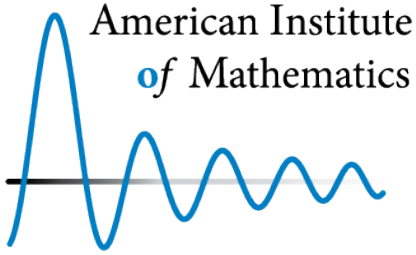
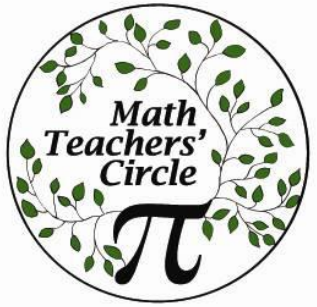




The Broad Impact of Math Teachers' Circles: Results from the First Decade

Brianna Donaldson

American Institute of Mathematics

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

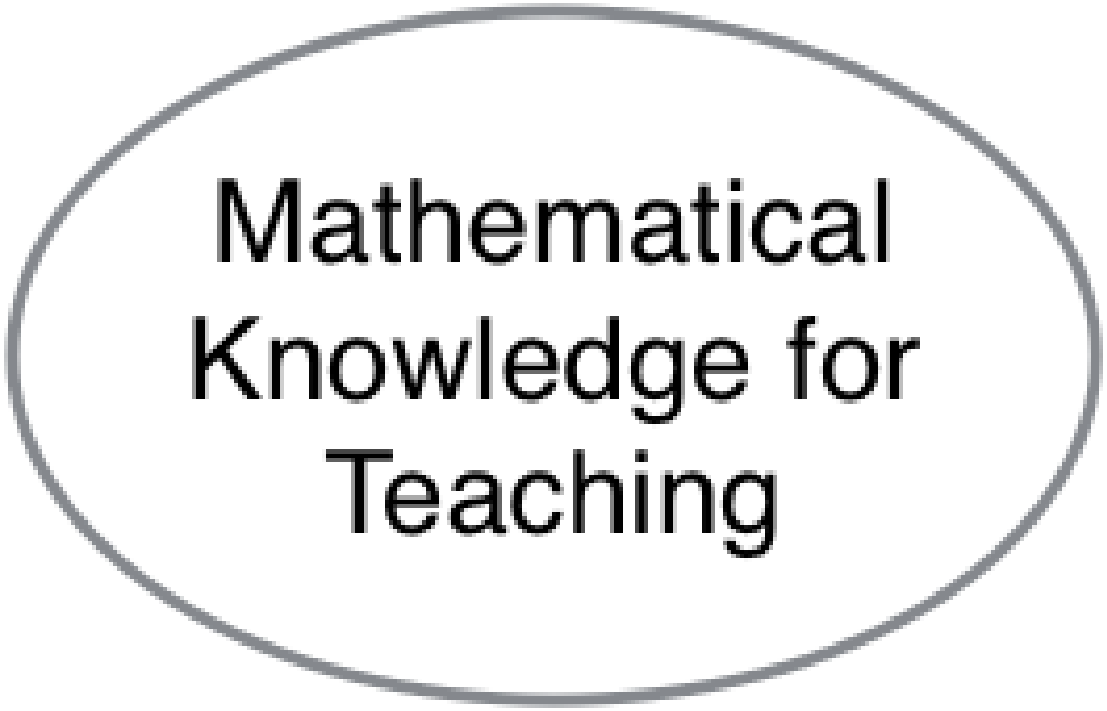
- Anecdotally, effects on teachers and mathematicians are profound
- Research has mostly focused on teachers

Acknowledgments

- NSF DRL-1119342 to the American Institute of Mathematics
  - 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

