MATH TEACHERS’ CIRCLE OF HAWAI’I: A PLAN FOR PROFESSIONAL DEVELOPMENT OF MIDDLE SCHOOL MATHEMATICS TEACHERS

1 INTRODUCTION AND BACKGROUND

The mission of the national Math Teachers’ Circle (MTC) program, originally developed at the American Institute of Mathematics (AIM) and now a nationwide movement, is to establish the foundation for a culture of problem solving among middle school mathematics teachers in the United States. By fostering the confidence to tackle open-ended math problems, middle school teachers become better equipped to initiate more student-centered, inquiry-based pedagogies in their classrooms. The primary goals of MTC programs are

1) to engage middle school math teachers in mathematical problem solving,

2) to involve them in an ongoing dialogue about math with students, colleagues, and professional mathematicians; and

3) to provide guidance, materials, and resources to middle school math teachers that will enable them to promote open-ended problem solving as a way of learning, thinking about, and practicing mathematics in their classrooms.

A typical MTC has two components:

1) a residential summer immersion program for 15 to 20 teachers that launches the program, and

2) monthly follow-up meetings held throughout the following academic year and indefinitely thereafter.

During the immersion component, teachers engage in various open-ended problem-solving activities throughout the day and evening, guided by professional mathematicians and
experienced facilitators. The monthly meetings continue to provide a content-based enrichment outlet for teachers but also have a more pedagogical focus intended to help teachers bring problem-solving techniques into their classrooms and clearly connect to statewide standards and practices.

The Math Teachers’ Circle Network links together MTCs from around the U.S. To help the MTC community grow, AIM organizes workshops designed to inform teams of middle school math teachers, school administrators, and research mathematicians about the program and equip them to begin MTCs of their own. These local MTC chapters are intended to become self-sustaining over the long term, and thus much of the workshop is focused on preparing each team to set goals for their MTC and discuss the recruitment of teachers and mathematicians, the evaluation of their program, and fundraising at the local or state level.

In June 2010, the PI organized a team from Hawai`i — herself, one Graduate STEM Fellow, a staff member of the Curriculum Research and Development Group (CRDG), and two middle school mathematics teachers — to attend the “How to Run a Math Teachers' Circle” workshop at AIM. The team returned home with a firm belief that Hawai`i would benefit tremendously from a Math Teachers' Circle, and with a plan in place to get one off the ground based on the model developed at AIM. See Section 3 for details of this plan.

Math Teachers’ Circle Hawai`i (MaTCH) will be a professional learning community of teachers, mathematicians, and middle school educators who meet regularly to do mathematics. Our fundamental beliefs, based on the literature review given in Section 2, are that when teachers engage in mathematical problem solving activities, they further their own mathematical knowledge as well as develop pedagogical content knowledge, and that raising mathematical content knowledge is a critical component of teacher professional development.
From June 1–4, 2011, twenty-one teachers participated in a four-day kickoff event. Mornings were spent engaged in mathematics activities led by the PI and graduate STEM Fellows from the mathematics department, and the afternoons focused on pedagogical connections and the Common Core State Standards or CCSS (2010). One follow-up meeting will be held on August 27, 2011. Again, teachers will participate in mathematics activities and think deeply about pedagogy, including sharing lesson plans that they have developed based on the experiences in the summer course. An evaluation of the summer component conducted by Diana White (see Section 5) showed that teachers in the summer workshop showed modest mathematical gains, including significant gains in number and operation. Exit questionnaires showed that the participating teachers had a uniformly positive experience, with nearly all of them citing the experience as a change in their way of approaching mathematics.

The PI and her team hope that this is just the beginning. The proposed project will allow us to continue MaTCH through the 2011–2012 school year and the following summer, following the MTC structure outlined above.

2 DATA-BASED NEEDS STATEMENT AND EVIDENCE FROM SCIENTIFICALLY BASED RESEARCH

Note: Much of the material in Section 2 was adapted from resources available to Math Teachers’ Circle Teams at the Math Teachers’ Circle Network website: http://www.mathteacherscircle.org/.

