

**FOCUS ON MATHEMATICS
SUPPLEMENT
MATHEMATICS TEACHING SCHOLARS PROGRAM**

Evaluation Report, Year 3

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by

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Focus on Mathematics
Mathematics Teaching Scholars
Year 3 Evaluation Report
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INTRODUCTION AND BACKGROUND

In September 2003, Focus on Mathematics (FoM) was funded by the National Science Foundation (NSF) as a 5-year, grades 5–16 Targeted Math-Science Partnership (MSP). The partnership included Boston University, University of Massachusetts at Lowell, Worcester Polytechnic Institute, Education Development Center, and 5 school districts in the greater Boston area with 10 high schools, 16 middle schools and 11 elementary schools (grades 5-6 only). At the middle and high school levels, there were approximately 230 mathematics teachers and 15,000 students.

In 2008, FoM partners were awarded a supplemental grant with continued support for their MSP, albeit with a reduced level of resources. Primarily, the supplement provided funds to initiate a Math Teaching Scholars Program while sustaining support for their professional development programs. In 2009, FoM received an MSP Phase II award and, in collaboration with the Boston University School of Education and *Math for America*, funding for a Noyce Teaching Scholars Program.

Under the Phase II grant, FoM expanded its partnership adding two public school districts in the greater Boston area, Cambridge and Framingham. The original districts -- Arlington, Chelsea, Lawrence, Waltham, and Watertown -- continue as members of the partnership. In addition, two mathematicians, one from Harvard University and one from Massachusetts Institute of Technology, joined the BU, UMASS/Lowell, EDC, and Lesley University-based mathematicians already involved in FoM's efforts.

EVALUATION

The Program Evaluation and Research Group at Lesley University serves as the external evaluator for (1) FoM's supplemental grant activities, (2) FoM's work under Phase II, and (3) the Math for American/Boston Noyce Scholars program. Working with most of the same leadership team members, evaluators seek ways to use the available resources efficiently to both detail the discrete strategies and outcomes of each program and to examine whether and how the efforts form a coherent approach to improving mathematics across the programs.

Planning

In fall 2010, evaluators met with the PIs to discuss the Mathematics Teaching Scholars Program, identified key questions, and planned changes for year 2. The design of the evaluation plan focused on the recruitment and selection of the second cohort of Mathematics Teaching Scholars, the structure of the MTS program – the resources and support FoM provides to the Scholars over the course of the year, the MTS leadership activities conducted on behalf of the partnership, and, finally, participants' reflections on the benefits and challenges of the program.

Data Collection

The following data were collected between June 2010 and May 2011.

- Interviews with Glenn Stevens and Suzanne Chapin.
- Interviews with the Cohort 2 Master Teaching Scholars and with the teacher enrolled in the Master of Mathematics for Teaching program (MMT) at Boston University in fall 2010 and May 2011.
- Surveys of 2010 summer institute participants.
- Surveys of participants that attended afternoon seminars during the 2010-11 school year.
- Observations of evening meetings for FoM's Teaching Scholars and MfA Master Teachers facilitated by Glenn Stevens, FoM PI, Steve Rosenberg, BU mathematician, and Juliana Belding, Harvard mathematician.
- Review of applications for the second cohort of Teaching Scholars as well as those applying for the 2011-12 school year.
- Attendance at FoM's bimonthly Executive Committee meetings.
- Ongoing communication with FoM PIs, mathematicians, district leaders, and program staff.
- Boston University's program database was accessed to determine program participation.

Reporting

This report focuses primarily on FoM's Math Teaching Scholars program between June 2010 and May 2011. Please note that additional evaluation reports over the past year address other aspects of the partnership's programs and should be read in conjunction with this report, as the work is often integrated and complementary. These include:

March 2011: *Math for America Boston: Noyce Teaching Scholars Program at Boston University Evaluation Report, Year 2*

April 2011: *Focus on Mathematics Phase II Evaluation Report, Year 2*

Together, the reports examine growth and change at the partnership's leadership level, the engagement and contributions of mathematicians and mathematics educators, the structure and purposes of the programs as well as their reach across urban and metropolitan Boston districts, efforts to build and nurture a broad mathematics community to influence mathematics teaching and learning in the region and beyond, and research to define, describe, document, and measure mathematicians and mathematics educators' 'mathematical habits of mind.'

FOM'S MATHEMATICS TEACHING SCHOLARS PROGRAM

The goal of FoM's *Mathematics Teaching Scholars* (MTS) program is to increase student achievement by recruiting and retaining highly qualified teachers in the teaching profession. The program provides financial and professional support for experienced, effective teachers with strong mathematics backgrounds who are well respected in their classrooms, schools, and districts and are recognized as "leaders" by their colleagues.

Teaching Scholars receive honoraria of \$10,000 per year. While continuing to teach in high needs school districts, they also serve as mentors and professional development facilitators for the FoM partnership. In this way, the MTS Program becomes a vehicle for retaining talented teachers, supporting and further developing their knowledge of mathematics for teaching as well as their capacity to provide leadership support to the FoM community and their local schools and districts. As math leaders, these teachers play a critical role in sustaining and extending the work of the *Focus on Mathematics* community.

In a nutshell, when I tell people who don't know what this is, I say I am participating in a grant-funded program that supports scholarship by high school teachers. It could be at a Summer Institute, where math rules, or pedagogical issues, or Common Core Standards. It provides a chance for us to participate in a level of scholarship that we wouldn't normally do in our district. By getting to do these things, the responsibility is on us to share with our district and schools.

(Math Teaching Scholar)

We get a chance to think about math and teaching math and come up with ways to help ourselves and everyone in the group and other teachers do a better job of it.

(Math Teaching Scholar)

Teaching Scholars 2009-11

As noted in last year's evaluation and program reports, FoM encountered a number of district-related issues that required adjustments to the partners' original implementation plan. As a result, the recruitment and selection of the first cohort of teachers was delayed until late spring 2009. Since then, FoM has established three distinct avenues of program support for teachers interested in taking on leadership responsibilities in mathematics education and/or gaining the knowledge and skills to do so.

- *In the past two years, twenty-two (22) teachers have been accepted into one of these three programs.*

Math Teaching Scholars

FoM awards stipends on an annual basis to 4 veteran teachers. To apply, teachers must have strong mathematics backgrounds, be active participants in FoM professional development programs, and hold a masters or other advanced degree in mathematics or mathematics education. Most of the successful candidates to date have graduated from

BU's MMT program, participated in BU's PROMYS for Teachers program, and/or the Park City Summer Institute. In addition, most have already assumed some form of leadership role in their schools or districts prior to their appointment as an MTS. Local administrators support their interest in the program.

