NARROWING THE GAP BETWEEN A VISION OF REFORM AND TEACHING PRACTICE: MIDDLE LEVEL TEACHERS' REFLECTIONS

Presented as a Distinguished Paper at the American Educational Research Association

Denver, Colorado, 2010

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ABSTRACT

The research objectives were to identify the middle level mathematics teachers' conceptions of mathematics teaching and learning and ascertain changes in their conceptions and instructional behavior at the end of a three-year professional development (PD) project. These changes were studied through the qualitative analysis of their reflective journals and observations of their teaching to determine the extent to which their conceptions and their instructional behaviors exemplified the PD vision. The results include the teachers' conceptions of their own learning being transformed into their conceptions of how middle level students learn mathematics and the expectations of the PD project; understanding mathematical concepts instead of memorizing rules, solving realistic application problems instead of practicing routine procedures, and students exploring and investigating instead of teachers lecturing. Supported by the evidence in their journals and teaching observations, the reflection process narrowed the gap between their teaching practice and the PD vision of reform. The results imply that the PD project focus should be at least considered for future programs; 1) strengthening teachers' mathematical content knowledge, 2) building proficiency in the use of effective teaching strategies, 3) developing mentor relationships between middle level teachers and university faculty, and 4) supporting teachers in the selection and implementation of reform curricula.

The contents of this article were developed under a grant from the U.S. Department of Education. However, the contents do not represent the policy of the U.S. Department of Education and one should not assume endorsement by the Federal Government.

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Introduction

After 30 years of research, the challenges of professional development (PD) still exist (Reiman, 2004). Reiman contends that PD remains brief and disconnected and PD usually calls for deep and abiding change, but teachers' conceptual understanding is resistant to change. Further, few PD projects have detectable effects on the instructional behavior of the teachers or on student learning. On the other hand, he reports promising trends such as the features that characterize the PD project described herein: mentoring, demonstration teaching, observations, reflections, practice in the classrooms, and the review of student work. As a means to improve teaching quality and student achievement, PD projects are pervasive in school improvement plans. Therefore, understanding what makes PD effective is necessary to determining the success or failure of many reform efforts (Desimone, 2009). As Desimone, Smith, and Ueno (2006) suggest, policymakers and administrators are focused on PD to address weak teacher preparation and content gaps and they found that since teachers usually participate in PD on a voluntary basis, teachers with strong mathematical content knowledge are more likely to take sustained PD than those weak in content. This result points to one of several distinctive characteristics of this three-year PD project, the Middle School Mathematics Academy, where schools collaborated in the project only if *all* their middle school mathematics teachers participated. Other characteristics of the project will be described as the research aspects are presented herein.

The Middle School Mathematics Academy (MSMA) project was a partnership between a state educational cooperative and 11 public schools with a shared vision to increase students' mathematics achievement by a) strengthening teachers' mathematical content knowledge, b) building teachers' proficiency in the use of effective teaching strategies, c) developing mentor relationships between middle school teachers and university mathematics faculty, and d) supporting teachers in the selection and implementation of research-based, standards-based mathematics curricula. There were 32 middle level teachers and four university faculty mentors in the first year. As the number of school districts increased, the number of teacher participants was increased to 62 in the second year and leveled to 55 in the third year. PD sessions and mentoring activities for the first year focused on deepening content knowledge related to the state mathematics framework. Mentoring focused on content, new strategies, technology, and performance assessments.

One of the common assumptions presented by Grant and Agosto (2008) in their review of the role of reflection is that reflection is expected in PD programs and it is influenced in part by the collaboration. A major goal of the project was to force the teachers to reflect on their past and present practice as they witnessed others teaching and as they received feedback on their own teaching. The intent was that teachers would then be able to provide challenging, coherent mathematical experiences for their students and the students would have a better conceptual base and greater engagement and interest in mathematics. Thus, students would learn and retain more and demonstrate their achievement.

PD sessions were held in summers (intensive) and at least four times during each academic year. University mentors collaborated with the teachers through eight site visits the first year and five the second year involving demonstrations, co-teaching, and pre- and post-

teaching conferences. In the fall of the second year, the curriculum from the Connected Mathematics Project (CMP) (Cain, 2002; Friel, 2005; Lowe, 2004; Star, Herbel-Eisenmann, & Smith, 2000) was selected by the teachers and implemented in the schools following teacher training in the summer. The CMP is a problem-centered mathematics curriculum designed for all students in grades six through eight with emphasis on number, algebra, geometry, measurement, probability, and data analysis. The major CMP goals include making connections within mathematics and between mathematics and other disciplines and the real world. In the third year, PD sessions included training where teachers formed collaborative groups, analyzed student work, created scoring rubrics, and evaluated selected lessons they had previously implemented with their students. The strength of the project was in the overall structure where teachers were provided the opportunity to select the new curriculum, construct, revise, share, and extend their ideas, develop relationships with mentors, and experiment with mathematics content and activities in classrooms with their own students. The teachers' selection of the CMP curriculum (from others they had evaluated) provided the opportunity for ownership of the project goals and enthusiasm for successful implementation.

One way to examine the impact of the PD project is through the reflective journals of the participants over time. The objectives of this research were to identify the teachers' conceptions of mathematics teaching and learning and ascertain changes in their conceptions and instructional behavior at the end of the three-year project. These changes were studied through the qualitative analysis of their reflective journals and observations of their teaching to determine the extent to which their self-reported conceptions and their instructional behaviors exemplified the mathematics content, delivery strategies, and curriculum implemented in the project. By reflecting on the gap between the reform vision of the PD project and their actual teaching

practice, the in-service teachers could consciously and continuously revise their practice and seek to close that gap (Shulman, 2004). The focus of this report centers mainly on the reflection process.

Theoretical Perspectives

At a time when research in teacher knowledge and instructional performance is in the forefront, the scope of this study involves the conceptions and instructional behavior of middle level mathematics teachers, initially and throughout the PD project. The theoretical perspectives stem from a range of views of teachers knowledge and teacher reflection.