The MTC program’s emphasis on problem solving is well aligned with numerous reports focused on college readiness and the education of the 21st century workforce. Problem solving and critical thinking are widely cited as among the most important skills for college readiness

However, mounting evidence from national and international assessments indicates that few U.S. students are proficient with mathematical problem solving, particularly in the context of unfamiliar problems (Gonzales et al., 2009; National Center for Education Statistics, 2009; Organization for Economic Cooperation and Development, 2007). Deficiencies in U.S. students’ mathematics performance start to become evident at the middle school level, which has emerged as a critical period for determining future success in high school, college, and the workforce (ACT, 2008; Fuller, 2009; Kay, 2009; National Mathematics Advisory Panel, 2008). Employers rank the majority of high-school graduates entering the workforce as “deficient” in problem solving, while the majority of two- and four-year college graduates are ranked as “adequate” but not “excellent” problem solvers (The Conference Board et al., 2006).

Currently, middle school students are lagging behind their international peers. On the Trends in International Mathematics and Science Study (TIMSS) in 2007, U.S. eighth graders scored significantly below eight Asian and European countries in mathematics, and U.S. 15-year-olds ranked 35th out of 57 countries that participated in the 2006 Programme for Student Assessment (PISA; Organization for Economic Cooperation and Development, 2007). In
addition, only around 32% of U.S. eighth graders scored at the “proficient” level or higher in math on the 2007 National Assessment of Educational Progress.

Students’ deficiencies in problem solving are hardly surprising given that the U.S. curriculum has consistently been found to lack opportunities for participation in creative problem solving and mathematical reasoning activities (Hiebert, 2003; Klein et al., 2005; Schmidt, McKnight, & Raizen, 1996; Wenglinsky, 2000, 2002). However, taking the time to develop students’ higher-order thinking skills is associated with improved student achievement in mathematics (Wenglinsky, 2000, 2002). In turn, teachers’ content knowledge of mathematics plays a critical role in the extent to which they engage students in rich mathematics (Hill et al., 2007).

A recent study on Mathematics Teaching in the 21st Century (MT21) (Schmidt et al., 2007) found that middle school math teachers in the U.S. ranked in the middle to the bottom in terms of content knowledge compared with the five other countries studied (Bulgaria, Germany, Mexico, South Korea, and Taiwan). There is reason to believe that improving teachers’ knowledge of mathematics will translate to increased student achievement (cf. Hill, Rowan, & Ball, 2005). At least two major factors related to teachers’ content knowledge are linked with improved student achievement in mathematics:

(1) formal degrees, certifications, or coursework in mathematics (Goe, 2007; Harris & Sass, 2007), and

(2) professional development that is focused on content and/or higher-order thinking skills (Harris & Sass, 2007; Wenglinsky, 2000, 2002).

Only approximately 54% of middle school mathematics teachers had completed a mathematics major or were fully certified to teach mathematics as of the most recent School and
Staffing Survey (National Science Board, 2008). Intervention is particularly needed in Hawai‘i. The 2007 Report Card on American Education contains alarming statistics for the state. Its national rank in academic achievement is 47 out of 50, and the NAEP average scores of proficiency in mathematics are far below the national average.

There are positives in the Hawai‘i school system: The 2007 Superintendents’ Annual Report released by the Hawai‘i Department of Education documents high attendance rates and low rates of violence in schools. But results of the latest statewide standards-based assessment show that students are underperforming. On the mathematics portion only 38% of students (in all grades) scored proficient or above; that is much worse than the 60% of students in the same category on the reading portion of the exam.

Statewide, just 85% of teachers are fully licensed, and only 29% of teachers have any advanced degree. Hawai‘i has an additional problem of high staff turnover — the statewide average for teachers at the same school for five or more years is just 51% — making it difficult to establish a culture of continuous school improvement, and for teachers to establish themselves as leaders in the school community. By energizing teachers around exciting work like this, and by providing them with support outside of their school, we will help with some of these retention issues, and we will create a cadre of mathematics content specialists at Hawai‘i schools.

Thus, providing effective content-based professional development to in-service teachers emerges as a critical priority for improving how mathematics is taught at the middle school level. Effective professional development is generally agreed to include the following features:

(1) content focus,
(2) active learning,
(3) coherence with other expectations and goals,
(4) sustained duration, and

(5) collective participation of teachers from a school, district, and/or grade level (Desimone, 2009).