- *Since the start of the program, 5 teachers have been awarded MTS stipends. Three (3) of these have served as MTS for both the 2009-10 and the 2010-11 school years. One MTS served last year, but resigned his position to teach abroad. He was replaced by one new MTS this year.*

Masters for Mathematics Teaching Program

The Master of Mathematics for Teaching (MMT) degree prepares graduate students to be experts in mathematics and professional development. It is designed for experienced teachers who seek to become leaders in mathematics education. The program is a joint offering of the College of Arts & Sciences (CAS) and the School of Education (SED) at Boston University. It is based on an immersion experience in mathematics, coursework in mathematics and mathematics education, and preparation for assuming leadership roles. Teachers enrolling in the program attend classes part-time for two academic years while continuing to teach full-time. They also participate in the PROMYS for Teachers program for 3 summers.

- *To date, 4 teachers from FoM districts have received tuition support through FoM's Supplemental Award from the NSF. Three awards were given last year to teachers completing their final year of the program. The fourth teacher to receive tuition support enrolled in the MMT program this year.¹*

Extension of the BU School of Education Noyce Scholars Program

Boston University Noyce Scholars Program is designed to prepare recent graduates that have majored in mathematics or a STEM field and/or career changers with experience in a STEM field who want to become middle and high school mathematics teachers for students in high need districts. Noyce scholars receive full scholarships to BU's Master of Arts in Teaching (MAT) degree program in mathematics. The one-year program leads to a master's degree and initial teacher licensure. In exchange, Noyce scholars commit to teach for at least two years in high-need districts upon successful completion of the teacher certification program.

- *Over the past two years, FoM awarded stipends to 13 Noyce scholars who completed the MAT program and are teaching in high needs districts. The award further extends their 2-year teaching commitment for one or more years.*

¹ Twelve teachers from partnering FoM MSP districts have completed the MMT program since 2003. During the first 5 years of the MSP; their tuition was covered by FoM in exchange for a commitment of 5 years of teaching. A more limited number of awards are now available through the Supplemental budget.

The table below outlines the number of teachers FoM is supporting through the program.

Table 1: FoM Teacher Leadership Support, 2009-11

	2009-10	2010-11	Award	Commitment
Math Teaching Scholars	4	1 new; [3 returning]	Stipend	Design/facilitate PD for FoM community; other leadership activities, as needed
Masters in Mathematics for Teaching	3	1	Tuition support	Design/facilitate PD <i>upon completion of MMT</i> , 5 year teaching commitment
Noyce Scholars	5	8	Stipend	Additional year commitment to teach in high needs district
Total Awards	12	10		

Math Teaching Scholars Cohort 2: Recruitment and Selection

Last spring, FoM invited teachers from partner districts to apply for the second year of the program. Based on feedback from the previous year, PIs clarified program expectations and revised the application process. Teachers meeting the qualifications required were asked to secure support from district and school leaders if they planned to apply.

Thirteen (13) teachers from 5 of FoM’s 7 districts completed applications for the program year 2. FoM PIs reviewed applicants’ documents and interviewed each candidate. A committee comprised of the PIs, FoM mathematicians, and district leaders made the final selections. Cohort 2 includes:

- *Math Teaching Scholars*: Three teachers who served as Math Teaching Scholars during the 2009-10 school year were awarded stipends to continue to their leadership role during 2010-11.² The fourth MTS, new to the program this year, is a high school mathematics teacher from Framingham, a district that joined the partnership in 2009 under the FoM Phase II program.

All 4 MTS in Cohort 2 are veteran teachers from FoM partner districts. Two are from Lawrence High School, a third works at the middle school level in Chelsea, and as noted, the fourth is from Framingham. All 4 have strong mathematics backgrounds, have been and remain active participants in FoM professional development programs, are graduates of the Masters of Mathematics for Teaching (MMT) program at BU, PROMYS for Teachers program at BU, and/or the Park City Summer Institute.

They have a range of prior leadership activities including collaboratively designing and offering professional development programs to peers, serving as a school-based mathematics coach, advising on curriculum materials selection,

² One MTS from the first cohort is teaching abroad this year.

developing coursework, offering afterschool support to talented students, and/or working as a counselor in the summer PROMYS for Teachers program.

- *Masters of Mathematics for Teaching participant*: One teacher from Watertown High School applied for and received funding to support his enrollment in Boston University’s Master of Mathematics for Teaching (MMT) program. He entered the program in January 2011.
- *Noyce Scholars*: Similar to last year, 8 full time teachers serving in high needs districts who had previously been supported through BU School of Education’s Noyce Scholarship Program and graduated from its MMT, also received stipends from FoM for the 2010-11 academic year.

Table 2: Mathematics Teaching Scholars Cohort 2, 2010-11

MTS	FoM District	Schl Level	BU/FoM Program	Gender	Race	Licensure
2	Lawrence	HS	MMT, PFT	M	Caucasian	yes
1	Chelsea	MS	PFT	F	Caucasian	yes
1	Framingham	HS	PFT	M	Causasian	Yes
MMT	District					
1	Watertown	HS	MMT (2011-13)	M	Caucasian	yes
Noyce Scholars						
8			MAT graduate			

Math Teaching Scholars Cohort 3: Recruitment

This spring, FoM again put out a cross-district call for teachers from partner districts interested in applying for the third year of the MTS program. Six teachers have submitted applications. Three are currently serving as an MTS this academic year; two are new applicants. The sixth applicant is applying for support to continue his work in the MMT program for a second year. At this time, FoM has not yet made final a selection for the 2011-12 academic year.

- *Six (6) teachers from 4 of FoM’s 7 districts completed applications for the program year 3.*

This evaluation report details the work of the Cohort 2 Math Teaching Scholars and the teacher newly enrolled in the MMT program this year. A separate evaluation report of Boston University’s Noyce Scholars Program describes the Noyce Scholars’ program and activities (NSF #0733762).

Focus on Mathematics Support for Mathematics Teaching Scholars

Focus on Mathematics leaders -- the PIs; mathematicians at Education Development Center, Boston University, University of Massachusetts at Lowell, and Harvard University; mathematics education faculty members at Boston University; district leaders; as well as the expanding mathematics community within the broader FoM network were available formally, informally or on an as-needed basis to provide support for Mathematics Teaching Scholars throughout the year.