Teacher Knowledge

Determining and acknowledging teachers' conceptions of mathematics and mathematics teaching are necessary in any mathematics reform effort. Due to the endeavors of Shulman (1986), a framework for discussions of teacher knowledge has been refined to include: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. Pedagogical content knowledge is more than knowing the content of a subject, but further, is the awareness of the means of teaching this content through various examples and representations. In an effort to integrate content and the teaching process, the PD project focused on mentors modeling research-based mathematics teaching. While the middle level teachers were exposed to subject matter content knowledge, they were simultaneously observing demonstrations of methods of teaching mathematics; pedagogical content knowledge. In addition, they used curricular content knowledge to evaluate curricula from which they selected a curriculum.

Improving Teaching

Improving the middle level teachers' content knowledge and instructional strategies was a worthy goal for the project, especially since the majority of the participants were initially

trained as elementary teachers. In addition to the aforementioned characteristic of all mathematics teachers from the partnership schools participating, the project employed a PD process that included components encouraged by previous research; namely, a) longitudinal rather than short one-time workshop format, b) mentors to sustain support, c) emphasis on pedagogical and mathematical content knowledge, and d) new instructional behavior, including the implementation of research-based delivery strategies, a standards-based curriculum, and appropriate technology (Anderson, Rousseau, & Hoffmeister, 2007; West & Curcio, 2004). There are cases in the literature where teachers have expressed the desire to include such components in their teaching, but when trained observers visited their classrooms, the teachers rarely or only sometimes exhibited the instructional behavior targeted by the PD activities. For example, Vacc and Bright (1999) stated that teachers may acknowledge the tenets of reform, but may be unable to use them in their actual teaching practice due to their level of understanding. In another project, Schuck (1999) reported teachers' beliefs about mathematics constrained their access to new ways of learning. The MSMA project intended to change teachers' conceptions of mathematics teaching and learning with research documentation based on what Stipek, Givvin, Salmon, and MacGyvers (2001) found; there are substantial associations between teachers' beliefs and their practices. By adding university mentors to support and encourage the participating teachers, the project expected to alter dispositions confirming what Fetters, Czerniak, Fish, and Shawberry (2002) concluded; the beliefs and dispositions of the PD participants and facilitators shape how they interpret and implement the reform vision. In the MSMA, the teachers assumed the roles of students constructing knowledge for themselves, guided by university faculty partners (mentors) to adopt a new teaching philosophy and develop a repertoire of new instructional strategies. To determine their interpretations and

implementation, the evaluation was extended beyond content knowledge tests to the point of documenting teachers' conceptions in their reflective journals and teaching practice (observations).

Zeichner (1996) claims that improvement in teaching will not occur unless teachers are respected contributors to school reform programs. Further, he purports that despite the efforts to help teachers become more reflective, teacher education has done little to enhance teachers' roles in school reform. In today's school environment, the same could be said for in-service teachers when school supervisors and administrators dictate reform curricula without input from the teachers they supervise. The PD project described herein enhanced the teachers' roles in reform by taking into account their opinions and suggestions and the school districts then acted on the decision of the teachers to implement the new curriculum (CMP).

Reflection

It seems the literature is replete with reports on the importance of teaching reflection in preservice teacher education, but with less emphasis on in-service teachers (Baird, Fensham, Gunstone, & White, 2006; Danielowich, 2007; Van Zee & Roberts, 2001; Zembal-Saul, Blumenfeld, & Krajcik, 2000). To be a reflective teacher means the teacher must be prepared to inquire into the foundations of their actions and become critics of scholarly knowledge (Sockett, 2008). Howard and Aleman (2008) contend that a critical consciousness requires teachers to reflect on the effect of their practice and see themselves as agents of change. To lead them to engage in this type of reflection, the teachers in this project were given particular journal prompts to encourage them to think deeply about their beliefs and practices in relation to the vision of the PD project.

Fendler (2003) suggests that the meaning of reflection is debatable and certain reflective practices such as journal writing and autobiographical narratives may include unintended and undesirable effects; for example, when reflection is understood as a turning back to oneself, the reflection may reveal no more than what was originally known. Further, Fendler (2003) asserts that practices of reflection may have thwarted past reform efforts. In response, the teachers' voices (journals) in this PD project and their behavior in their classrooms (observations) were used to document their initial conceptions of mathematics teaching and learning, their revised conceptions, and the innovation in their classrooms. On the one hand, in their comparative study, Korthagen and Wubbels (1995) found no indication of a link between reflectivity and innovation. On the other hand, in their description of a new role for a teacher educator, Korthagen and Kessels (1999) tout the importance of reflection in the process of leading preservice teachers from concrete experiences to dynamic behavioral changes. They advocate a realistic approach first described by Korthagen (1985), involving action, looking back, awareness of essential aspects, creating alternative methods of action, and trial (ALACT). Extending this idea to the in-service teachers, Korthagen's and Kessel's (1999) description involving the ALACT model is the underpinning of the reflection process in this PD project. The teachers experienced the activities and mentoring sessions (Action), looked back on the activities and their mentors' evaluations (Look back), became aware of the essential aspects (Aware), created alternative methods (Created), and implemented the methods to continue the learning process (Trial). After "Action" in the PD activities, the teachers shared their "Look" and "Aware" stages in their journals and then "Created" and implemented lessons with their students and continued the learning process (Trial) after reflecting on their students' understandings. Reflection was an essential part of the project whether written, verbal, or internal. If reflection is a way to gain

insight into teacher development as Korthagen and Kessels (1999) suggest, the analysis of the teachers' reflective journals may shed light on the relationship between in-service teachers' perceptions and the changes in their perceptions and their instructional behavior. This study answers the call by Luttenberg and Bergen (2008) for study on the development of the "breadth and depth" of reflection and the relationship between teacher reflection and their instruction.

