the MMP, math has come alive in my school. I have loved just about every minute of being an MTL.*

The MMP has been on a remarkable and noteworthy journey in establishing the capacity of schools for continuous improvement in student success with genuine learning of mathematics. As this MTL noted, we are just at a rest stop, and the Partnership is poised to continue its collaborative journey.

MILWAUKEE
MATHEMATICS
PARTNERSHIP

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Appendix A

MMP Continuum of Professional Work for Mathematics

Milwaukee Mathematics Partnership (MMP)
Continuum of Professional Work for Mathematics

Stage 1 Learning Targets	Stage 2 Align State Standards and Math Program	Stage 3 Common Classroom Assessments	Stage 4 Student Work on Common Assessments	Stage 5 Descriptive Feedback on Common Assessments
Understand importance of identifying and articulating big ideas in mathematics to bring consistency to a school's math program.	Develop meaning for the math embedded in the targets and alignment to state standards and descriptors and the school's math program.	Provide a measure of consistency of student learning based on standards, descriptors, and targets.	Examine student work to monitor achievement and progress toward the targets and descriptors and to inform instruction.	Use student work to inform instructional decisions, and to provide students with appropriate descriptive feedback.
School Professional Work • Teachers develop awareness of district learning targets for each mathematics strand. • Teachers discuss what each learning target means and can articulate the math learning goals students are to reach. • Teachers examine the development of mathematical ideas across grade levels.	**School Professional Work** • Teachers examine alignment of state standards and state assessment descriptors to district learning targets. • Teachers identify the depth of knowledge in the state assessment descriptors. • Teachers study how the mathematical ideas in the descriptors are developed in the school's math program. • For each lesson, teachers inform students of the math learning goals in terms that students understand.	**School Professional Work** • Teachers select and study common classroom assessments based on standards (CABS) to use for a grade level or course. • Teachers identify math expectations of students on the assessments. • Teachers identify potential student misconceptions revealed through the assessments. • Learning team members and teachers examine student state test and district benchmark assessment data to identify areas of strengths and weaknesses for focusing teaching and learning.	**School Professional Work** • Teachers collaborate in grade-level meetings to discuss student work and implications for instruction. • Teachers meet in cross grade-level meetings to discuss common math expectations of student learning and implications for school-wide practice. • Learning team monitors and discusses student learning on CABS results from across the school, shares observations with staff, and uses data for school improvement plan.	**School Professional Work** • Teachers collaborate to write descriptive feedback to students on benchmark assessments and on common CABS. • Students use descriptive feedback to revise their work and improve learning. • Teachers use descriptive feedback to adjust and differentiate instruction. • Learning team monitors successes and challenges of writing descriptive feedback and identifies professional learning needs of teachers.
Tools • Grade level learning targets (9-11 big ideas per grade). • Progressions of learning targets across grades. • Comprehensive Math Framework (CMF).	**Tools** • Target-descriptors alignment worksheet. • Depth of knowledge analysis. • Curriculum pacing guides. • Lesson planning with formative assessment principles (WALT).	**Tools** • Assessing an assessment guide. • CABS assessment overview. • District model CABS. • Curriculum pacing guides. • Depth of knowledge analysis. • Student math test data reports.	**Tools** • MMP protocol for collaborative analysis of student work. • DVD on MMP protocol. • CABS class summary report. • School improvement plan.	**Tools** • Types of feedback overview. • Class feedback summary recording sheet. • Student record of descriptive feedback.