I've received mathematician help from people within the MTS group—Al Cuoco, Glenn Stevens, Steve Rosenberg, Matt Chedister, my peers, I've received some good ideas and support as far as implementing these new standards. And, this year more than last, I find that we participants help each other out a lot. We're all on each other's speed dials. We email each other regularly; send curriculum stuff back and forth. (MTS, Spring 2011)

The support from BU in general is really great, especially in terms of raw amount of talent or teaching talent. There are 30 people I can ask and get great feedback. So it's great to be plugged into that network. My math frustrations don't burn me too much, because it will be no more than a month that goes by and there will be someone I can ask. Also, in my district, I work with very strong competent people. Usually I can walk down the hall. But if it's beyond that, I can go to Steve or anyone at BU. (MTS, Spring 2011)

I kicked around the idea [for the seminar] with some [district] people—we are bouncing things off each other all the time. I talked a lot with BU people in general—other MTSs. I asked Al and Bowen some questions at some of the PROMYS workshops. I feel like I talked to a lot of people about the problem. That's a community of people I draw off of all the time for ideas. Whenever there's a workshop or seminar, I'm always bouncing hard math ideas off people there. There's a lot of math expertise [at BU/FoM], and in [the district]. I feel like I'm constantly asking questions and getting ideas. (MTS, Spring 2011)

There were also a number of more structured meetings and professional development sessions during the year to which MTS were invited and/or strongly encouraged to participate. All FoM-related programs examined and explored mathematics, pedagogy, curriculum issues, the Common Core Standards, and/or other topics focused on teaching and learning mathematics. These programs included:

- The Math Teaching Scholars evening dinner meetings
[8 sessions, October-June, 6-8 pm]
- Masters in Mathematics for Teaching program at Boston University
[Part-time, 3-year, 38 credit graduate program offered jointly by the Graduate School of Education and the College of Arts and Sciences.]
- PROMYS for Teachers seminars at EDC
[5 all-day sessions/year]

- The Math for America/Boston seminar series on Friday evenings [6 sessions, September-March, 4-8 pm]
- On-going Focus on Mathematics seminars, study groups, colloquia, and summer institutes

The Math Teaching Scholars Meetings are discussed in this report; other FoM professional development programs were reviewed in the 2011 FoM Phase II and Math for America/Boston evaluation reports.

Math Teaching Scholars Evening Meetings

The first meetings of the MTS (cohort 2) with FoM PI, Glenn Stevens, and BU mathematician, Steve Rosenberg, were held in October and November 2010. The group gathered to clarify expectations for the teachers' contributions to the FoM partnership, schedule the annual seminars for district partners that, over the past year, were designed and facilitated by the Math Teaching Scholars, and identify opportunities for the members' own professional growth and development.

The seminar was designed to be a study group for the Math Teaching Scholars, cross-districts. We'd like it to dovetail with what the Math for America Master Teachers will be doing. We'll keep mathematics in there, but we're thinking about it helping to develop a core of teacher leaders who will run seminars, summer institutes, and have discussions about various things. (FoM PI)

Stevens was exploring ways to bring both MTS and MfA Teaching Fellows together, as a first step to designing a longer-term professional development program "that incorporates mathematics distinctively."

We are working with phenomenal teachers. I want to build a structure so that they will feel special and that they belong to a group. Math for America will provide that structure in the long term. ...The idea [is to foster] a national core of people -- leaders for other teachers that are both graduate students and mathematicians -- designing courses, sharing math problems with one another. (FoM PI)

During their first two meetings, seminar members discussed the critical qualities of the afterschool seminars for teachers (a clear, mathematical focus, teachers work with others to solve problems, relate their experiences to what they do in their classes). Each MTS signed up to facilitate a seminar during the academic year in a location that would rotate among the FoM districts but be open to and draw from teachers across FoM's 7 partner districts. Some MTS began to discuss their initial ideas and plans for fall sessions.

The group also reviewed the recently released and adopted Common Core Standards for mathematics, considered the classroom and assessment changes these would entail, and discussed how the teaching scholars might support districts' work in this area. Questions about the value of MTS members pursuing National Teaching Board Certification were also considered.

Math Teaching Scholars, when interviewed in fall 2010, were pleased with the program start-up this year, the intended purpose for and design of the monthly meetings.

The main purpose of the meetings, it seems from our practice, is to plan out activities that we MTS will then implement. We talk a little about strategy and how we integrate that. We've talked a little bit about the differences between the 7 school districts. ... We talked about what the content of the seminars should be, what we've done, and Glenn's provided feedback on seminar topics; we talk as well about possible topics for summer institutes. The intent is for us to have some scholarly activities in addition to just being good teachers and leaders in our communities. So any of these topics we choose for seminars or summer institutes are topics we should know something about, but which involve a fair amount of legwork and scholarship on our part. To identify it early on, gives us a chance to do our work. We do it above and beyond our school activities, which is why we get a stipend. And it's considered a prestigious thing. (MTS, Fall 2010)

MTS reported that the program felt more organized this year than last, and the program's expectations for their work were clear.

When we spoke last year, one of the things I mentioned was that the expectations were really not terribly well defined, and I think that went with it being the first year. The expectations that Glenn has are [now] quite well defined. By the end of the first meeting [this year], we identified who would do what seminars when, had a draft of what seminars we would do and how they would be delivered, problem sets, and the involvement of other teachers. We fleshed out a lot of that—we were looking for that kind of detail. But this year, we know up front what we want to do and how it will happen, instead of it just evolving as it did last year. (MTS, Fall 2010)

We will serve as mathematical and teaching leaders in our respective school districts [where] we will volunteer to conduct professional development, which I've done above and beyond what we've discussed. I've conducted 3-4 sessions, after school and during professional development time. That's the informal part, which, I assume, varies by person, since we each do that which we feel passionately about. Then the expectation is that there are some specific activities we will lead--FOM seminars, delivering some of the content institutes, 4-day courses offered during the summer. (MTS, Fall 2010)

In early December, Stevens brought the two leadership program participants together (the 5 Math Teaching Scholars and the 3 Math for America Master Teaching Fellows) and asked Juliana Belding, a mathematician teaching at Harvard University and facilitating a FoM study group in Cambridge, to join him in facilitating the MTS seminars. Steve Rosenberg, BU mathematician and Matt Chedister, a BU doctoral student in mathematics education, continued to support the MTS work. Erica Litke, a doctoral candidate at the Harvard Graduate School of Education, was also asked to participate in the group meetings.

To determine the direction of their joint work for the 2010-11 school year, the combined group of math teacher leaders first discussed the mathematical and pedagogic challenges they had faced as teachers and within their schools and districts in the past year.