Methods and Data Sources

There are essentially two research perspectives for mathematic education, a conventional one (analytical) based on quantitative methods; the other, naturalistic, involving qualitative methodologies in which interpretation and meaning are foremost (Brown, Cooney, & Jones, 1990). The qualitative method provides the advantage of learning about teachers' conceptions of mathematics and mathematics teaching and learning. As a source of data to determine the characteristics of changes in their conceptions and instructional behavior, the teachers were asked to keep reflective journals and allow classroom observations of their teaching by a third party (not their mentor). While labor intensive, the journals and observations provide a snapshot of their views of learning and their acceptance or rejection of the reform vision of the PD project. Journal prompts were designed to solicit their conceptions (Foss & Kleinsasser, 2001). Multiple prompts were given for each of the five journal entries that were submitted each year for three years. In the following examples, items 1- 7 were in the first journal in 1st year and final journal of 3rd year, items 8 – 10 were in the last journal of 3rd year, and 11 – 14 were in the first journal of 3rd year.

1. If someone were to ask you what mathematics is, what would you say?
2. What does it take for you to learn mathematics?
3. How do middle school students learn mathematics?
4. Describe how you typically taught mathematics prior to your participation in the Academy?

5. Describe any concerns you may have about your capabilities in regard to mathematical content knowledge, instructional strategies, engaging students, assessment, and curriculum planning.
6. Describe, in your opinion, a "good" mathematics teacher.
7. Describe a "poor" mathematics teacher.
8. What mathematics topics or instructional strategies were not covered in this professional development Academy that you had hoped would be?
9. How has this professional development Academy influenced your ability to teach mathematics?
10. Overall, what are the most important results of your participation in the Academy?
11. As a result of the Academy experience thus far, describe at least one connection you have made between two different mathematics strands in the mathematics framework.
12. Based on the Academy emphasis on multiple representations of mathematical data or events, please describe and give examples of the mathematical representations that you have taught your students to use in problem solving.
13. What materials/tools have you found the most useful in mathematics teaching and how did you use them?
14. Summarize the "Standards in Practice" process for analyzing student work and how well you think it worked.

Following Spradley's (1979) model analysis, the participants' conceptions of mathematics and mathematics teaching and learning were identified by reviewing and coding the data using a procedure similar to the Constant Comparison Method (Strauss, 1987). While these data are self-reported, the teachers shared reflections on their teaching, their mentors' teaching, and their students' learning. They also provided details concerning their beliefs about mathematics, their conceptions of their former, current, and future teaching, and their reactions to the PD project. All qualitative data were reviewed, coded, and sorted in a computer program (Ethnograph). The coding of the data is a process of sorting to place similar descriptions or quotes together in what Glesne and Peshkin (1992) call "code clumps," thus allowing theory to emerge.

There were 32 teacher participants who completed the reflective journals in the first year, 62 in the second year, and 55 in the third year. Patterns related to the teachers' conceptions were identified with three major themes emerging: defining mathematics, learning mathematics, and

mathematics teaching. From their definitions of mathematics and their descriptions of how they learn mathematics themselves and how middle level students learn mathematics, the teachers' views of mathematics learning emerged. Through their descriptions of their teaching, mentoring activities, and good and poor mathematics teachers, the teachers' conceptions of mathematics teaching were revealed. It should be noted that the researchers were not involved in the PD project as organizers, presenters, or mentors and pseudonyms were used in reporting the data. Citations from the reflective journals indicate the year and the journal number of that year; for example, Y1J4 means the quote is from the 4th journal entry of Year One.

Results

At the beginning of the first year, teachers expressed three main PD goals for improvement: learning to engage students in mathematics, developing new teaching strategies, and increasing their curricular planning skills. The teachers generally indicated their concerns about their lack of mathematical content knowledge and the time constraints in their daily schedules that might preclude their implementation of new instructional strategies. However, the majority described their classrooms as inviting and open to experimentation with new curricula. To portray other reflections, the descriptions of the teachers' conceptions of mathematics, mathematics learning, and mathematics teaching will be emphasized including the changes as they progressed from year to year.

Year One: Mathematics and What It Takes to Learn It

The view of mathematics described by the teachers at the beginning of the PD project was based mainly on mathematics as the study of numbers and number patterns pursued in order to solve problems in science and real-life situations with a small number of the teachers focusing on the logic and reasoning involved in mathematics. In contrast, the last journal entries of the

first year referred to logic or reasoning as well as problem solving and life applications. For example, Janis stated, "Mathematics is the logical understanding of numbers and how they are applied to everyday life. Mathematics is used in every aspect of our lives. That is one reason that I love teaching it. It is a combination of numbers, problem solving, patterns, reasoning, shapes, designs, and much more. There is something involving math in every area (Y1J5)."

In their first and last journal entries of the first year, the teachers were asked to describe how they learn mathematics themselves. At first, the majority explained that their learning mathematics required practice and repetition, good explanations and demonstrations of examples, hands-on manipulatives, and connections to real-life situations. Two attributes mentioned were patience and a willingness to learn. In spite of the focus on connections to realistic applications, one-third of the teachers said they learned by just studying examples or a step-by-step process and another third said it takes patience, willingness, ability, or an open mind to learn mathematics. In contrast, in the last journal entries of the first year, the teachers emphasized hands-on activities, problem solving applications, and seeing the relevance to realistic situations in life, with only a few mentioning practice and repetition. For example, Connie said, "It takes more than just a definition or a quick explanation to grasp relationships. Those relationships did not come easy for me. I learned in school to mimic my teachers and did just great. However, for me to understand what I was doing took more than that. I learn by doing explorations or hands-on activities. I need time to try out what I think (Y1J5)." Though limited in the first year, the focus on their own learning shifted to activity-based learning and how mathematics is used to solve problems. The evidence suggests that at the end of the first year, the teachers viewed their own mathematics learning more in line with the expectations of the MSMA project; understanding mathematical concepts instead of memorizing rules, solving

application problems instead of practicing routine procedures, and active lessons instead of teacher lectures.