High-Quality Instructional Practices

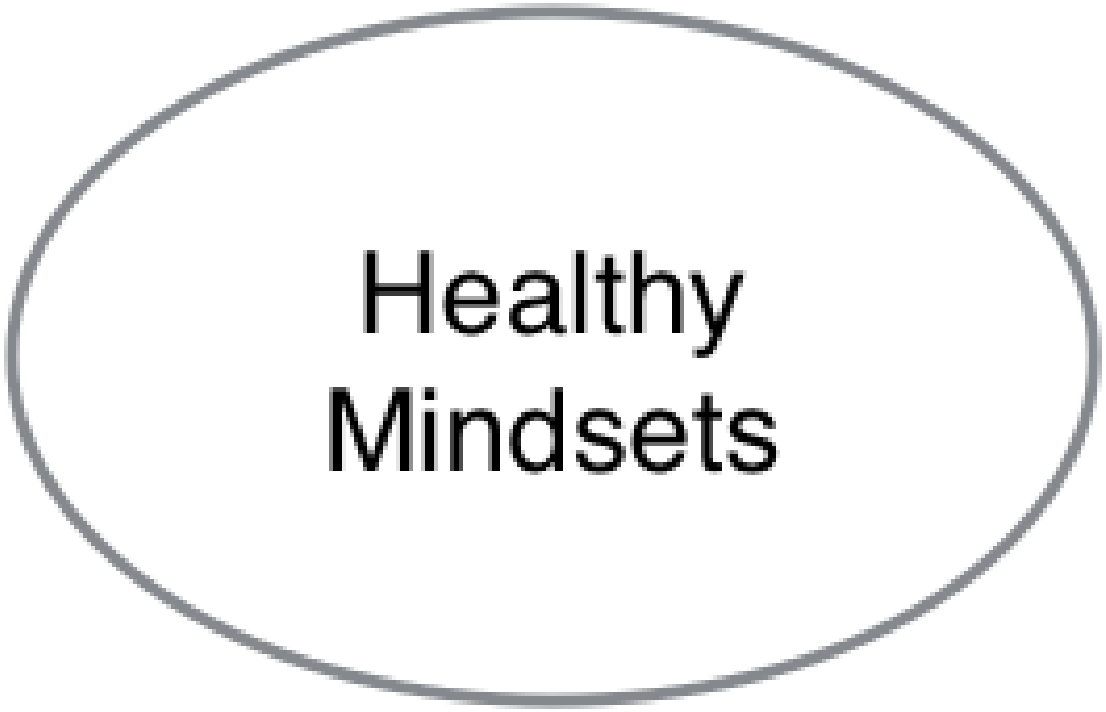
- National MTC Surveys: 79% of respondents self-reported at least one specific change to their classroom teaching
  - More than half of these listed instructional practices such as improved questioning techniques and supporting students in struggling with problems
  - Approximately 40% cited specific 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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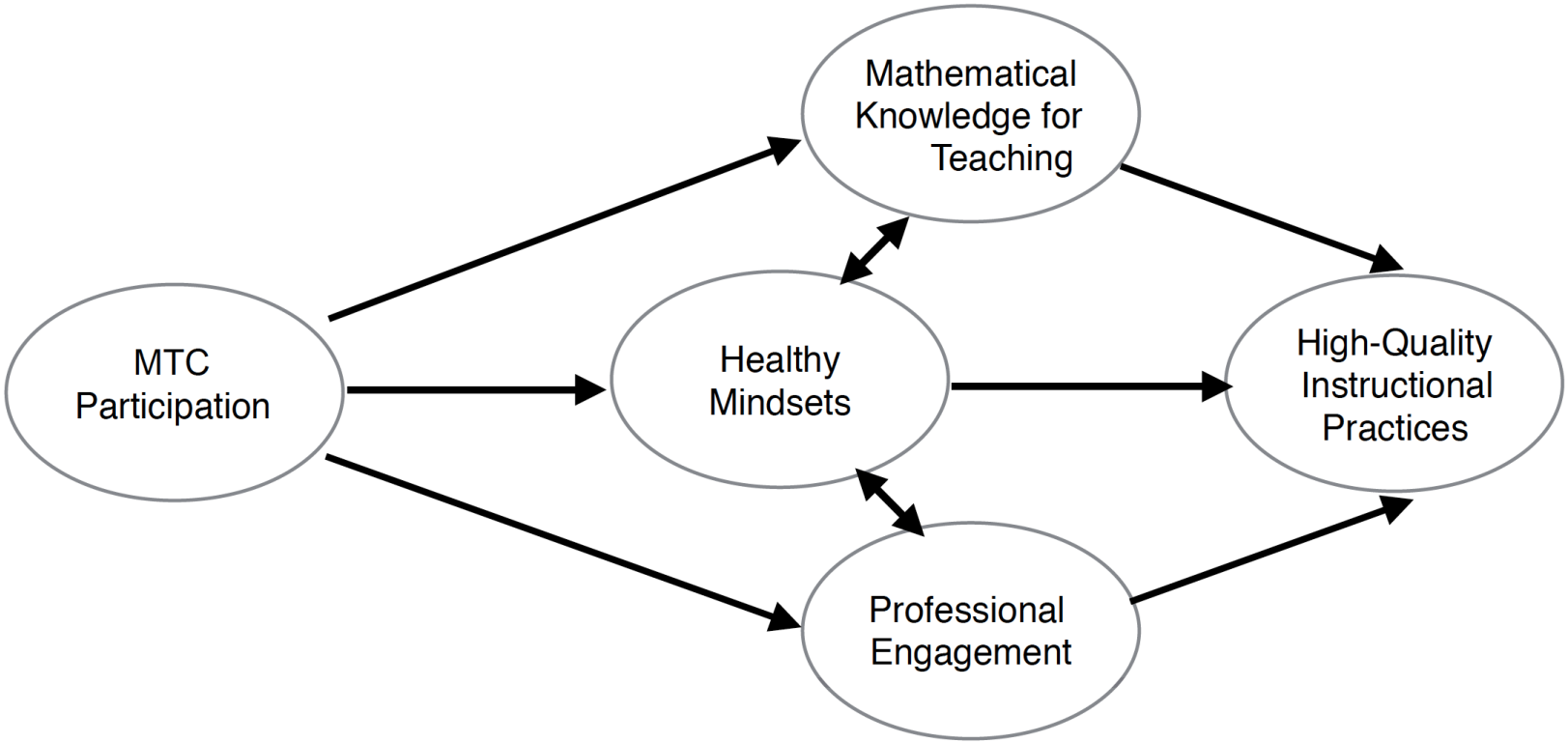

Discussion

- 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!

Brianna Donaldson
American Institute of Mathematics
brianna@aimath.org

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