Appendix B

MMP Toolkit

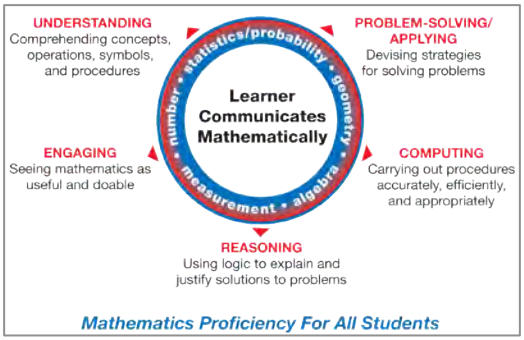
MMP Toolkit

The *Milwaukee Mathematics Partnership* (MMP) created many tools to support the collaborative work of teachers and learning team members in their schools. Many tools were aligned to specific stages of the *MMP Continuum of Professional Work for Mathematics*. The tools were developed and revised in response to a growing understanding of the needs of teachers and schools and learning from evidence-based research findings. Tools were also generated and revised for program evaluation needs. This listing provides a short description of the tools that proved important to our work. Some tools were used more in the early stages and years of the MMP, and other tools became critical in the later stages and years in alignment with the MMP Continuum. Whereas other essential tools were used throughout the work of the MMP. Most of these tools are available on the MMP website (www.mmp.uwm.edu).

Framework and Planning Tools

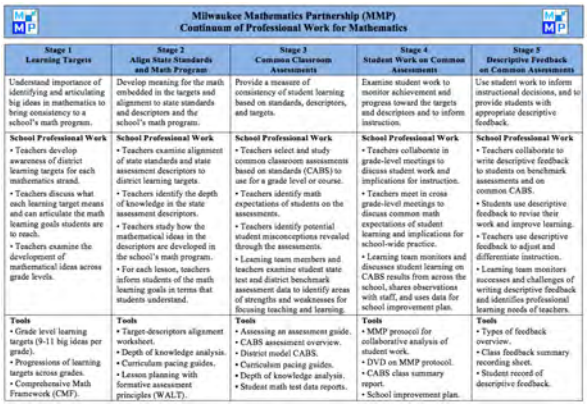
Comprehensive Mathematics Framework

The *Comprehensive Mathematics Framework* (CMF) was developed as a vision for the PK-16 learning and teaching of mathematics. This framework was represented by a cycle that revolved around the Wisconsin content standards of number, algebra, statistics, probability, geometry, and measurement. The five components of mathematical proficiency—understanding, computing, problem-solving/applying, reasoning, and engaging defined high quality teaching of challenging mathematics.



MMP Continuum of Professional Work for Mathematics

This continuum identified five stages of formative assessment practices and defined the professional work of teachers in a school related to each stage, along with associated tools to support the work. This tool became a multi-year framework and road map for the learning and work of math teacher leaders, classroom teachers, and learning team members.



Milwaukee Mathematics Partnership (MMP)
Continuum of Professional Work for Mathematics

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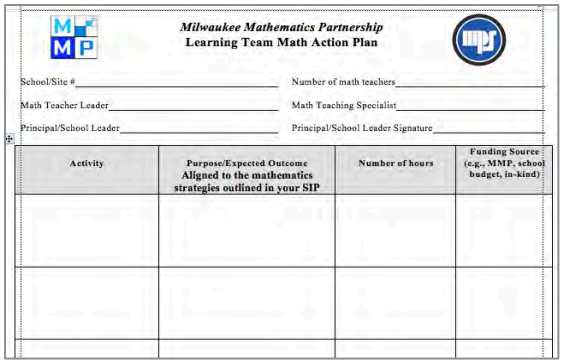
School Self-Assessment Guide for the MMP Continuum

Learning teams used the self-assessment guide to reflect on the work within their schools along the MMP continuum. They rated their schools on a four-point rubric (i.e., weak, emerging, moving forward, and strong) for each stage of the continuum. They then established goals and plans for school-based professional development. This tool was the basis for district monitoring conferences at each school site.

Math Action Plan

The learning team in each school was asked to develop a math action plan each year to focus the math related work in its school and define priorities for the work of its math teacher leader. Plans were submitted to the district math specialists and additional funds were available to support approved plans.



Milwaukee Mathematics Partnership
Learning Team Math Action Plan

School/Site #_____ Number of math teachers_____

Math Teacher Leader_____ Math Teaching Specialist_____

Principal/School Leader_____ Principal/School Leader Signature_____

Activity	Purpose/Expected Outcome Aligned to the mathematics strategies outlined in your SIP	Number of hours	Funding Source (e.g., MMP, school budget, in-kind)

Learning Target and Alignment Tools

Grade Level Learning Targets

The learning targets provided a consistent set of student expectations for K-12 mathematics across the Milwaukee Public Schools. The learning targets were based on the Wisconsin Model Academic Standards, that included mathematical processes, number operations and relationships, geometry, measurement, statistics and probability, and algebraic relationships. A set of targets was developed for each grade level from K-8 and for high school.