In their first and last journal entries of the first year, the teachers were asked to describe their conceptions of how middle level students learn mathematics. Initially, approximately half of the participants stated that middle level students learn by participating in hands-on activities and using manipulatives. About one-third of the teachers indicated that middle level students learn in different ways and have different learning styles and therefore a combination of strategies and multiple methods are needed. While a few mentioned that students need good explanations, practice, or step-by-step procedures, there were several who said that exploration, discovery, working together, relevance to life, or understanding why they are doing the mathematics makes the difference in whether the students learn or not. The journal entries at the end of the first year essentially portrayed the same emphasis on hands-on activities, a variety of instructional strategies, and working together to discover or explore relevant problems. For example, Fran stated, "Middle school students learn math through application. Middle school students are an exceptionally hard group to convince of the relevance of learning……..must be taught skills by making them relevant to their everyday lives….Getting middle school students involved in hands-on activities that involve food, measurement, and patterns that relate to them at their age in addition to teaching them how they will need these skills in the future help to get their attention and help them learn (Y1J5)." In sum, the teachers' conceptions of their own mathematics learning were transformed into their conceptions of how middle level students learn mathematics. As they experienced new learning in the MSMA project, what the teachers described as needed in order to learn mathematics themselves was expanded to include the same needs of the middle level students; not just good explanations and practice, but instead, emphasis

on multiple instructional strategies that fit their own learning styles or needs and their students' learning styles or needs.

Year One: Mathematics Teaching

At the beginning of the project, the participants were asked to respond in their journal reflections to prompts regarding their teaching methods. Only a few teachers had experience with the CMP lessons. Most of the teachers portrayed their teaching as based on introducing mathematical concepts or problems by demonstrating examples and then allowing their students practice before assigning homework. While a few of the teachers mentioned group work, standards-based curricula, or supplementing with hands-on materials, the majority described their teaching as traditional; modeling problems at the chalkboard for the whole class with verbal explanations and little time for the students to interact. These descriptions of their teaching were in marked contrast to their explanations of what middle level students need in order to learn mathematics. While the changes were subtle in the first year, the participating teachers did move away from journal reflections that emphasized teaching as demonstrations of example problems coupled with practice, feedback, and homework. At the close of the first year, they focused on engaging their students in hands-on activities or manipulatives with time to explore and interact with each other.

> Betty: Gone are the worksheets with fifty problems using the same algorithm. Math that can be used in the real world and requires math reasoning and critical thinking skills….In the future, I will try to make math meaningful to my students. I want to teach new concepts because students get frustrated doing the same thing each year. I want concepts to be reviewed as new concepts are taught. Students need to be challenged and not told step by step what to do. I hope to let my students do more exploring and explaining what they have discovered. I want to be a listener (Y1J5).

In the first and last journal entries of the first year, the participants were asked to describe in their opinions, good and poor mathematics teachers. Their initial descriptions of good

teaching were focused on the use of innovative instructional strategies, hands-on activities, strong content knowledge, interaction with and among their students, and exploration coupled with discovery of meaningful mathematics. At the end of the first year, the teachers were emphasizing the classroom ethos that included positive environments where all students were interacting with the teacher and each other. Their new focus on the classroom environment set the stage for the second year when the CMP curriculum was implemented.

> Hank: I believe a good mathematics teacher is able to show their students how they really can use this stuff in their life. A good teacher connects with his or her students on a personal, yet professional level and builds a certain amount of trust with each individual student….But I think the most important quality of a good math teacher is he or she must be able to break down the walls that almost every student brings into the math classroom. These are the walls that say, I can't, I won't, or I give up. These are the walls that keep a student from learning no matter their ability. And these are the walls that we, as math teachers, must break down (Y1J5).

At the end of the first year, the teachers were asked to reflect on how the MSMA influenced their teaching. The most prevalent theme in these journal entries focused on how the Academy had provided new methods, strategies, and ideas about how to teach mathematics using manipulatives and standards-based materials. Furthermore, the teachers gave the Academy credit for forcing them to use their mathematical skills, for changing their views of teaching, giving them confidence to try new ways of teaching, and for providing support throughout the year. For example, Ellen cited, "Overall, the most important results of my participation in the academy are: it has changed my view of how I need to be teaching math. It also has given me the encouragement to try new things. I have a difficult time with change, but with the help of the academy and my fellow teachers, I feel like I have the support system I need to make this positive change (Y1J5)." In sum, the results of the first year suggest that the teachers generally moved from doubts about their mathematical abilities to feelings of confidence and support for one another. With their new focus on the classroom ethos involving exploration and discovery,

their goals to learn how to engage students, improve curriculum planning, and increase their instructional skills were met at least in part by their participation in the Academy.

Year Two: Reflecting on Mathematics and Mathematics Teaching and Learning

During the second year of the MSMA, the teachers were asked to reflect on their teaching, their mentors' teaching, and the reactions of their students and record these reflections in their journals. Only about 30% of the descriptions of their lessons in the second year were sufficiently detailed, but all revealed the implementation of the CMP curriculum. Of the adequate lesson descriptions, most involved CMP investigations that led the students to develop mathematical generalizations that in the past the teachers typically told their students at the beginning of the lessons with no opportunities to investigate, conjecture, or generalize. The teachers expressed their delight that their students had developed the mathematical processes themselves through some type of exploration or investigation, instead of being told the mathematical "rules" and procedures. For example, after Bea described a CMP lesson, she wrote about how she had changed as a teacher.

> Bea: I will never be able to teach math the same again. I have loved the way I have seen the CMP reasoning unfold before my very eyes. I have taken what we learned as students in the Math Academy training last summer and implemented it in my classroom. I have seen how the very bright students have been challenged for the first time by having to discover concepts on their own, and how the failing students have passing grades for the first time as they were given opportunities to experience math concepts. To be able to reach both ends of the spectrum is the greatest validation, in my opinion. I will continue to teach math with open-ended questions, with situation problems presented to students to discover on their own, and with opportunities to discuss strategies and methods with a peer. I will teach with the new mind set that math is not just about taking notes and practicing problems….it has totally changed my ability to teach mathematics. I have seen how their ideas have worked in the live classroom setting, and have met the needs of all my students. I have already mentioned how I now utilize open-ended questioning techniques, partner work to discuss strategies and discover concepts, and situational problems presented in order for students to discover their own methods for working a problem. I have learned to stress the process for arriving at an answer, not merely the correct answer (Y2J5).