However, relatively few teachers appear to be offered professional development opportunities that can be characterized as meeting these criteria in a meaningful way (Desimone et al., 2002; Garet et al., 2001; Hill, 2004; Scotchmer et al., 2005).

The MTC program provides middle school teachers with deep content knowledge enrichment as well as increased practice and facility with mathematical habits of mind. The MTC model is a novel method of professional development that centrally involves mathematicians in long-term collaborations with middle school mathematics teachers in order to increase the teachers’ content knowledge, mathematical problem-solving skills, and ability to bring rich mathematics into their classrooms. By tapping into mathematicians’ expertise in the process of doing mathematics, the MTC model provides a natural mechanism for them to serve as resources for the teachers.

The MTC model both meets the criteria for effective professional development and also has potential as a cost-effective, scalable, and sustainable model for enriching teachers’ knowledge of mathematics and mathematical problem solving.

3 Plan of Operation

Instructional Plan

Objectives of MaTCH include:

(1) to expand teachers’ mathematics content knowledge;

(2) to develop teachers’ abilities to identify behaviors consistent with the Common Core Mathematical Practices (CCMP);
(3) to train teachers to provide opportunities for their students to develop mathematical behaviors consistent with the CCMP; and

(4) to build a network of mathematics teachers, mathematicians, and mathematics educators throughout the state of Hawai`i for the purpose of bringing resources to support K-12 mathematics education.

The proposed project will support just the first year of MaTCH. Eventually, we hope MaTCH will become self-sustaining, with local sponsors providing supplies and space for the workshops. Other MTC sites have found that incentives like teacher stipends are necessary to recruit initially, but can be phased out once projects have a core group of teachers who attend regularly and find value in the experience.

We believe the University of Hawai`i Mathematics Department will adopt this outreach project, with faculty and graduate students taking turns running the Saturday workshops. In the 2012–2013 school year, we plan to work with UH to establish a course in the Mathematics Department that participating teachers can take for credit, which will serve as a sustainable incentive as new teachers consider joining MaTCH. (See attached letters of support.)

In addition, we have plans to collaborate with mathematicians from other campuses and faculty from other STEM departments at UH, all of whom will bring their expertise and ideas to the teachers. (See attached letters of support.)

We plan for six MaTCH Saturday morning workshops each year and occasional summer retreats as funding allows. All workshops will follow similar structure: mathematics activities led by a local expert, followed by pedagogical discussion facilitated by colleagues from CRDG. The pedagogical discussions will focus on illuminating the Common Core Mathematical Practices (CCMP), especially in drawing explicit connections between the teachers’ experiences
in their explorations and the experiences they are asked to provide for students.

We are lucky to be able to leverage the existing School and University Partnership for Educational Renewal in Mathematics (SUPER-M) project to help establish and run MaTCH. The project team will draw on mathematics faculty and graduate Fellows from the SUPER-M project to organize and run mathematics activities. In addition to teachers from the 2011 MaTCH summer workshop, our initial cohort of participants will include current and former partner teachers in the SUPER-M program. This includes teachers from Oahu, Maui, and Moloka`i (the PI has a grant from the National Science Foundation that includes travel funds for teachers from outer islands to participate in MaTCH as well as travel for MaTCH teachers to local and national conferences to share their experiences); and it includes teachers from DOE schools, charter schools, and private schools.

Also, because Math Teachers’ Circles have been established at many sites around the country, there is an electronic clearinghouse of mathematically rich activities available to MTC sites. (See http://www.mathteacherscircle.org/.) These activities are organized by content area; they all have a problem-solving focus along with clear ties to the Common Core Standards and content in the middle grades mathematics curriculum. Because they have been thoroughly tested and revised, these activities are ready to be used by skilled facilitators with a minimum amount of preparation and organization time required. The PI and STEM Fellows used several of these off-the-shelf activities with great success in the Summer 2010 MaTCH workshop.