This generated an interesting discussion, mainly concerning challenges teachers faced when addressing weakness in student backgrounds. ... Teachers mentioned their frustration at how to access students' previous knowledge, and whether to spend time re-teaching a topic versus building it into the current material. ... The most commonly reported 'student weakness' seemed to be arithmetic of fractions and algebra. (Facilitator notes, December 2, 2010)

Teachers suggested it would be useful to trace the origins and uses of algebra through the grade levels. Facilitators, Stevens and Belding, recommended they begin by examining how algebra is addressed in the Common Core standards, and read two documents in preparation for their next session: a presentation by H. Wu "From arithmetic to algebra" and the National Math Panel report on *Critical Foundations for Algebra*. The idea that the group's further exploration of these issues might lead to the development of a summer institute was raised.

As a final item on the December meeting's agenda, the group generated a list of ways to strengthen the FoM MTS program. Suggestions included: (1) that FoM extend its partnership to additional districts and specifically involve more Boston Public School teachers in the program (those teaching in urban settings), (2) that during their meetings together they examine the work of teachers in high-achieving urban and suburban schools through classroom visits or videos, and (3) that they investigate what 'teaching for understanding' vs. 'procedure' looks like.

At the February and March sessions, teachers and mathematicians discussed the issues raised by H. Wu in his paper, especially the idea that students struggle with the transition from arithmetic to algebra due to 'misleading and/or non-existent definitions.' In February, they decided they would try to draft definitions for fraction, line, and function based on how (1) teachers use the idea/concept in the classroom at their own grade level, and (2) what teachers thought should be the definition presented to students when they are first learning about the idea/concept in the classroom. In March, teachers shared their individual drafts and struggled together to define 'rational number.'

The MTS, during spring interviews, said they found these collaborative conversations interesting and useful. Some members of the group appear to continue to consider and reflect upon the issues raised in their meetings over time; others see the discussions as helping to build a more cohesive community.

We have had some interesting discussions about how do you define terms that we throw around all the time. What's a fraction? What's a line? Glenn likes to tell PROMYS students that we're here to talk about simple things, but it's not so simple. (MTS, Spring 2011)

The atmosphere we have in the meetings is very interactive, so everybody can talk and say their opinion. Juliana is very, very good. She is the main person who puts things together for the meetings. She makes me comfortable.

(MTS, Spring 2011)

As an outgrowth of their readings, discussions, and creating definitions for key mathematical terms, facilitators and teachers began to focus on designing a 4-day summer institute that would engage other teachers, across grades, in these conversations and discoveries. From March through June, during as well as in between meetings, the group discussed in-person and by email ideas for the institute. They defined key goals, determined who the audience would be, outlined a structure for the program, examined available resources, and designed and shared problem sets. By June, the session was nearly set. The group had worked collectively and in small groups to design and develop the institute.

The institute is set for August 15-18, and was announced to the FoM community before the school year ended. Two MTS, one from Framingham and one from Lawrence, agreed to facilitate the institute. A flyer was sent out to FoM districts describing the institute and encouraging teachers to attend.

Focus on Mathematics, 2011 Summer Institute

Session 2: Transformation and Number. Making connections between arithmetic and geometric transformations through mathematical practices.

The Common Core State Standards were adopted by Massachusetts in the summer of 2010. Each grade delineates the key components to be covered in areas such as geometry, number and quantity and the number system. These standards not only map the development of key concepts through the grades but also discuss eight key mathematical practices that are necessary for students' mathematical development. In this weeklong seminar, teachers will explore how the threads of arithmetic and geometric transformations develop throughout the middle school and high school grades and how the eight practice standards can play out in this context.

Each day of the institute will start with an exploration using Geometer's Sketchpad (No prior knowledge with the software is required.) Teachers will learn how to use Sketchpad to facilitate investigations, make conjectures, and perform basic constructions. The remaining time will be spent working as a group on problem sets that develop the structural connections between the arithmetic of numbers and the geometric transformations explore in the morning Sketchpad session.

A key focus will be on understanding congruence and similarity in terms of geometric transformations (as described in the CCSS for 8th grade), the development of this and related topics in the early grades, and the extensions to the upper grades including connections to polynomials and complex numbers.

The institute is aimed toward Middle and High School mathematics teachers (grades 6-12) and the math coaches who work with these grade levels. Teachers from the same district but who teach different grade levels (for example, an 8th grade and a 10th grade teacher) are especially encouraged to apply.

There are also plans to follow-up with a few (optional) one-day seminars in the fall. These would be a chance for participants who wish to reconnect, share issues and

ideas and continue to explore the mathematics content and practices from the summer seminar.

When interviewed in spring 2011, MTS clearly valued these meetings. They noted how the considerable knowledge and skills of this group of participating teachers, as well as the facilitators, contributed to the development of the summer institute. Despite the intensity of their work together and the challenges they faced in making time to contribute to it, teachers appreciated the opportunity the meetings provided to collaboratively plan this professional development program.

I think working together with other math teachers is something we don't get a lot of opportunity to do. The Summer Institute project is the best opportunity I've had to really collaborate on something. (MTS, Spring 2011)

I feel like [the work on the summer institute] is going well. It's hard, because so many different people are involved in the planning process. I feel like we had a couple of meetings and started to crystallize concrete ideas of the threads—arithmetic and how it is connected to geometric transformations. It's been a little hectic having so many people. At the same time, with very diverse backgrounds—people have a range of strengths. We've sub-divided down to work on problem sets. It's really coming around. It's going to be great. We have come up with some very interesting problems. (MTS, Spring 2011)

Usually my participation [in the MTS meetings] is about bringing my experience with middle school – what is worth teaching in middle school, what students learn in middle school, how it looks in the middle school. So now [for the institute], I will prepare a set of problems about transformation, and then we will discuss again which of them are the best. (MTS, Spring 2011)

I helped prepare the institute that we will give this summer. I will not be a primary facilitator, but I have been part of the group developing the curriculum and contributed some of my geometers' sketchpad problems on transformation and number. (MTS, Spring 2011)

Masters of Mathematics for Teaching Coursework

The MMT program, offered jointly by the School of Education and the Graduate School of Arts and Sciences at BU, is designed to provide content-rich experiences for mathematics teachers interested in improving their classroom instruction while also preparing for leadership roles in developing curriculum and facilitating professional development opportunities for peers. Teachers participating in the program continue to work in the classroom and take courses part-time over 3 years to accrue a minimum of 38 credits.

For three summers, teachers attend six-week summer programs of intensive study in mathematics. During the academic year, they work to complete their required coursework. In the School of Education (18 credits) courses include geometry and advanced topics in algebra, a study of mathematics curriculum, and a course focused on designing professional development programs in mathematics education. In Mathematics

(20 credits), teachers study topics in number theory, problem solving in number theory, and research methods in mathematics. Teachers then select from a range of possible elective courses in mathematics and education.