It is interesting to note the definition of mathematics generally described by the teachers in the second year mimicked the first year; based mainly on mathematics as study of numbers and number patterns used to solve problems in science and real-life situations with a small number of the teachers focusing on the logic and reasoning that mathematics involves. While logic and reasoning were more prominent in the last journal entries of the second year, the study of numbers and problem solving applied to real world situations was still a significant theme.

> Danny: To me, mathematics is a way of thinking. Knowing how to efficiently manipulate numbers – be it through number crunching or estimating – in order to solve a problem or compute a value is a way of thinking that makes many of life's tasks (i.e. shopping, cooking, etc.) easier. Also, algebra, one branch of mathematics, encompasses an entire way of problem solving and representing life's situations which is essential in many situations (Y2J1).

In their first and last journal entries of the second year, the teachers were asked to describe how they learn mathematics themselves. As in the first year, the majority explained that their learning mathematics required practice and repetition, good explanations, hands-on manipulatives, and applications in real-life situations, but now with a greater emphasis on understanding the mathematical concepts as Paul described.

> Paul: The Academy has given me a better understanding of the mathematics behind what I teach. Sure, I could work the problems that I teach, but that doesn't necessarily mean I understood them. It's a very different thing to be able to work a problem and knowing why different methods work. I think as a teacher, the more you know about a problem, the better equipped you are to teach it. Seeing other educators demonstrate lessons in ways that I may not have thought of helped me immensely in my own class room. Many times, we can work problems in one way, but that isn't necessarily the way that students will understand the problems. Being fluent with different methods of working the same problem, allows the teacher to address different students learning needs. Overall, I would say that my participation in the Academy has helped me become a better teacher by allowing me to see different methods of teaching (Y2J5).

In their first and last journal entries of the second year of the project, the teachers were asked to describe their conceptions of how middle level students learn mathematics. Initially, approximately 60% of the participants stated that middle level students learn by participating in

hands-on activities and using manipulatives. About 50% of the teachers indicated that middle level students learn with different learning styles and therefore multiple strategies and methods are necessary. While a few mentioned that students need good explanations, practice, or step-by-step procedures, there were many more who cited the importance of exploration, discovery, working cooperatively, and relevance. The journal entries at the end of the second year essentially portrayed the same emphasis on hands-on activities, but with more emphasis on using a variety of instructional strategies and working together to discover or explore relevant problems. The teachers cited the Academy as an influence on their teaching as Marcus stated, "In the MSMA, I have found a way to teach math effectively on a daily basis. The kids are engaged and for the most part learn the concepts. Overall, I feel I have not only helped to show my kids mathematics in a new light, but they have also shown me how to look at math in a new way. It is amazing how much new math that I have picked up by being in the Academy. I feel more effective as a math teacher because I can explain the hows and whys behind the math (Y2J5)."

Year Three: Connections, Materials, and Strategies

In the third year, the MSMA teachers were asked to write about the connections they had made between strands of the state mathematics curriculum framework and connections they had made between mathematics and another discipline or subject area. The connections between strands were apparent in their journal entries. Of the 55 teachers, 18 wrote about connections between the Geometry and Algebra strands. The Number and Operations strand was linked to Geometry (3), Data and Probability (6), Measurement (7), and Algebra (12). The Data Analysis and Probability strand was cited in connection with Algebra (4) and Geometry (4). In fact, some noted that problem solving and graphing are in all the strands and thus provide connections

across the curriculum. Many of the teachers actually cited examples. Of the 68 citations of connections to other disciplines, 33 were science and 35 were in other areas such as reading, writing, and language arts (total of 25), social studies (7), and three stated "real life." They cited data collection, analysis, scientific notation, literature, geography, time, distance, velocity, and many others. In their efforts to make mathematics meaningful and realistic, the teachers emphasized connections exemplified in the CMP curriculum, as well as those they had researched and provided as supplements to the curriculum. The teachers were also asked to describe examples of the various mathematics representations that they taught their students to use in problem solving. Graphs, tables, equations, concrete objects or hands-on materials were touted most frequently (84). Others mentioned diagrams, drawings, models, and writing in words. For example, Paul said, "I use a variety of mathematical representations in my classroom. When teaching equation solving, my students are taught to make rate tables and graphs before they are ever shown how to solve equations with inverse operations. Terms like rate of change and y-intercept are much more obvious if they can relate the information to a table or graph. They have a deeper understanding if they can see things in multiple ways (Y3J1)."

In their reflective journal guidelines, the teachers were prompted to describe the materials they found the most useful in teaching mathematics. Their journal entries revealed multiple items in the broad categories of technology, concrete objects, and the curriculum. Of the 55 teachers, 30 indicated the graphics calculator as the most useful tool. Other technologies described were the Smart Board, computer, Elmo, overhead projector, and the TI presenter. The concrete materials were manipulatives such as pattern blocks, color tiles, fraction strips, color cubes, base 10 blocks, geoboards, grid paper, and games. The teachers touted the CMP curriculum as the most useful because of the approaches to learning that involved cooperative

groups, questioning techniques, and the use of tables, graphs, and equations to solve problems. The teachers were also asked to describe the methods they used to improve their students' abilities to communicate mathematics. More than 75% (43) of the participants cited that they focused on vocabulary by requiring students to keep notebooks, give verbal and written explanations for their problem solutions, discuss questions in small groups, contribute to a word wall in the classroom, write on smart boards, display their work on individual marker boards, or use some form of technology to communicate their solutions. Their descriptions included suggestions that good questioning techniques and certain types of questions such as open-response encourage meaningful classroom discussion. Their journals also revealed the teachers' views of the most effective instructional strategies that they had implemented during the project. Cooperative groups and visual and hands-on manipulatives were the most prevalent responses. Other methods that were mentioned include relating problems to the lives of their students, providing time for exploring or investigating on their own, and allowing multiple methods of solving. For example, Rhonda stated, "I have found that students learn more from their own investigation than from my direct instruction (Y3J5)." It should be noted that in the end, only three of the 55 teachers said repetition through practice is the way to learn mathematics and only one teacher suggested that his students were perhaps not capable of learning mathematics using the new instructional strategies.