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<tr>
<th>Timeline of Project Activities</th>
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<tr>
<td>September 2011</td>
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<tr>
<td>Recruit teachers (including teachers from both public and private schools, with an emphasis on teachers from rural and high-need areas), facilitators, and sponsors.</td>
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<tr>
<td>Purchase materials and supplies</td>
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### MANAGEMENT PLAN

As P.I., Manes’s primary role is to oversee the delivery of the MaTCH session activities, including facilitating some of the professional development herself and overseeing the selection and training (in the case of graduate students) of other facilitators. Venenciano’s role on the project is co-P.I. Her responsibilities include:

- contributing to the MaTCH session activities, particularly in developing teachers’ understanding of CCMPs,
- monitoring the effect of project activities on teacher learning and instructional practices,
- supporting teachers’ abilities to analyze student learning behaviors, and
- structuring focus group meeting to collect formative feedback.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Persons Responsible</th>
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<tbody>
<tr>
<td>Administer funds</td>
<td>Manes, Venenciano</td>
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<tr>
<td>Write reports</td>
<td>Manes, Venenciano</td>
</tr>
<tr>
<td>Run MaTCH sessions</td>
<td>Manes, Venenciano, recruited</td>
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<tr>
<td>Task</td>
<td>Responsible persons</td>
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<tr>
<td>Recruit mathematician facilitators</td>
<td>Manes, Lau</td>
</tr>
<tr>
<td>Recruit teachers</td>
<td>Lukonen, Kamakeeaina, Vines,</td>
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<tr>
<td>Support teachers’ data collection and analyses of student behaviors</td>
<td>Venenciano, Manes</td>
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<tr>
<td>Oversee evaluation plan</td>
<td>Venenciano, Manes</td>
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<tr>
<td>Build and help maintain electronic sharing</td>
<td>Venenciano, Manes</td>
</tr>
<tr>
<td>Recruit support from local businesses to sponsor meals/refreshments during MaTCH sessions</td>
<td>Venenciano, Lukonen, Kamakeeaina, Vines,</td>
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**4 The Partners**

The three partners in this work are the Hawai`i Department of Education (DOE), the Mathematics Department at the University of Hawai`i at Manoa, and the UH Manoa Curriculum Research and Development Group (CRDG).

The state of Hawai`i Department of Education is a high-needs local education agency. The state’s report for school year 2010-2011 for the No Child Left Behind state assessment showed that the proficiency objective for mathematics of 64% was not met. Although 99% of the students statewide participated in taking the assessment, only 55% of the students were proficient. The status for the state’s adequate yearly progress (AYP) was not met. This data shows the immanent need for supporting improvements in mathematics education in Hawai`i.

In recent years, the Department of Mathematics at the University of Hawai`i at Manoa has increased its outreach activities, working regularly with K–12 teachers and students. Recent activities include:

- undergraduate students partnering with K–8 educators to bring engineering activities to their classrooms;
• graduate STEM Fellows partnering with local teachers and schools, working in classrooms, and bringing a culture of mathematics exploration to the students;
• graduate STEM Fellows designing and teaching summer enrichment classes in mathematics for elementary and middle grades students;
• presentations by mathematics faculty and graduate students at every Hawai‘i Council of Teachers of Mathematics meeting in the past two years;
• the PI leading district-level workshops for mathematics teachers;
• the PI and her graduate student participating in a community outreach event focused on “Math Power for Girls;” and
• community outreach events focused on mathematics and science activities, held twice per year on Oahu and annually on Moloka‘i.

Many of these activities grew out of Dr. Monique Chyba’s work with the Student Teacher Outreach Mentorship Program of Hawai‘i (STOMP@HI, http://www.math.hawaii.edu/stomp/STOMP/) and the more recent School and University Partnership for Educational Renewal in Mathematics (SUPER-M, http://www2.math.hawaii.edu/superm/). To date, the work has focused primarily on reaching children by bringing them in contact with undergraduate and graduate students from science, engineering, and mathematics.

The Department already works with pre-service teachers by providing the fundamental mathematics coursework necessary for students in the College of Education. A natural next step is to begin serving practicing teachers by providing ongoing quality professional development. A fundamental goal of the SUPER-M project was to establish ongoing relationships between the UH Department of Mathematics and local schools. The department has successfully built those
relationships, and now must find ways to continue supporting local teachers.