This year, one teacher from a FoM partner district applied for and was accepted into the program. S/he receives tuition support from the MTS program. Evaluators asked the MMT to reflect on this first half-year involved in the first course in the program.

We read a lot about teaching in inner city schools, but didn't visit any or tutor any students from those schools. ... I would have liked some chance to practice what we were reading. Otherwise, it was a very good course. I really liked it.
(MMT)

The coursework increased my perspective on the kinds of pressure kids have outside of school; the way students perceive school, the challenges that immigrant students face when they come to this country. The easiest example is when I create math problems. I think more about ESL students. It has influenced how I interact with students one-on-one.
(MMT)

S/he also participated in the program's MTS/MfA evening meetings.

We had some good math discussions talking about defining certain math terms, using consistency in the way we taught, and coming up with ideas for a seminar. That's been refreshing because very rarely as a teacher do I get to look at the big picture from K-12. That's been rewarding and educational. I've also gotten to hear other math teachers' perspectives different than my own.
(MMT)

PROMYS for Teachers Workshops at EDC

During the academic year, PROMYS teachers [are invited to] attend five full-day workshops offered jointly by Education Development Center and Boston University's Department of Mathematics. These seminars are designed to help teachers "unpack" the pedagogical approaches used in PROMYS to enrich the school curricula. Another important goal of the workshops is to establish an ongoing network of teachers, mathematics educators, and research mathematicians.
<http://www.promys.org/pft/details.html>

MTS, many of whom have attended PFT in past years, are invited to participate in the 5 workshops held at EDC each year. Teachers spend the full days together, making presentations of their work, sharing experiences from their classrooms, working on mathematics topics of interest, and, at times, exploring curriculum materials under development or newly published or hearing from a mathematician or scholar visiting the area for the week.

- *At the time the report was written, 4 PFT workshops had been held. Of these, 2 MTS had attended 1 session; 2 had attended all 4.*

MTS' Contributions

Contributions to the Focus on Mathematics Community

The Math Teaching Scholars made considerable contributions to the FoM community between June 2010 and May 2011. These included:

- Focus on Mathematics professional development programs for mathematics teachers across the seven partner districts.
MTS designed, developed, and facilitated:
 - six 3-hour afterschool seminars during the 2010-11 academic year and
 - four summer institutes: two in summer 2010 and another two planned for summer 2011 (all 4-day sessions).
- Focus on Mathematics Math Fairs and Math Expo
Some MTS coordinated district math fairs, encouraged and supported teacher and student participation during the 2010-11 academic year.
- PROMYS for Teachers six-week summer program at Boston University.
Some MTS served as 'T-squares,' counselors to the mathematics teachers and graduate students enrolled in the PFT program summer 2010 and 2011.
- Cooperating teacher for Noyce Fellows Program
One MTS served as a cooperating teacher for a Boston University's Noyce Fellow.
- Focus on Mathematics Executive Committee
Two MTS represented their districts on the governing and decision-making committee for the FoM partnership this year.
- FoM Advocate
MTS were strong advocates for teacher participation in FoM professional development programs.

I guess the way I see it is that, we have FOM, but we need people to be active above and beyond regular participation in study groups. If we want to have 3-hour seminars after school, it is time intensive, so we need people in leadership roles who can rally the troops and get the word out about them. So the end result is that I can be a leader and be vocal and increase the number of people involved and increase the participation. (MTS)

Afternoon Seminars

Focus on Mathematics' partner districts take turns hosting afternoon seminars each academic year. Seminars are open to FoM teachers primarily in grades 5-12, district/school administrators, university faculty members, and to undergraduates and graduate students in teacher preparation and mathematics degree programs at partnering institutions. Seminars offer all attendees opportunities to explore mathematical problems, deepen their knowledge of mathematics, and increase their confidence teaching mathematics. Participation is voluntary.

Participating teachers from the same districts and schools, or those working at the same grade levels across districts, spend time together solving problems, discussing strategies and approaches, and considering applications for their classrooms. A consistent, core group of teachers have attended FoM seminars for the past 8 years and often encourage their colleagues to attend. The seminars contribute to FoM's broader goal of creating a vibrant within school as well as cross-district and institution mathematics community.

This year, six seminars were developed and facilitated by the MTS. The descriptions listed below were sent to all district leaders and teachers in the partnership.

1. Performance Tasks for Math
Standards-based teaching and learning, including the new Common Core State Standards for Mathematics, emphasize the importance of performance-based assessment. Seminar facilitators will introduce the concept of performance-based assessment in mathematics, including the ingredients of a valuable performance tasks. There will be three work sessions, each centered around a mathematical task.
2. Measurement Problems
Students consistently have difficulty with measurement problems. Seminar facilitators will present interesting measurement problems for middle and high school students and discuss different methods of approaching these problems with students. Teachers will have the opportunity to work together to solve different types of measurement problems and will leave the seminar with a packet of problems that they can use in their classrooms.
3. “Like” This Group? Exploring Groups with Circles and Triangles
The structure of a “group” will be explored in various settings, including that of clock arithmetic and symmetries of an equilateral triangle. Teachers work on activities together, and discuss further applications of groups to investigate.
4. Math Fair
A team teachers from several FoM districts that have effectively engaged students in developing and submitting mathematics research projects at school and district math fairs provided information and resources to help those not yet involved, new to their districts, or member of new partner districts get started.
5. Absolute Value Equations and Inequalities
This seminar first look at strategies for solving absolute value equations involving linear terms and then progress to absolute value equations and inequalities that have non-linear terms. While working through the problem sets, the emphasis will be on how much educators should scaffold difficult problems for their students.
6. Teaching and Learning Proof Throughout the Grades
Most students do not encounter the concept of mathematical proof until they reach Geometry in high school and then, typically, never again. Proof is one of the core concepts of mathematics if not indeed it's very heart. In this

seminar, we will look at some activities we can use to teach the concept of proof in other classes before and after Geometry.

The full set of seminar topics offered during the 2010-11 school year are listed in the table below, along with the teachers that facilitated the sessions, the dates the seminars were offered, and the number of participants that attended.