Year Three: Analyzing Student Work and Action Plans

The teachers were asked to reflect on the impact of their participation in the Standards in Practice (SIP) process of analyzing student work. SIP is a professional development model developed by The Education Trust in Washington, D.C. and is rooted in the belief that students can do no better than the assignments they receive. SIP helps teachers and school leaders inject

rigor into assignments and align them with state curricular standards (Kennedy, 2007). Of the 55 participants, 45 had positive comments, ranging from the benefits of learning to create rubrics to thinking more deeply about what and how to assess student work. The teachers wrote extensively about their experiences and complimented the opportunity to create and test rubrics, collaborate with other teachers, clarify teachers' expectations of the students, understand the rigor of rubrics in benchmark exams, and learn to critique their own teaching.

> Belinda: The best thing that I have learned about evaluating student work is the importance of using rubrics. It is important that the problems are broken down into specific skills and that students are evaluated according to these skills and given positive feedback for the skills that they show. Another good thing about this year's Academy was my being reminded of the benefits of sharing with your colleagues, whether it be teaching practices or evaluation techniques. I think it is important to share what has worked in your classroom and what has not. I would like to see more of this "sharing" among math teachers here at CSMS including special education teachers (Y3J4).

The MSMA teachers were also asked to write about their plans of action developed as a result of the SIP sessions. Most of the journals indicated the teachers' planned to create, refine, and implement rubrics as a means of grading and providing feedback to their students, including more specific rubrics for assessing for partial understanding. In many cases, they planned to develop rubrics collaboratively with their school colleagues and analyze the problems in advance of assigning them. They suggested that students be given the opportunity to view samples of graded work and to perhaps grade others. There were five teachers who did not construct a plan of action, but several revised their classroom procedures or standards after having experienced the SIP process. These revisions included incorporating math journals, grading with students assisting, raising expectations, asking students to write presentations of their solutions, and revising homework evaluation.

> Hank: After going through the "Standards in Practice" with my group, I decided to incorporate some of the grading techniques with my students. Once a week, I give the students a homework quiz over lessons from that week. When they finish I have them

> exchange papers and we grade them as a class. I give the students a chance to defend their answers and explain why they put the answers that they did. Many times the students gain a much deeper understanding by doing this. This method also helps the students understand how I grade and what I look for when grading, which will directly reflect in their comprehension of the Benchmark Exam as well as on the unit tests throughout the year (Y3J3).
>
> Gary: First analysis of student work, I learned that we all have the same issues as teachers. We all do the best we can, and are sometimes thrown by the lack of experiences on the part of students who cannot understand a concept because they have no way to relate. I also learned that some students who are not thought of as good math students are really good at mathematical concepts, they just use different language to represent ideas (Y3J1).

In their last journal entries at the end of the third year, the MSMA teachers were asked to describe the best thing they learned in the Academy about evaluating student work. The majority (80%) discussed some features of the rubrics they had learned to create and implement. Their critiques included constructive comments such as: create the rubric before making the assignment, learn to look for unusual solutions, anticipate different approaches, give partial credit for understanding even if the answer is not correct, rubrics should be specific and objective, use the results to correct misconceptions, and allow students to review graded work and participate in the creation of some rubrics.

> Bonnie: The best thing I have learned in the Academy about evaluating student work is that it reflects how the skill was taught. With few exceptions, the students' work reflected how effective the teacher was in relating the learning to the students. Participating in this activity made me more aware of how thorough and how very prepared I must be to present a lesson to my students. I must assume nothing about the previous learning and I must relate to my students the "why" in the lesson, not just the "how." Another benefit to me in this process of evaluating student work was getting to see examples of how other teachers from other school districts require their students to show their work. I came away from this process with ideas for requiring my students to write their answers and show their work. I also found that some of the most interesting and challenging work to evaluate was not the work that scored a 4, but the work that scored 3 or 2. A student that was not completely sure of how to answer the assigned work was often creative or made it challenging to follow the math reasoning (Y3J4).

Year Three: Student Learning

The MSMA teachers were asked to reflect on what they had taught that increased their students' abilities to reason, their most successful problem solving lesson, and to describe the most inventive solutions that their students created. The teachers described their implementation of questioning techniques, cooperative learning (groups and pairs), investigations in the CMP curriculum, discovery and exploration activities, multiple representations, and requiring their students to explain their work in verbal and written form. The teachers also described their most successful problem solving lessons which highlighted lessons from the CMP curriculum including Filling and Wrapping, Bits and Pieces, Growing Growing, and other sections. They described investigations such as using rate tables for proportional reasoning, finding fractions between fractions, finding the volume of rectangular prisms, studying ratios using the Pizza problem, Tupelo Township plots of land, measures of central tendency, the Golden Apple problem, factor pairs, translations and rotations, areas of irregular polygons, and others. Every journal contained a citation of a problem solving activity. While they were able to cite successful lessons, the teachers had difficulty describing the most inventive solutions of their students. However, they did make general comments about how their students were developing as problem solvers who find multiple ways of solving.

End of Year Three: Defining Mathematics, Learning Mathematics, Mathematics Teaching

In the end, the MSMA teachers had developed definitions of mathematics that demonstrated a broader view. Initially, their definitions of mathematics were based on the study of numbers and their operations; patterns and relationships used to solve problems in realistic situations with little mention of logic and reasoning. At the end of the first year, logic and reasoning did appear more often in their descriptions of mathematics and "everyday life" was

replaced in some cases with "universe" or "world." However, at the end of the third year, most definitions included references to problem solving using multiple methods, connections to science, relationships, systems that organize the world, communication, reasoning, language, logic, way of thinking, or "everywhere in life." Many of the brief definitions in the first year were revised to include more detailed descriptions that demonstrated a more comprehensive view of mathematics as a powerful system or tool for understanding the world. For example, Anna stated, "Mathematics is the field of science that studies relationships in numbers, figures and designs. Mathematics is everywhere in life and not limited to the classroom. It is the most amazing field of science. Nothing else could exist without mathematics (Y3J4)."