Progressions of Learning Targets across Grades

A progression document showed how the targets grew from kindergarten to grade 8 for each math content strand. Teachers studied the progressions to know what big math ideas were learned in previous and subsequent grade levels.

Grades 5–8
Mathematics Learning Targets

	Grade 5 By the end of this grade, students know and are able to:	Grade 6 By the end of this grade, students know and are able to:	Grade 7 By the end of this grade, students know and are able to:	Grade 8 By the end of this grade, students know and are able to:
Number Operations and Relationships	(1) Pose real-world problems, and use strategies, including number theory concepts and place value, to compare numbers, make estimates, and solve single and multi-step word problems. (2) Generate and represent equivalent forms of commonly used fractions, decimals, and percents; estimate with benchmarks; and use strategies to compare, add, and subtract fractions and decimals with and without context.	(1) Represent and rename numbers, identify prime and composite numbers, and use factors, multiples, and prime factorization to solve and explain problems. (2) Apply, explain, and evaluate strategies to estimate, compare, and compute fractions, decimals, and percents using a variety of methods (e.g., mental computation, technology, manipulatives) with and without context.	(1) Represent, rename, compare, and identify equivalent forms of fractions, decimals, and percents using place value and number theory concepts. (2) Estimate and justify solutions to problems with and without context involving whole numbers, integers, and rational numbers, including applications of proportional reasoning.	(1) Explain comparisons and operations on real numbers and use proportional reasoning (including ratios and percents) to solve problems with and without context.
Geometry	(3) Describe, construct, and classify polygons and polyhedra using properties (e.g., angles, lines of symmetry, parallel lines, similarity) of plane and coordinate geometry. (4) Evaluate the results of transformations from rigid motions and movement between polyhedron and nets, and describe three-dimensional figures from multiple perspectives.	(3) Identify and contrast properties of polygons and polyhedra (e.g., sides, angles, symmetry, faces) and draw or describe relationships (e.g., congruency, regularity, similarity, decomposition, transformations) of figures from multiple perspectives. (4) Use specifications to plot, construct, and transform points and shapes using the coordinate plane.	(3) Identify and describe polyhedra from multiple perspectives and determine the measure of angles and angle pairs in polygons. (4) Design and classify symmetrical figures, transform points and figures using the coordinate plane, and apply properties of similarity in problem solving situations.	(2) Analyze relationships among figures and their parts, including the Pythagorean Theorem, using properties of plane and coordinate geometry, and use proportional reasoning, transformations, and spatial visualization in problem-solving situations.

Target-Descriptor Alignment Worksheets

These worksheets supported teachers in study, discussion, and identification of the alignment of the state assessment descriptors to the district learning targets. An alignment worksheet was developed for each grade from grade 1 to grade 8 that listed the targets for a math content strand and the descriptors of what would be assessed on the state test.

Grade 5 Geometry

MPS Learning Target #3 (Grade 5)	MPS Learning Target #4 (Grade 5)
Describe properties of a class of two-and three-dimensional shapes (e.g. parallel sides, measures of angles, congruent faces, regularity, line and rotational symmetry.)	Move between three-dimensional objects and two-dimensional representations of shapes by building and drawing and evaluate the results.

MPS Target Alignment	Wisconsin Sub-skill Descriptors (Beginning Gr. 6)
Sub-skill: Describing figures	
	A) Recognize and name polygons with 3, 4, 5, 6 or 8 sides.
	B) Identify lines and line segments in a plane figure.
	C) Classify plane figures by characteristics of angles (acute, obtuse, and right) and describe rays found in open-angle situations.
Sub-skill: Spatial relationships and transformations	
	D) Use tangrams to describe, model, and construct plane figures
	E) Identify figures that are congruent and/or similar.
	F) Describe and compare cubes, rectangular and triangular prisms, and rectangular and triangular pyramids from nets (flat patterns).
	G) Use slides, flips, and turns on figures. Identify congruent shapes using figures that have been manipulated by one or two motions (slides, flips, and turns).
	H) Identify lines of symmetry and the number of lines of symmetry in figures, and design shapes that have at least one line of symmetry.
	I) Identify and describe 3-dimensional figures from multiple perspectives.
Sub-skill: Coordinate systems	
	J) Identify and plot the coordinates of locations or objects on simple one quadrant grids using numbers only for coordinates, (e.g. (3,2)).
	K) Locate the fourth coordinate pair when given three vertices of a rectangle or parallelogram on a coordinate grid.