This is especially necessary as Hawai‘i adopts the rigorous CCSS, and more will be asked of mathematics teachers than ever before. The PI is uniquely qualified for this work, thanks to eight years’ experience working in the popular and ongoing “PROMYS for Teachers” summer and school-year programs. She has assembled an incredible team to join in the work.

The Curriculum Research & Development Group (CRDG) has nearly 40 years of experience in researching, developing, publishing, and disseminating effective programs. One of their foundational beliefs is that teachers need to engage in on-going professional development in order to produce significant changes in their practice. CRDG designs and delivers such opportunities for teachers, incorporating up-to-date research about teaching and learning, modeling successful instructional strategies, emphasizing the building of teachers’ content knowledge, and most recently, addressing CCSS standards.

The co-PI has over ten years of experience in designing and conducting mathematics professional development at CRDG. She has expertise in the middle grades, having taught students at that level for eight years, four of which were concurrent with responsibilities in the curriculum research and development project, the Reshaping Mathematics for Understanding. Her work on this project was in conjunction with delivering professional development to teachers across the state.

5 Evaluation Plan

To formatively evaluate objective (1) expanding teachers’ mathematics content knowledge, the project staff will track teachers’ engagement in problem solving activities during MaTCH sessions. Tracking will occur via observations of the nature and frequency of teacher participation in the problem solving activities and feedback forms from the teachers. Focus group
meetings will also be opportunities for teachers to share feedback directly with project staff about the mathematics. Sample discussion topics for focus group meetings are,

- To what extent did you find the mathematics activities challenging, and
- In what ways do anticipate incorporating what you learned into your practice?
- How will you know if your new practices are effective in helping students learn?

Summative evaluation of this objective will be conducted by Diana White of the University of Colorado, Denver. White is well qualified for this task as she recently conducted a nationwide study in summers 2010 and 2011 to investigate if participation in a Math Teachers’ Circle immersion workshop resulted in increases in teachers’ mathematical knowledge for teaching. MaTCH teachers participated in the 2011 study during the June 2011 kickoff retreat. White used the *Learning Mathematics for Teaching* instrument developed at the University of Michigan (2008) under the direction of Deborah Ball and Heather Hill. Pre- and post-tests will be prepared and analyzed by White. The pre-assessment will also provide information about participants’ mathematical knowledge base at the beginning of the project. A different version of the post-assessment will be used for this project due to some teachers’ prior experience with MaTCH from the 2011 summer retreat.

Preliminary findings showed that the MaTCH teachers had statistically significant gains in some of the subsections of the assessment, namely number and operations.

To formatively evaluate objective (2) developing teachers’ abilities to identify behaviors consistent with the CCMP, the project staff will track responses on writing assignments where the teachers describe characteristics or episodes that exhibit the one or more of the CCMPs. Focus group meetings will serve as opportunities to probe and monitor teachers’ developing abilities.
Summative evaluation of objective (2) will be conducted with the use of an instrument to score teachers’ abilities to identify which, if any, CCMP were apparent in videos of mathematics lessons. The Mathematical Quality of Instruction (MQI) instrument purports to be consistent with identifying instructional and learning behaviors consistent with the CCSS. It is disseminated by the National Center for Teacher Effectiveness and requires potential users to attend the online MQI training. This instrument will be piloted in this project in hopes that a full implementation will follow in subsequent proposals to advance our work. Video footage from classes will be captured for use of the MQI tool. Inter-rater reliability will be developed with the assistance of Dr. White, a researcher/evaluator who used the MQI with some success on other projects.

To evaluate objective (3) training teachers to create opportunities for their students to develop mathematical behaviors consistent with the CCMP, the teachers will submit lesson plans and accompanying sample student work. A scoring rubric will be designed by project members to rate the effectiveness of the lesson. Teacher participants will provide feedback to contribute to validating the intent of the instrument. Teacher consultants will be hired to assess the lesson plans together with project members. At least two assessors will rate each lesson plan.

To evaluate objective (4) to build a network of mathematics teachers, mathematicians, and mathematics educators throughout the state of Hawai`i for the purpose of bringing resources to support K-12 mathematics education, we will report the number and backgrounds of people participating in the MaTCH sessions.