In the first year of the project and at the end of the third year, the teachers were asked to describe their conceptions of how middle level students learn mathematics. Initially, approximately half of the participants stated that middle level students learn by participating in hands-on activities and using manipulatives. About one-third of the teachers indicated that middle level students learn in different ways and have different learning styles and therefore a combination of strategies and multiple methods are needed. While a few mentioned that students need good explanations, practice, or step-by-step procedures, there were many more who said that exploration, discovery, working together, or relevance to life are important. The journal entries at the end of the third year essentially portrayed the same emphasis on hands-on activities, a variety of instructional strategies, and working together to discover or explore relevant problems, but many more participants (90%) indicated hands-on activities, discovery, exploration, or connections to the real world and students' lives. Only three teachers said middle level students need "practice."

> Paul: Middle level students learn mathematics by experiencing things. Simply giving them a formula doesn't teach them anything. They need to be entertained and interested.

> If a lesson becomes boring, a middle level student will quit paying attention. The topics discussed should relate to things they know, such as skateboard prices or saving your allowance in order to buy something you want. If the problems and topics discussed are not relevant to them, they will have a hard time focusing on the problem at hand. Middle school students wake up in a new world everyday. Ideas that were discussed one day may not be in their memory the next….Middle school students should be shown a variety of methods to use when solving a problem. What is easy to understand for one student, may be difficult for another student to understand (Y3J4).

> Oliver: Middle level students learn mathematics by doing and exploring. I think my students learn more when they have hands on activities to do and when they discover the math behind a concept than if I just lecture them and tell them how or why something works (Y3J4).

At the beginning of the first year of the project, the participants were asked to respond in their journal reflections to prompts regarding their own teaching methods. Remember, most of the teachers portrayed their teaching as based on introducing mathematical concepts or problems by demonstrating examples and then allowing their students to practice before assigning homework. While initially a few of the teachers mentioned group work, standards-based curricula, and supplementing with hands-on materials, the majority described their teaching as the tradition of modeling problems at the chalkboard for the whole class with verbal explanations and little time for the students to interact. At the end of the three-year project, all the teachers were describing how they would teach mathematics with characteristics such as cooperative groups and pairs, relative to the lives of their students, discovery lessons, explorations and investigations, hands-on materials, students' written and verbal explanations, and the CMP curriculum.

> Steve: I have been teaching for thirty-three years, the last fourteen of those years have been spent teaching math. The Middle School Mathematics Academy has changed everything about my teaching style and my philosophy of education. I have changed from an out dated, dull style of teaching to lessons that actively engage and involve my students during learning. I think the Connected Math curriculum helps all of my students (both gifted and academically challenged) discover "the way" and "the how" of mathematics—the rules—that I never let my students discover the way. I thought I was

> almost ready to retire. I was "burned out!" The Math Academy and Connected Math have given me new life (Y3J3).
>
> Sam: As a result of MSMA, I have changed my classroom completely. My classroom became a group and collaborative learning environment instead of a teaching and listening environment. My children daily get hands-on experience with manipulative and group time to encourage talk and understanding of each concept. My homework has become practice not punishment. I send home only what they need to practice their understanding. They are graded on completion not correctness because it is practice. My students' abilities to reason have increased because of the group time. They form their opinions and have to explain them and teach them at times to the people in their groups. I also make them try to convince me that they have come up with the correct conclusions, so they must have good understanding (Y3J3).

In the journal entries of the first year and again at the end of the three-year project, the participants were asked to describe in their opinions, good and poor mathematics teachers. Their initial descriptions of good teaching were focused on the use of a variety of instructional strategies, strong content knowledge, interaction with and among their students, and exploration coupled with discovery of meaningful mathematics. The descriptions in the final journals included the same characteristics with much more detailed explanations of the characteristics of good mathematics teaching which matched their personal descriptions of how they planned to teach in the future. Generally, at the end of year three, they described good mathematics teachers as obtaining the appropriate content knowledge and who are willing to collaborate with others, provide problem solving activities, allow multiple methods, consider learning styles of their students, involve and excite students, allow exploration and discovery, and make mathematics meaningful and relevant to their students' lives. Poor mathematics teachers were described as unconcerned about their students' learning with characteristics such as requiring memorized facts with no connections to real life. Some mentioned that poor mathematics teachers teach the way they were taught and have no desire to learn new strategies. In summary, their descriptions moved from short sentences using the hands-on teaching jargon with some

attention to learning styles to rich descriptions of the characteristics they are seeking in themselves as good teachers and that infuse the CMP curriculum. The characteristics of the learning environment needed by middle level students that the teachers initially described in the first year had become the features they developed in their own classrooms. For example, Bea stated in response to a question about how she now teaches mathematics:

> Bea: By asking students open-ended questions and prompting them to share their ideas and strategies. I have seen how students can solidify their own thinking processes in discovering key mathematical concepts. Through partner work, they discover those concepts, and generate their own learning. I have used these techniques as they were modeled in our math academy training so that I could truly become a facilitator of learning instead of a presenter. The impact on student learning has been very significant as students have retained information longer and become successful in all aspects of the mathematics curriculum (Y3J1)."

Observations of Teaching

One of the evaluators observed the classroom teaching of 20 of those continuing throughout the PD project. The results of the observations revealed the teachers were implementing the CMP curriculum with what appeared to be detailed planning, including activity-based lessons, cooperative groups, manipulatives, probing questions, and crafted discourse that resulted in their students participating with enthusiasm. In fact, their students were testing their ideas, exploring possible outcomes, drawing conclusions, creating their own mathematical statements, graphs, and problems, and freely sharing their results with each other and the teachers. In summary, the teachers generally implemented the prescribed CMP curriculum and engaged the students in meaningful mathematics, regardless of the students' intellectual levels. It was interesting that the observer reported being unable to determine the students' intellectual levels (advanced, regular, and inclusion students) and was surprised when students that had taken the lead in group solving were identified after a lesson as inclusion students.

Did the Academy Influence Their Teaching?