Sharing the Grade 10 Assessment Descriptors

State testing occurred at the beginning of grade 8 and then not again until the beginning of grade 10, so this document made it explicit that teachers for grades 8 and 9 were both jointly responsible for the math content tested in at the beginning of grade 10. The document identified which of the state assessment descriptors should be emphasized in grade 8 and in grade 9 or in both.

Curriculum Pacing Guides for Grades K-8

Grade-level curriculum pacing guides were developed for each of the three adopted textbook programs in grades K-5 and grades 6-8. The units of study were connected to the district learning targets, state standards, and state assessment descriptors, as well as to the district model classroom assessments. The guides provided a suggested sequence and pacing of units for each grade level and text program.

Classroom Assessment Tools

Model Classroom Assessments Based on Standards (CABS)

The MMP developed a set of performance assessments in mathematics for each grade level, K-8, and for both the foundation level courses (algebra and geometry) in high school. These were to serve as models of good assessments aligned to state and district standards, and were referred to as CABS. The assessments were aligned to the district learning targets and state descriptors and the district curricular programs. Teachers were to work together to study, select, and use them as common assessments at a grade level or for a course to monitor student learning, inform instruction, and provide descriptive feedback to students.

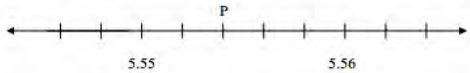
Mathematics Grade 8
Classroom Assessment Based on Standards

Using the number line below:

What number would be located at point P? _____

What is the value of the interval being used? _____

Indicate on the number line the approximate location of the $\sqrt{31}$.



Justify your placement of $\sqrt{31}$ on the number line.

Assessing an Assessment Guide

This tool provided a protocol for teachers to follow if they chose to use performance assessments other then the district model CABS. Teachers first solved the assessment. Then they identified its alignment with district learning targets and state descriptors, as well as the depth of knowledge in the questions. The teachers then reflected on the assessment task, anticipated student responses, and discussed potential implications and value in using the task.

Depth of Knowledge Analysis Worksheet

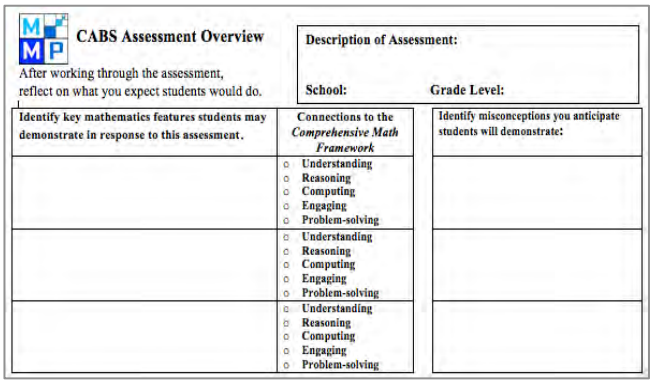
Teachers used this tool to examine assessments and assign a "depth of knowledge" level to each question: (1) recall and recognize, (2) use concepts and procedures, (3) conclude and explain, and (4) evaluate, extend, and connect. A bar graph was then plotted for each item so teachers could visualize the typical knowledge level of the assessment items.

CABS Assessment Overview

This tool asked teachers to preview key math features in the task before a CABS was administered. Teachers identified the math content, its alignment with the CMF, and brainstormed potential student misconceptions that may emerge in student responses.

CABS Class Summary Report

Teachers used this report to summarize how their students performed on a CABS and provided a consistent template for sharing this data with other teachers and the school learning team. It included identification of strengths and weaknesses in students' understanding and defined next steps in classroom teaching as part of the formative assessment process.