Table 3: Focus on Mathematics Seminars, 2010-11

Seminar title	Presenter/s	District/Role	Location	Date	Participants
Performance Tasks for Math	A. Katz A. Chay R. Aboagye-Kodioe B. Marlow	LHS MTS LHS Teachers	Lawrence	11.15.10	46
Measurement Problems	S. Hristova K. Fulser	CMS MTS, District leader	Chelsea	12.9.10	29
“Like” this Group? Exploring Groups with Circles and Triangles	Members, Cambridge Study Group	Cambridge MS and HS Teachers	Cambridge	1.20.11	21
Math Fairs	O. Brauner S. MacDonald S. Hristova A. Halteman	Arlington, Lawrence, CMS MTS Chelsea	Boston University	2.3.11	18
Absolute Value Equations and Inequalities	Chris Strader	FHS MTS	Framingham	2.10.11	17
Teaching and Learning Proof Throughout the Grades	Robert Weldin	LHS MTS	Waltham	3.21.11	23
Total Participation					154

During this academic year, seminar attendance ranged from 17-46 people per session. The mean per seminar was 26, about the same as last year’s average. While the total count of participants at all 6 seminars was 154, further examination of the data shows that *107 unique individuals came to one or more seminars.*

The majority of these (76 of 107, or 71%) attended one seminar; 20 attended two seminars (19%); 5 attended three seminars (4.7%); 2 attended 4 seminars (1.8%); 1 attended 5 seminars (<1%); and 2 attended all six seminars (1.8%).

Participants included primarily middle and high school teachers from all seven districts. Despite the fact that we do not have accurate data to distinguish which teachers were middle and which were high school teachers in two districts, it appears that about twice as many high school teachers as compared to middle school teachers attended seminars. Three district leaders, a middle school principal and high school administrator, and math coaches also attended sessions. MTS attended two or more seminars each. Not included in this count were the mathematicians who also came to seminars.

Table 4: Seminar Participation by District/School Level, 2010-11

District	Gr. 5-12 Math Teachers	Seminar Participants	High School	Middle School	Others: District/School Administrators Lead Teachers
Arlington	23	7	6	1	
Cambridge	na	19*	na	na	HS Administrator FoM District Leader/ Math Coordinator Math Coach MTS
Chelsea	36	16	11	5	MTS
Framingham	na	11*	na	na	Administrators Math Coaches MTS
Lawrence	91	43	25	18	MS Principal FoM District Leader/ Math Coordinator Math Coaches MTS
Waltham	31	8	7	1	Math Coordinator MTS
Watertown	15	3	3	0	FoM District Leader/ Math Coordinator MTS
		107	52	25	

Note: In Cambridge and Framingham, distinctions between middle and high school teachers that attended seminars were unclear.

The number of teachers listed by district attended one or more sessions.

We calculated the percent of total teachers that participated in one or more seminars this year by individual district (where we had teacher totals). In Arlington, about 30% of the middle and high school teachers attended one or more seminars. In Chelsea the percent was 44%; in Lawrence, 47%, in Waltham 26% and in Watertown 20%.

Participant Feedback

The Mathematics Teaching Scholars facilitating the seminars asked participants to complete the standard FoM evaluation at the close of the sessions. Participants' feedback was shared with evaluators. Of the 154 participants at the 6 seminars this year, 118 completed a survey directly after the sessions, a 77% return rate. Most respondents were teachers, but 6 school or district administrators completed a post-seminar survey, and one mathematician did so as well.

Participants were asked to rate the following statements on a 4-point scale: strongly agree, somewhat agree, somewhat disagree, or strongly disagree.

- The seminar met my expectations
- The seminar addressed issues of interest to me

- I learned mathematics
- The mathematics presented was valuable to me.

The Math Fair meeting survey differed somewhat from the one used for the other 5 seminars. Findings from that survey are discussed later in this section of the report.

As indicated in the table below, teachers' responses were extraordinarily favorable on all four indicators for the 5 seminars that used the same survey questions. Ninety-eight percent (98%) of the teachers agreed that the seminar met their expectations and the same percent (98%) said it addressed issues of interest to them; 93% reported that they learned mathematics; and 97% said the mathematics presented was of value to them.

Table 5: Participants' Overall Assessment of Five Seminars [N=103]

Seminar Goals	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
This seminar met my expectations	78%	20%	1%	1%
This seminar addressed issues of interest to me	82%	16%	2%	0
I learned mathematics	71%	22%	5%	2%
The mathematics presented was valuable to me	81%	16%	>1%	2%

Participants attending the sessions were asked to comment on what was most useful about the seminar, what did not work well, and what suggestions for improving the seminar they could offer the facilitators.

What was most useful?

The seminar, just as other FoM seminars, pushes you to increase your base knowledge of math. I am comfortable teaching at my level, but these seminars make me uncomfortable with my knowledge of math at higher levels. This motivates me to continue to build my base knowledge to improve my teaching.

I continue to enjoy problems with multiple solutions' particularly solutions or approaches that apply to different grade levels. Problem 21 could be solved with perimeters or with systems of equations. Problem 1 could be solved by counting, addition, or by algebra.

I like to see how student thinking develops over the year. (Any math topic is fine with me.) I could see (*during the seminar*) that many of the problems young students have remain problems in middle and high school.

I would like to question students more in class, asking them to support commonly thought concepts with some sort of reason. Even something informal can open up a meaningful conversation in the classroom challenging students to question the concepts in math they take for granted.

Teachers all noted their appreciation for the thoughtful design of the sessions. They liked having time to 'do' math, and to collaborate with peers on challenging problems.

Seminars presented interesting topics teachers had wanted to learn more about and/or topics they were unfamiliar with and were introduced to for the first time. They liked the

challenges that were presented, and felt their existing knowledge and skills were being ‘stretched.’

Several participants mentioned how the seminars directly and/or indirectly left them reflecting on their lesson planning and classroom teaching practices and ways they might shift those practices to incorporate what they had learned or how they interacted with peers during the seminars. A few said they gained new insights into students’ thinking about mathematics.

Finally, teachers found that their experiences in the seminars and their discussions with colleagues working at different grade levels helped them think about their mathematics programs cross-grades and schools. Below is a sorted, representative sample of teachers’ responses to the open-ended questions on the survey.

- Doing math, thinking math, solving challenging problems
 - The way the problems stretched my thinking.*
 - Given time to work on problems. The variety of difficulty was very useful as well.*
 - Playing with the examples alone before discussing.*
 - Very interesting mathematics, excellent problem solving techniques.*
 - Broad insights into challenging problems.*
- Interesting topics for teachers to think about
 - Completely different approach to measurement problems than what we teach.*
 - A different way of looking at geometry problems.*
 - I come away with a plethora of useful problems to either attempt alone or look at with students.*
 - It reintroduced a topic that I feel will become more important in years to come.*
- Working together with other teachers (and mathematicians); sharing ideas
 - The collegial collaboration.*
 - Working together with multiple teachers and looking at the different points of view.*
 - The wide range of participants, from middle school to calculus teachers, and the collegiality of the participants.*
 - Getting to meet other math teachers from the different districts.*
- Classroom applications – useful materials; considerations for instructional practices
 - Being able to take what we learned and adapt it to classroom use.*
 - Teachers sharing real ideas we can use in class.*
 - Concrete ideas for work I can do with my students.*
 - Seeing actual classroom applications.*
 - Being able to leave with problems I can take back to my class.*
 - It made me reflect on how I teach certain concepts related to absolute value and inequalities.*
 - Understanding the importance of teaching concepts instead of just problems. It*

provided clear examples of how our automatic process can mislead us.

