The Broad Impact of Math Teachers’ Circles: Results from the First Decade

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Brief History of Math Teachers’ Circles

• 2006: First MTC founded at the American Institute of Mathematics (AIM)
• 2007: AIM began disseminating the MTC model
• Today:
  – 90 MTCs in 38 states
  – 1,500 teachers
  – 300 mathematicians
Core Features

• Regular meetings
• Involvement of both K-12 teachers and mathematicians
• Focus on non-routine, mathematically rich, low-threshold, high-ceiling problems
• Substantial time for collaborative mathematical exploration
Impact

- Anecdotally, effects on teachers and mathematicians are profound
- Research has mostly focused on teachers
Acknowledgments

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  – Collaborators: Brian Conrey, Catherine Good, Michael Nakamaye, Kristin Umland, Diana White

• Math Teachers’ Circle leaders and members from across the U.S.
Overview of Results

• Mathematical Knowledge for Teaching
• Professional Engagement
• High-Quality Instructional Practices
• Healthy Mindsets
Mathematical Knowledge for Teaching
Mathematical Knowledge for Teaching

- Mathematical Knowledge for Teaching (MKT) is the knowledge about mathematics needed to teach it.
- Significant increase in MTC participants’ MKT scores after participating in a 4- to 5-day intensive summer workshop (White, Donaldson, Hodge, & Ruff, 2013; Donaldson et al., in preparation).
- Previous research by Hill and her colleagues established an association between higher Mathematical Knowledge for Teaching and higher student achievement (Hill, Rowan, & Ball, 2005).
Mathematical Knowledge for Teaching

• National MTC Surveys:
  – 63% of respondents identified improved understanding of mathematical practices (e.g., problem solving and constructing and critiquing mathematical arguments)
  – 33% identified improvements in their content knowledge about topics such as fractions, geometry, and probability
  – Teachers also reported a strong connection between their MTC experiences and the Common Core State Standards for Mathematical Practice.
Professional Engagement
Professional Engagement

• National MTC Surveys: 57% of respondents reported that their experience with MTCs had increased their participation in professional activities outside the classroom:
  – Collaborating more with other teachers
  – Participating in decisions about curriculum for their school or district
  – Attending professional conferences
  – Leading extracurricular math activities for students
Professional Engagement

• In-depth case studies of 9 MTC participants over a two-year period (Donaldson, Nakamaye, Umland, & White, in preparation)
Professional Engagement

• Sharon
  – Relatively weak math background prior to MTC participation
  – “I felt like the dumbest person in the room, but I learned so much. I felt like a light bulb went on…. In the past, I identified as a language arts kind of person. Now I’m passionate about math.”
  – By the end of the study, Sharon had become the math resource teacher for her elementary school
Professional Engagement

- Lisa
  - Stronger mathematical background prior to MTC participation
  - By the end of the study, she had taken on multiple leadership roles, at her school, for her district, and nationally
  - She reports that one reason she has had these opportunities is a 200% growth (two times expected) in her students’ achievement scores since she began teaching using a conceptually and inquiry-oriented style that she says was inspired by MTC participation
  - “I owe my success to MTC—my only source of content-related PD. Anything I do I feel comes from my math circle.”
High-Quality Instructional Practices
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• National MTC Surveys: 79% of respondents self-reported at least one specific change to their classroom teaching
  – More than half of these listed instructional practices such as improved questioning techniques and supporting students in struggling with problems
  – Approximately 40% cited specific problems, activities, or new approaches to content
High-Quality Instructional Practices

• Video classroom observations suggested a relationship between higher levels of MTC participation and:
  – consistent use of precise mathematical language in the classroom (cf. Hill et al., 2007)
  – more frequent use of non-routine problems, as evaluated by mathematician coders (cf. Woodward et al., 2012)
High-Quality Instructional Practices

• Marle et al. (2012):
  – Observations and surveys of new MTC participants over the course of one year
  – Increased teaching self-efficacy
  – Increased reform-oriented teaching practices
  – Teaching self-efficacy and reform-oriented practices have both been previously linked with improved student motivation, attitudes, learning, and achievement (cf. Stipek et al., 1998; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998).
Healthy Mindsets
Healthy Mindsets:
Nature of Mathematical Intelligence

• Fixed (entity theory) vs. malleable/growth (incremental theory)
• Students who hold an entity theory:
  – are highly concerned about performances that reveal their “true” abilities (Blackwell et al., 2007; Dweck & Leggett, 1988; Grant & Dweck, 2003; Mangels et al., 2006)
  – tend to avoid real challenges for fear that poor performance will demonstrate low ability (Hong et al., 1999; Mueller & Dweck, 1998)
  – become unmotivated in the face of difficulty (Blackwell, et al., 2007; Marocchio, 1994; Wood, 1989).

