

## Math Teachers' Circle Teacher Outcomes (as of January 2011)

### Pilot Study: Mathematical Knowledge for Teaching

In Summer 2010, White (2011) conducted a pilot study examining MTC participants' scores on the Mathematical Knowledge for Teaching (MKT) instrument for teachers of Grades 6-8 developed by the Learning Mathematics for Teaching project at the University of Michigan (Hill, Schilling, & Ball, 2004). This instrument consists of several subsections in different content areas that have each undergone extensive testing and revision to establish adequate psychometric soundness (Hill et al., 2004). Previous research has linked higher MKT scores with the presentation of richer mathematics in the classroom (Hill et al., 2007) and with increased student achievement (Hill, Rowan, & Ball, 2005). White administered two subsections of the instrument—Number and Operation, and Geometry—on the first and last day of three intensive summer workshops that were 4-5 days in length. Teachers showed a significant gain in their Number and Operation score at all three workshops, with an average overall  $z$ -score increase of .34 standard units ( $SD = .52$ ),  $t(48) = 4.56$ ,  $p = .00001$ . Geometry scores increased significantly at one of the three workshops, but the increase just missed significance overall ( $M = .14$ ,  $SD = .62$ ),  $t(48) = 1.59$ ,  $p = .06$ . White's preliminary results indicate that the MTC model may be successful in increasing teachers' MKT through focusing primarily on mathematical problem solving and reasoning in the context of meaningful content.

### Teacher Surveys

On surveys conducted by MTCs around the country, teachers have consistently cited increased content knowledge, confidence about approaching unfamiliar problems, and use of problem solving in the classroom as outcomes of their participation. However, not every MTC has consistently surveyed its participants, and survey forms have not been standardized. In an effort to begin collecting more systematic data, White and Donaldson (2011) conducted an online survey in Fall 2010 of MTC participants around the country. A total of 169 teachers from 13 MTCs took the survey, with most items answered by between 141 and 159 people. Of the 169 respondents, 42% were in their first year of MTC participation, 24% were in their second year, and 34% were in their third or higher year. Most were experienced mid-career teachers. Only 20% had taught for 5 years or less, with 51% having between 5 and 15 years of teaching experience and 29% having taught for over 15 years. Most taught in an urban (43%) or suburban (49%) setting, with 8% describing their school setting as rural. Approximately 38% taught in a high-needs school.

The survey was modeled on the Student Assessment of their Learning Gains instrument (SALG; Seymour et al., 2000) and asked teachers to rate gains they experienced in several areas—mathematical content knowledge, attitudes and dispositions toward mathematics, classroom instructional practices, and professional activities—as a result of participating in MTC. Rating-scale items were constructed using the SALG's 5-point Likert scale, with 1 being “no gain” and 5 being “great gain.” The survey also included several open-ended items asking teachers to comment on the effects of their MTC participation.

Over 75% of respondents reported at least “moderate” gains in their overall content knowledge of mathematics, mathematical problem-solving skills, understanding of various problem-solving strategies, and understanding of connections between different areas of

mathematics, with approximately 60% reporting either “good” or “great” gains. A number of teachers commented on how MTC participation has deepened their understanding of mathematics as an interconnected subject, for example, “I feel like the Math Teachers’ Circles have given me the opportunity to see a bigger picture in mathematics,” and “The logic and order that mathematics creates seems to become more clear the deeper we explore.”

Respondents also reported large gains in their enthusiasm for mathematics, interest in discussing mathematics with colleagues, and interest in discussing mathematics with professional mathematicians, with over 80% reporting at least “moderate” gains and over one-third reporting “great” gains in each of these areas. Many comments touched on themes summarized by this teacher: “My confidence with problem solving has increased a lot. I realize that just because I don’t totally know a topic in math, I can still look at a problem and try to break it down to solve it. I’m not as intimidated. Also, being able to look at problems in this way enables me to be more likely to discuss the problem with other teachers or mathematicians who may suggest ways to solve the problem.” Half of the respondents reported “good” or “great” gains in the likelihood of their working on mathematical problems during their spare time. Commented one teacher, “I’ve become much more of a recreational problem solver—I always have my problem notebook with me for ‘down times.’” Several commented that MTC participation had allowed them to think of themselves as mathematicians, rather than “just” math teachers: “You encouraged me as a mathematician. I have never actually seen myself as one before.”