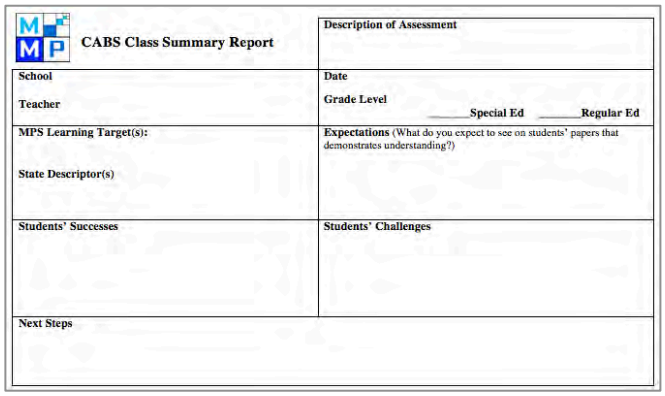
CABS Assessment Overview

After working through the assessment, reflect on what you expect students would do.

Description of Assessment:

School: **Grade Level:**

Identify key mathematics features students may demonstrate in response to this assessment.	Connections to the *Comprehensive Math Framework*	Identify misconceptions you anticipate students will demonstrate:
	○ Understanding ○ Reasoning ○ Computing ○ Engaging ○ Problem-solving	
	○ Understanding ○ Reasoning ○ Computing ○ Engaging ○ Problem-solving	
	○ Understanding ○ Reasoning ○ Computing ○ Engaging ○ Problem-solving	



CABS Class Summary Report

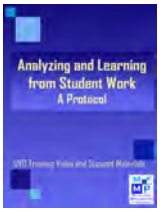
	Description of Assessment
School **Teacher**	**Date** **Grade Level** _____Special Ed _____Regular Ed
MPS Learning Target(s): **State Descriptor(s)**	**Expectations** (What do you expect to see on students' papers that demonstrates understanding?)
Students' Successes	**Students' Challenges**
Next Steps	

Student Work Protocol and Descriptive Feedback Tools

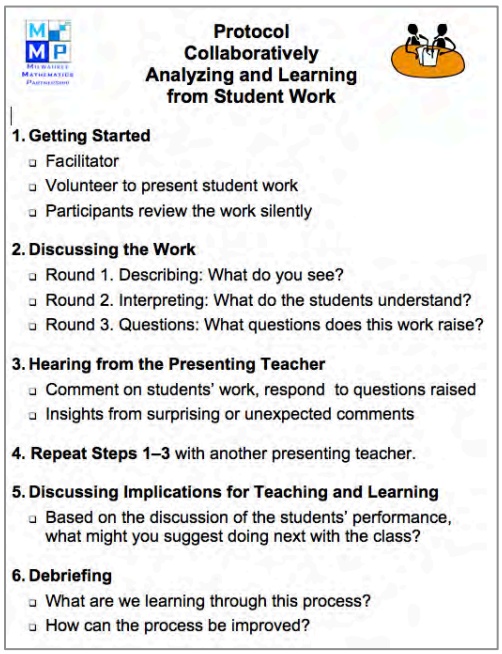
Protocol for Collaborative Analysis of Student Work

This set of guidelines structured conversations among teachers about student work in a safe and focused manner that allowed for public discussion of one's student work. The goal of the protocol was to foster a common understanding of student learning expectations for mathematics and to provide a collaborative forum for examining student work to inform mathematics instruction. the six steps that were a part of this process included: (1) getting started, (2) discussing the work, (3) hearing from the presenting teacher, (4) repeating steps 1-3 for each teacher who had student work, (5) discussing implications for teaching and learning, and (6) debriefing the protocol process.

DVD on Protocol for Analyzing and Learning from Student Work



The purpose of this professional development video was to model a collegial conversation that pushed deep thinking on the teaching and learning of mathematics. It created a common district view of this collaborative process around student work and provided a tool for professional learning of teachers, teacher leaders, and school administrators.