To determine aspects of the influence of the Academy on the teacher participants, the MSMA teachers were prompted in the journal guidelines to describe the most significant content knowledge, new understanding, awareness or appreciation that developed as a result of the Academy. Their journals at the end of the third year indicated that every teacher had a positive experience with some component of the project. Teachers described increases in their content knowledge in algebra, geometry, and probability and better understandings of the connections between these areas and connections to realistic applications. They expressed realizations that their students need to be active learners in investigations and discovery lessons that are connected to their lives. They had learned the mathematical concepts that support the rules and formulas that they had just memorized earlier in life. They expressed an appreciation for the advice and ideas from other professionals (mentors and fellow teachers), the importance of being prepared to teach, and the usefulness of creating and implementing rubrics. The comments are too numerous to include samples of each. Suffice it to say that the teachers expressed an overwhelming appreciation for the Academy and set their future goals centered on continuing the curriculum, strategies, content, methods, and reform vision of the PD project. Typical of the responses was Belinda's statement.

> Belinda: The most significant awareness that I have developed as a result of the Academy is my realization that students really do need to be active in their learning. They really do need to participate in activities that help them to make connections with the real world. I already knew that reading comprehension is improved if you can make connections to something you have experienced….I just never thought about the importance of making connections in math….As I am writing this, I am looking at the mobiles of geometric shapes that my students made from nets and thinking that we also should have made mobiles of real world objects....Most importantly; my participation in the Academy has made me more aware of what I need to do to become a good mathematics teacher (Y3J4).

One of the goals of the MSMA was to establish collaborations. Therefore, a natural question at the conclusion of the project was "How have you continued your professional development learning community with your colleagues?" Most of the 55 teachers have continued in some way to develop professionally. They cited math coaches, concurrent planning periods in their schools, internet sources of information, workshops on student success, observations of their teaching, e-mails with colleagues, district meetings on CMP, vertical and horizontal curriculum meetings at the schools, weekly meetings, monthly meetings, group meetings to create assessments and rubrics, and some had only occasional meetings. There were only three of the 55 teachers who mentioned not continuing their collaborations or professional development activities. The teachers described their enthusiasm for the project activities, but also in their journal writings committed to continue the curriculum, strategies, methods, and collaborations exemplified in the Academy. Comments from Simon capture the sense of collaboration.

> Simon: The Academy has allowed me to continue to build a network of rapport and collaboration with my colleagues….our department meets to collaborate on how to differentiate instructions for lessons, and how to devise a purposeful assessment instrument to evaluate student progress. We reflect on instruction and technology implementation that we have learned at the Academy. We connect our lessons to the standards examined through the Academy, and reflect on applicable resources and strategies for instruction. The collaboration of learning continues to us as a department reflecting on various methods that have been incorporated throughout a lesson….As we explore new content, a teacher and I begin to reflect over the goals of a lesson, and ask the question what I could do to improve the instruction for the next class. We communicate ideas together to gain feedback on how we should approach future lessons. The Academy has taught us how to better reflect on student learning (Y3J4).

In summary, the MSMA teachers moved from doubts about their mathematics abilities to feelings of confidence and support for one another. Their conceptions of how they learn mathematics became their conceptions of how middle level students learn mathematics. Based on these new conceptions, they established collaborations with other teachers and transformed

their classrooms into interactive problem solving investigations centered on the discovery learning of CMP. They described their resolve to implement the curriculum with detailed planning and preparation, activity-based lessons, cooperative groups, manipulatives, and conscientiously designed questioning techniques and rubrics. Their commitment is exemplified in Reece's comment, "…middle school math can be very complex, and a lot is expected out of middle school math students (and teachers). It is a process of learning, trying, failing, succeeding and a persistence that I intend to continue (Y3J4)."

Discussion and Conclusion

The ALACT model described by Korthagen and Kessels (1999) is exemplified during the MSMA project. From the first year forward, the teachers experienced the PD activities (Action), reflected on their conceptions of mathematics teaching and learning (Look), and with their new awareness of what it takes to learn mathematics (Aware), they implemented mathematics lessons designed for their students to develop mathematical concepts through explorations (Create). They continued their learning by reflecting on what transpired with their students in the classroom (Trial). As this model of the reflection process was repeated for three years, the majority of the teachers demonstrated their adoption of the content and strategies of the PD project. While employing a different method of forcing reflection, the results are similar to what Wise, Spiegel, and Bruning (1999) found in their use of teacher reflection to evaluate a PD project in mathematics and science; a clear link between the PD activities and the teachers' classroom practice. The analysis of the reflective journals contributes to the record of how reflection can inform teaching practice and the evaluation of PD projects. Such analyses can lead to understandings of how and what teachers learn in PD as called for by Kazemi and Hubbard (2008) in their study of designing and evaluating PD.

Evaluating PD projects in the best world would involve experimental designs. Wayne, Yoon, Zhu, Cronen, and Garet (2008) contend that conducting experiments in PD programs will provide researchers with control over the sample size, treatments, and contexts of the study. In contrast, this study was obviously not experimental, but it is a case that may be more typical of grant-funded PD projects where the characteristics of a true experiment are not feasible. Given the complexities of the management of such a project, the results add to the literature regarding the process of reflection and teacher learning by focusing on the changes in the teachers' perceptions over the three-year period as seen their journals and observations of their teaching. (Changes in the teachers' content knowledge and their students' achievement scores are deferred to a future report when data are available.)

As mentioned earlier, Fendler's (2003) claim that certain reflective practices such as journal writing may include undesirable effects contrasts with the evidence in the teachers' voices (journals) in this PD project and their instructional behavior (observations) which document that generally their initial conceptions of mathematics teaching and learning were converted to the reform vision of the project. While Fendler (2003) asserts that practices of reflection may have thwarted past reform efforts, the teachers' journal reflections in this PD project indicate their implementation of the reform curriculum. However, future research should include returning to the classrooms of at least a random subgroup of the 55 teachers to determine if a gap remains between the reform vision of the PD project and the resulting teaching practice (Shulman, 2004). Would we find frustrated teachers, disenchanted with a reform vision or would we find the gap narrowed or closed and the vision of reform significantly exemplified in their teaching practice, not just proclaimed in the written word (reflections)?

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