In terms of instructional practices, 65 to 70% reported at least “moderate” gains in classroom time spent on problem solving, letting students work together on mathematically rich, non-routine problems, exploring student questions, and helping students understand general strategies for solving problems, with around 40% reporting “good” or “great” gains in each of these areas. Forty-nine percent reported “good” or “great” gains in time spent planning lessons that include problem solving. Teachers often commented on their belief that changing their own understanding of and attitudes toward mathematics had changed their classroom practice:

“While I understood math algorithms very well, my understanding of why and how the algorithms work has increased. I also look for more than one way to solve problems and ask my students to do the same. I believe I have become a better teacher of mathematics as a result.”

“I’m much more comfortable not knowing how to do something that a student brings up. By expanding my horizons of the scope of mathematics, I’m much more comfortable in not knowing one of them.”

“Math Teachers’ Circle activities reinforce my feeling of math as a creative endeavor. I try to pass this attitude on to my students.”

Many teachers also cited specific ways that they believed their classroom practice had changed, stating, for example, that they use more student-centered approaches, provide more opportunities for problem solving, introduce more challenging problems, and have increased their expectations for student participation and success:

“My classroom teaching has become more student-centered and engaging. Students are working together and discussing problems in groups, or exploring individually before sharing with a larger group.”

“I have increased my level of expectations for all students. I incorporate more problems

into the weekly homework and we discuss them in class. I used to have more difficulty finding times and places to incorporate problem solving strategies. Now it is becoming part of the routine.”

“As a teacher I tell students that I don’t have an answer key and we as a class have to decide if we solved a problem and whether our solution is reasonable. It is getting my students to understand the problem solving process and be able to reflect on their thinking and justify their solution. It has helped build a community of problem solvers in the classroom.”

The professional community created by MTCs was cited by many respondents throughout the survey as a valuable aspect of their participation. Comments included “I feel that working on mathematics with my colleagues gives me a wider perspective on how to view mathematics and what it means to teach mathematics,” “I am inspired by a group of people who just want to get together and talk about math. I am not usually surrounded by people like that,” and “I am highly charged intellectually when I am surrounded by other mathematicians who are sharing their perspectives. It is truly a community of learners coming together to learn from each other and share experiences.” Some respondents also described an increased level of involvement in the profession, for example: “Participating in the MTC meetings has encouraged me to network with others and attend conferences with them,” “It has given me the confidence to step into more of a leadership role and a role in developing curriculum and lesson plans,” and “I have started giving presentations at meetings and conferences, have become the mentor for new math teachers, and am peer reviewer of math activities for the classroom at my level for the region.”

## References

- Hill, H. C., Ball, D. L., Blunk, M. Goffney, I. M. & Rowan, B. (2007). Validating the ecological assumption: The relationship of measure scores to classroom teaching and student learning. *Measurement: Interdisciplinary Research and Perspectives* (5), 2-3, 107-117.
- Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42, 371-406.
- Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal*, 105, 11-30.
- Seymour, E., Wiese, D., Hunter, A. & Daffinrud, S.M. (2000, March). *Creating a better mousetrap: On-line Student Assessment of their Learning Gains*. Paper presentation at the National Meeting of the American Chemical Society, San Francisco, CA.
- White, D. (2011). *Math Teachers' Circles - Impacting teachers' Mathematical Knowledge for Teaching*. Paper presented at the MAA Session on Fostering, Supporting, and Propagating Math Circles for Students and Teachers, I, Joint Mathematics Meetings, New Orleans, LA.
- White, D., & Donaldson, B. (2011). *How do Math Teachers' Circles affect teachers? Themes from teacher surveys*. Paper presented at the MAA Session on Fostering, Supporting, and Propagating Math Circles for Students and Teachers, I, Joint Mathematics Meetings, New Orleans, LA.