Protocol Collaboratively Analyzing and Learning from Student Work

1. Getting Started
- Facilitator
- Volunteer to present student work
- Participants review the work silently

2. Discussing the Work
- Round 1. Describing: What do you see?
- Round 2. Interpreting: What do the students understand?
- Round 3. Questions: What questions does this work raise?

3. Hearing from the Presenting Teacher
- Comment on students' work, respond to questions raised
- Insights from surprising or unexpected comments

4. Repeat Steps 1–3 with another presenting teacher.

5. Discussing Implications for Teaching and Learning
- Based on the discussion of the students' performance, what might you suggest doing next with the class?

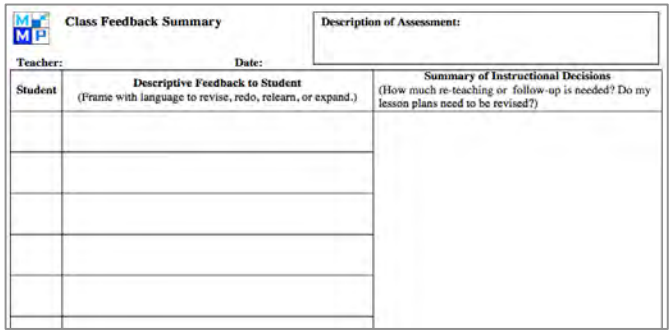
6. Debriefing
- What are we learning through this process?
- How can the process be improved?

Types of Feedback Overview

This document categorized the types of feedback that a teacher might give to a student. The types of feedback were presented on a continuum that ranged from *motivational* to *evaluative* to *descriptive* to *effective*. The intent of the document was to raise the awareness of teachers as to the different types of feedback they might give to students, the purpose of each type of feedback, and the impact that each has on student learning. The anticipated outcome of the this tool was to move teachers to begin providing more descriptive and effective feedback to students.

Class Feedback Summary

This tool was used to make a record of the descriptive feedback given to a class of students on a specific assessment. This helped teachers to build consistency in descriptive feedback and made it available for further examination and discussion to make instructional decisions. For example, teachers could identify groups of students that needed similar follow-up support or identify areas that needed re-visiting by the entire class.



Class Feedback Summary

Description of Assessment:

Teacher: Date:

Student	Descriptive Feedback to Student (Frame with language to revise, redo, relearn, or expand.)	Summary of Instructional Decisions (How much re-teaching or follow-up is needed? Do my lesson plans need to be revised?)

Formative Assessment Tools

Formative Assessment Principles

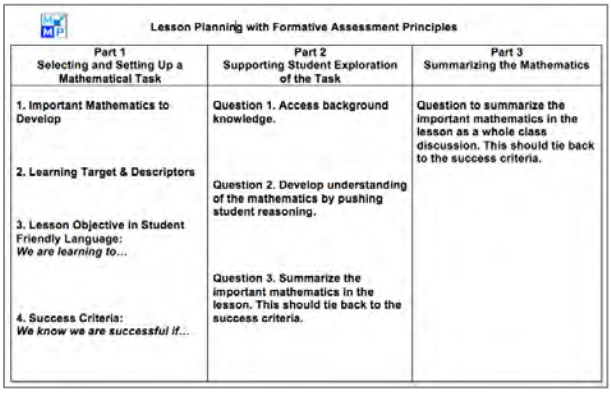
The MMP identified ten principles of formative assessment for mathematics. This tool broaden the view of what comprised formative assessment practices and established a common vision and common language. The principles were grouped into three categories (1) teacher and student articulation of learning goals, (2) teacher focus on using assessment information to guide teaching, and (3) student focus on using assessment information to move learning.

Alignment Framework of Principles of Formative Assessment with the MMP Continuum

The ten principles of formative assessment were aligned with the stages of the MMP Continuum. This framework document was used to more clearly articulate formative assessment practice for each stage of the continuum. It also surfaced how each previous stage needed to be continuously embedded in subsequent stages.

Lesson Planning with Formative Assessment Principles

This template was a tool that math teacher leaders used in their schools with teachers. This three part lesson planning form focused on (1) setting up a mathematics lesson, (2) formulating questions to support student exploration during the lesson, and (3) summarizing the importance mathematics in the lesson. It also emphasized the articulation of the lesson objective in student-friendly language using "WALT" (We are learning to) and the use of success criteria (We know we are successful if).