-Discussion about giving students a problem that forces them to try things on their own as opposed to looking back at earlier problems completed.

-I learned more about how students think.

- Curriculum alignment across grade levels

-Seeing the value of the activities at my instructional level.

-Getting a glimpse of what my students will be doing in high school.

-The ability to work problems out with high school teaches and see how the same problem can address both levels.

-Simple examples even useful at the elementary level up to complex questions appropriate for graduate level.

-To see what I encounter at the grades that I teach is not unique to these grades.

What did not work well?

Participants felt that some facilitators had planned too large an agenda for the time available. A key complaint from teachers was not having ‘enough’ time to work on the mathematics problems presented or to discuss varied strategies and approaches for solving problems with peers.

A few teachers reported finding the content ‘beyond’ their reach, or commented that the topics were not at a level useful to their everyday work with students. Once again, a representative sample of teachers’ responses are provided below.

- Seminar design: pacing and amount of work planned for the session.

-Such great math, but unable to discuss in great depth.

-Too many presentations in this seminar; would have preferred more time to work with partners and share out

- Insufficient time available for doing and sharing problems.

-Not enough time to explore.

-More time to present the problems to the group.

-Would like more review of problems.

- Difficulty of the mathematics for participants.

-I needed a little more scaffolding for the last presentation. Peers helped. Assumption of prior knowledge.

- Relevance of the mathematics to classroom teaching.

-Some questions may be too difficult for an average high school student.

Suggestions for improving the seminar?

Teachers’ recommendations included limiting the amount of time facilitators spent ‘presenting’ and increasing the time teachers could work on problems together, and ‘in more depth.’ A few asked for facilitators to provide more emphasis on lower level mathematics classroom topics and problem sets.

- Seminar design: pacing and amount of work planned for the session.
 -Limit number of presentations so we can work in more depth.
 -More people sharing reasoning at the board rather than in conversations. I like to look and think.
- Insufficient time available for doing and sharing problems.
 -More time engaged in math, less time talking.
- Relevance to students and classroom teaching.
 -Examples of how problems can be changed for lower grades – middle school friendly seminars.
 -How can you differentiate for different levels of learners?
 -A few problems for lower grade levels.
 -This was specifically advertised as being from a junior high perspective and met that definition very well. Perhaps extending it with high school level as well would have improved it.
 -Would like to have traced proof from earlier grades through different courses.

The Math Fair Meeting: Participant Reflections

The Math Fair seminar used a different set of indicators appropriate to the session. The participants were asked to evaluate the meeting on the following 3 indicators.

- This meeting met my expectations
- I learned about what makes a good research project
- I learned the principles of how to run a math fair

Table 6: Participants’ Assessment of the Math Fair Meeting [N=15]

Seminar Goals	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
This meeting met my expectations	47%	40%	6.7%	6.7%
I learned about what makes a good research project	29%	50%	6.7%	14%
I learned the principles of how to run a math fair	79%	21%	0	0

This seminar was most helpful in preparing teachers to organize and run their first math fair. Given that nearly all of the participants had not been involved in a math fair yet, this was a needed and well-timed session. Many that attended expressed their appreciation for the handouts that provided detailed information for setting up a math fair – planning, logistics, resources and tips, and examples of students’ work. However, the session was weaker in terms of providing sufficient information about how best to engage students. What does a ‘good’ research project looked like? How do teachers help students get started and develop a meaningful project? Participants provided the following assessments of the Math Fair seminar.

- I didn’t feel that I came away with any real idea of what makes a quality project.
- I needed to get more of a sense of how kids generate exploratory project ideas, and ways to help kids form a conjecture and work towards a proof.

-How can I mentor students to ‘mathematize’ their interests and turn them into math fair projects?

A focus on these issues, while certainly the most difficult to address, needs to be part of further programs designed to help teachers involve students in meaningful mathematics research projects.

Summer Institutes

The FoM Summer Institutes are intensive, 4-day, 28-hour courses offering teachers an immersion experience in mathematics. A \$350 stipend is offered to participants that complete an institute, and 28 professional development points (PDPs) are available as well. MTS facilitated summer institutes for FoM teachers in 2010, and will do so again this summer.

I helped prepare the institute that we will give this summer: *Transformation and Number*. I will not be the primary facilitator, but have been part of the group developing the curriculum, and I contributed some of my geometers’ sketchpad activities. On same topic I am in the process of revamping the institute that I gave last summer, which by popular demand will be given again this summer. This is the institute on Recursion and the Fibonacci sequence and the Golden Ratio.
 (MTS, Spring 2011)

A culminating piece will be working with the group on the curriculum for the summer institute. I’ll be hosting that with [MTS].
 (MTS, Spring 2011)

The table below displays the session topics, facilitators, and the numbers of middle and high school teachers that attended last summer’s sessions. This summer, the institutes are scheduled for August.

Table 7: Focus on Mathematics Summer Institutes, 2010-11

Date	Summer Institute Title	Presenter/s	District/ Role	Participants		
				Total	MS	HS
6.28-7.1.10	Mathematical Modeling	K. Werst	AHS, MTS	16	6	10
8.16-19.10	Exploring Topics in Number Theory	A. Katz	LHS, MTS	15	4	11
8.1-4.11	Recurring Themes: Recursive Functions, Fibonacci, and the Golden Ratio	A. Katz	LHS, MTS	na		
8.15-18.11	Transformation and Number	C. Strader R. Weldin	FHS, MTS LHS, MTS	na		

Participant Feedback

Mathematics Teaching Scholars facilitating the institutes last summer, like their seminar counterparts, asked institute participants to complete an evaluation at the end of the sessions. Participants' feedback was shared with evaluators. Of the 31 participants at last summer's institutes, 27 completed surveys directly after the sessions, a high 87% return rate. Participants were asked to rate the institute they attended on a series of indicators on a 4-point scale, as shown in the table below.