• Students who hold an incremental theory:
  – are less focused on measuring and proving their abilities, and more focused on learning, i.e., improving their abilities (Blackwell et al., 2007; Dweck & Leggett, 1988; Mangels et al., 2006).
Healthy Mindsets: Nature of Mathematical Intelligence

- **Teachers’** beliefs about mathematical intelligence impact their pedagogical practices (Anderman, et al., 2001) and classroom culture in a way that conveys their underlying mindsets and affects students’ motivation, interest, and investment in the class (Rattan, Good, & Dweck, 2012).

- “It has been neat to see such high level math become ‘reachable’ and ‘doable’ for me. It has made me feel that, maybe I really CAN do it!”
Healthy Mindsets:
Sense of Belonging to Mathematics

• Linked with achievement, learning, and intrinsic motivation (Good, Rattan, & Dweck, 2012)

• 58% of all survey respondents identified belonging to a professional math community as a major motivation for participating

• “Math Teachers’ Circle moved me from being a math teacher to feeling like I am a mathematician”
Healthy Mindsets: Role of Grit and Persistence

• Students who have “grit” and are able to persist through difficult tasks have higher learning outcomes than their less “gritty” peers (Duckworth et al., 2010)
• “I have increased my level of expectations for all students”
• “I feel much more confident letting my students struggle and take time to solve problems. I use this concept with most lessons and my students have grown because of it.”
Healthy Mindsets:
Conceptions of Mathematics

• 20-item Conceptions of Mathematics scale under development by Good and Donaldson

• Two views of mathematics described in the literature (Beswick, 2012; Beswick & Callingham, 2014; Burton, 2002; Ernest, 1989; Thompson, 1984): professional mathematician vs. traditional school math or instrumentalist

• Subscales indexing the “mathematician” and “instrumental” approaches had high internal reliability (Cronbach’s alpha = .81 and .77, respectively)
Healthy Mindsets

- Pilot study with 275 participants who had varying levels of experience with MTCs
- The more MTC meetings teachers reported attending, the more likely they were to see math “like a mathematician” ($p = .045$)
- The more teachers participated in MTCs, the more they incorporated mathematics as part of their identity ($p = .046$)
- Seeing math like a mathematician was strongly predictive of other healthy mindsets, including:
  - More incremental theories of intelligence ($p < .02$)
  - Higher sense of belonging ($p < .02$)
  - More grit ($p < .01$)
- This view of math also predicted desirable pedagogical practices like endorsing mastery of content ($p < 0.04$) and normalizing mistake-making in the classroom ($p < .001$).
What is the impact of MTCs?
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Diagram:
- MTC Participation
- Mathematical Knowledge for Teaching
- Healthy Mindsets
- High-Quality Instructional Practices
- Professional Engagement
Discussion

• MTCs are not a comprehensive model of teacher professional development, but they can be a catalyst for change for those who are ready
• Fostering healthy mindsets about mathematics, while at the same time increasing teachers’ mathematical knowledge for teaching and their professional engagement, could have a truly broad impact on mathematics in the U.S.
Thank you!

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Which teachers participate?

• Average of 15-20 teachers per session
• Grades taught:
  – Elementary school (ES): 10-20%
  – Middle school (MS): 50-60%
  – High school (HS): 10-20%
• Educational background: degree in math or math ed
  – 15% of ES teacher participants (vs. 4% nationally; Banilower et al., 2013)
  – 55% of MS teacher participants (vs. 35% nationally)
  – 49% of HS teacher participants (vs. 73% nationally)
• Approximately half report teaching in a high-needs school
• 39% of 275 participants in Good and Donaldson (in preparation) reported that the majority of students at their school were not meeting grade-level expectations in math
  – 14% said that most students were exceeding expectations