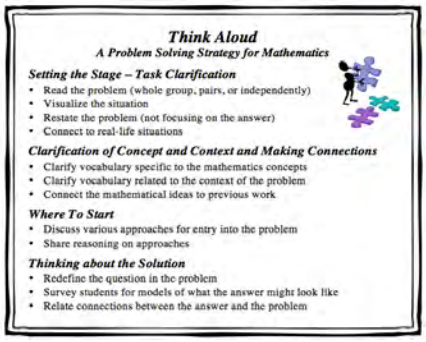
Lesson Planning with Formative Assessment Principles

Part 1 Selecting and Setting Up a Mathematical Task	Part 2 Supporting Student Exploration of the Task	Part 3 Summarizing the Mathematics
1. Important Mathematics to Develop	Question 1. Access background knowledge.	Question to summarize the important mathematics in the lesson as a whole class discussion. This should tie back to the success criteria.
2. Learning Target & Descriptors	Question 2. Develop understanding of the mathematics by pushing student reasoning.	
3. Lesson Objective in Student Friendly Language: *We are learning to...*	Question 3. Summarize the important mathematics in the lesson. This should tie back to the success criteria.	
4. Success Criteria: *We know we are successful if...*		

Think Aloud Tool

Think Aloud: A Problem Solving Strategy for Mathematics

This instructional tool provided a protocol for teachers to model and demonstrate the usually hidden mental processes that enable learners to be successful in solving mathematical problems. The goal was to help students develop independent thinking during problem solving situations. The general steps were to (1) visualize the situation, (2) clarify the important mathematical concepts and the context, including clarification of vocabulary, (3) students share approaches for entry into the problem, and (4) focus on what is needed for a solution.



Think Aloud

A Problem Solving Strategy for Mathematics

Setting the Stage – Task Clarification

- Read the problem (whole group, pairs, or independently)
- Visualize the situation
- Restate the problem (not focusing on the answer)
- Connect to real-life situations

Clarification of Concept and Context and Making Connections

- Clarify vocabulary specific to the mathematics concepts
- Clarify vocabulary related to the context of the problem
- Connect the mathematical ideas to previous work

Where To Start

- Discuss various approaches for entry into the problem
- Share reasoning on approaches

Thinking about the Solution

- Redefine the question in the problem
- Survey students for models of what the answer might look like
- Relate connections between the answer and the problem

Communication Tools


September 200

The MMP Messenger

www.mmp.uwm.edu

Volume 6, Issue 2

Updated Benchmark Constructed Response (CR) Rubrics

MTLs examined student work from the updated constructed response items on this years first Benchmark Assessments. The MTLs participated in a training session where they were asked to:

- analyze anchor papers to clarify key mathematics features in the prompt,
- study the task specific rubric, and
- provide feedback to inform instruction.

Working through the format of the training session, the MTLs are excited to guide school-based scoring sessions in the constructed response prompts.

Many MTLs still questioned how to use the information from the constructed response items. They considered:

- addressing student misconceptions in written effective descriptive feedback statements,
- sharing rubrics with students, and
- engaging grade-level groups of teachers in discussions of possible mathematical trends and of instructional decisions that could be determined. Formative assessment information analyzed around the CR could prove insightful in the work around the schools

MTL Leadership: *What does it take to be a leader of mathematics education?*

As it turns out, the answer to this question is quite intricate! This year the MTLs will embark on a journey to identify personal stages of leadership in the areas of assessment and of teaching and learning. The *PRIME Leadership Framework: Principles and Indicators for Mathematics Education Leaders*, a National Council of Supervisors of Mathematics publication is being used as a reference and tool in our understanding of leadership.

Looking Ahead…

October 23 & 24 K-7 Focus MTL Meetings, 7:45 a.m-2:35 p.m., Marshall High School Complex

October 21 & 22 8/9 Focus MTL Meetings, 7:45 a.m. – 2:35 p.m., Marshall High School Complex

Finding the Connection: Algebraic Reasoning is Embedded in Early Mathematical Experiences

At what age do students begin to think algebraically? Many would say ninth grade, but MTLs who attended the September meeting will tell you differently. The MTLs engaged in activities ranging from Kindergarten through sixth grade. These activities helped develop a conversation around the idea of **relational thinking**.

42 60	64 33

Looking at the number cards above. Without computing, how would you decide which card has the largest total?

You might have found a relationship between the numbers on each card, or you might have found yourself estimating. Do you need to compute to find identify which is the larger set? By exploring the idea of relational thinking, MTLs found out many Kindergarteners use relational thinking when working with numbers. After exploring the concept of relational thinking, MTLs examined this question… *What is the mathematical knowledge teachers need to have in order to capitalize on this thinking as it surfaces in classrooms?* The Mathematical Knowledge Needed for Teaching (MKT) is an important idea we will be discussing all year as we continue to explore algebraic reasoning. As teachers continue to learn about their textbook series it's important for them to (1)develop an understanding as to why algebra is correlated with the other math strands and (2) figure out how to promote this kind of thinking with children. That's what we mean by MKT! Ask your MTL to demonstrate some of the activities with your staff! It might just be the catalyst that promotes mathematical conversations in classrooms!

MMP Archive Professional Development Sessions

All content sessions (slides, handouts) from the MTL meetings from the last four years are on the MMP Web site for your use. www.uwm.edu/Org/MMP/: resources/math_content.htm

Of particular interest might be the session on "equality" located at www.uwm.edu/Org/MMP/: resources/Math_Content/equality.htm

MMP Messenger

This monthly one-page newsletter summarized the topics from the monthly MTL seminars and included MMP announcements. It was sent to principals, learning team members, math teacher leaders, and central services staff. It was important for keeping stakeholders informed on a regular basis.

HS Math Minutes

This monthly one-page newsletter reported on the mathematics work occurring at the high school level. It also provided information on the professional development opportunities for high school math teachers.

Monthly MPA Report

The Milwaukee Partnership Academy (MPA) included regular updates on the work of the MMP in its monthly update to the Milwaukee Board of School Directors and to its executive partners.

Evaluation Tools

MMP Annual Online Survey

This survey was designed to assess the overall impact of the *Milwaukee Mathematics Partnership*. It was administered to all teachers of mathematics in the district and to all learning team members towards the end of the school year. The online self–report survey assessed differences in the quantity and quality of school level participation in MMP related activities. The responses were utilized to create variables for use in statistical models linking MMP involvement to student achievement.

MTL Annual Survey

This survey was revised annually to collect data on specific activities for a specific school year. It was administered to the Math Teacher Leaders (MTL) at the end of each school year. The MTLs reported on the math related work in their schools, identified the MMP Continuum stage that best represented their school, and wrote a few paragraphs sharing a nugget of information about a critical element of their work that year.

Mathematical Knowledge for Teaching (MKT) Content Assessments

MKT assessments were administered to Math Teacher Leaders, classroom teachers, and preservice teachers each year. The assessments utilized items from the Learning Mathematics for Teaching project at The University of Michigan. Items were selected to construct scales specific to the MMP. The results were converted to ability estimates using a two-parameter item-response-theory (IRT) model.

Mathematical Knowledge for Teaching (MKT) Beliefs Instrument

This instrument, developed by the MMP, was a survey instrument on beliefs and efficacy about mathematical knowledge needed for teaching. It was comprised of three scales on a six-point likert scale. The instrument was administered to undergraduate students, education majors, and classroom teachers.

Social Network Analysis (SNA) Survey

The SNA survey was administered to all teachers and administrators within a school. The respondents were asked to list up to 15 individuals with whom they had communicated with about mathematics education in the past several months, along with indicating the frequency and extent of collaboration.

Observation Protocol for Mathematics Focused Meetings

The purpose of this protocol was to facilitate observations of MPS school-based meetings that focused on mathematics. These meetings included professional development sessions, learning team meetings, math department or committee meetings, and grade-level team meetings.

Appendix C

MMP Publications

MMP Publications

Website

MMP Project website: www.mmp.uwm.edu

Articles and Book Chapters

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