Most teachers (81%) reported that they strongly agreed that the 2010 Summer Institutes met their expectations. The three aspects that were rated highest by participants were:

- *The instructor provided an atmosphere that was conducive to my learning style.*
- *The institute promoted a community of learners.*
- *The institute helped me grow as a mathematician.*

On all indicators of program success listed on the survey except one (*The mathematics was appropriate for the grade level I teach.*), 90% or more of the participants agreed with the statements. The institutes were designed, as were most FoM programs, to provide challenging problems that would stretch teachers' existing knowledge and help them make connections across different strands of study. Yet, at the same time, the programs were designed also to address the learning needs of teachers with a range of backgrounds. Facilitators introduce problems that all can access at some level, yet still let those with considerable mathematics knowledge explore further. Teachers work individually and in small groups, and share their approaches and solutions at intervals throughout the day, giving rise to further discussions and discoveries.

Table 5: Participants' Overall Assessment of the 2010 Summer Institutes [N=27]

Indicator	Strongly agree	Somewhat agree	Somewhat disagree	Strongly disagree
The institute met my expectations.	22 [81%]	4 [15%]	1 [3.7%]	
This institute addressed issues of interest to me.	18 [66.7%]	9 [33.3%]		
Information in the institute was well organized and presented at a pace that was comfortable for me.	18 [75%]	6 [25%]		
The instructor for this institute provided an atmosphere that was conducive to my learning style.	25 [96%]	1 [4%]		
The institute promoted a community of learners.	24 [89%]	3 [11%]		
The mathematics presented was meaningful and valuable to me as a teacher.	17 [63%]	10 [37%]		
The mathematics was appropriate for the grade level I teach.	10 [34%]	14 [48%]	3 [10%]	2 [7%]
The mathematics will be useful to me in the upcoming school year.	16 [50%]	13 [41%]	3 [9%]	
The institute helped me grow as a mathematician.	26 [96%]		1 [4%]	

There is evidence from teachers' ratings that the facilitators were striving for and succeeded at providing a collaborative atmosphere where all participants could learn, and all could feel that they had grown as mathematicians. Teachers appeared to know and seemed comfortable with the fact that the institute's mathematics content while accessible at their adult level would need further adaptation for classroom use.

In addition to rating these specific aspects of the institutes, participants were also asked to comment on several open-ended questions, specifically, what was most useful and valuable to them, and what they planned to incorporate into their instructional programs. They were asked to provide further information about the effectiveness of design and format of the institute, what they thought did not work well, and to offer suggestions for improving the institute.

What was most useful?

- I enjoyed the way it was presented – low key, very supportive.
- Delving into a topic deeply, being able to tease out useful topics for my classroom.
- These institutes put me back in the roll of being a student. They give me empathy for many of my students when asked to work on tough problems.

Teachers reported that they liked working in a supportive setting with knowledgeable facilitators and curious colleagues, and still be able to proceed at their own pace. They felt the sessions were well designed and the materials prepared by the presenters to be effective and useful. The facilitators presented topics and problem sets that participants found interesting, engaging, and accessible. Below is a sorted, representative sample of teachers' responses to the open-ended questions on the survey. All are direct quotes.

- Design of the institute

- This institute was hands-on and practical. The small group setting allowed the group leader to work with everyone.
- It allowed me to learn at my own pace and to be able to get a lot from sharing with others.
- Freedom to interact and get help from others.
- Good routine of working on activities, then discussing, then working.

- Learning

- Learning math and making all previous knowledge of math connect.

- Working with other teachers

- Collaborating with other math teachers to solve tough problems and seeing how their approach was different than mine.

- Materials and resources
 - Working with technology.
 - Differentiated problem sets – from beginning to advanced.
 - Problem sets were at the appropriate level – challenging but not impossible.

What did not work well?

Teachers had little to say about what did not work well for them.

- There was some down time. Different groups had different paces.
- I don't have access to that software at my school.
- I had misunderstood the level of background required to fully benefit. I had never seen a graphing calculator before.
- The long drive home.

And they offered very few suggestions for improving the institutes.

- Possibly a few more extensions.
- Perhaps more presentations.

A number of teachers planned to use the graphing calculators and/or the geometers' sketchpad in their classrooms, if it was available at their schools. The high school teachers reported that they would use some of the problem sets and exercises introduced at the institute with students.

Contributions to local Schools and Districts

The Math Teaching Scholars contributed their knowledge and skills to administrators, colleagues, and students in their own schools and districts in important ways this year.

Some district administrators, in recognition of the teachers' expertise, have been inviting MTS to serve on district- or school-level committees. This year, MTS were asked to help review curriculum materials in preparation for an upcoming school accreditation process, to join a committee to discuss how to implement the Common Core Standards and Practices, and to assist in hiring new teachers.

I have contributed to some discussions about implementing the common core, or the mass curriculum frameworks, which are subsuming the common core. I participated with the group about how we will do that at district levels and in our schools and how we will provide leadership. (MTS, Spring 2011)

Here in [district], I have continued to serve as a thought leader and facilitated professional development on a range of topics from performance-based assessments in math, the use of technology to enhance math education, and the whole notion of exploration-based math investigations, much like I learned in PROMYS and FOM activities. So I've been a proselytizer. (MTS, Spring 2011)

Other MTS contributions to their schools and districts are listed below.

- Mathematics coach and lead teacher.
One MTS was appointed to serve as a high school math coach and asked to mentor other teachers, especially those new to the profession; a second serves as the lead teacher in a district middle school.

One of the initiatives that we are enthused about in [district], related to the Common Core and the development of the new standards, is the idea of supplementing traditional assessments with performance-based assessments. So it is any assessment where the student has to somehow perform and thereby show evidence of understanding. Performance based vs. answering questions on paper. It is something that could be more personal for the student, could be more engaging. It can certainly bring in other learning goals not specific to the textbook or math curriculum that has to do with communication, articulation, and application in real world situations. There's been a lot of study that shows all these things are not only good other facets of learning but really fundamental in helping people internalize new knowledge. I've been spending a lot of time helping teachers figure out how to develop performance tasks around particular topics. I developed a website for the high school math teachers, and I maintain that website. There is a page with a whole plethora of performance tasks, some developed by me, for the seminar I facilitated this year, and some by other teachers. It is a clearinghouse for teachers to use. It is also related to math fair projects.
(MTS, Spring 2011)
- School or district-based professional development for math teachers.
Some MTS are asked to provide professional development for peers at both formal and informal settings – for departmental meetings and/or for regularly scheduled school or district-wide professional development days.

I've been involved in delivering PD on a more informal basis, in my school and the district more generally. I led 3-4 math technology sessions, helping teachers understand and use math technology. During our Wednesday school-wide professional development once a month, I've been involved in my school in running parts of that program. (MTS, Spring 2011)
- Study Group leadership.
MTS played a number of important roles to initiate, promote, and/or help lead study group sessions in their own schools and districts.
For example, in Framingham, the MTS has been instrumental in getting the high school study group started last year and in successfully setting up the middle school group this year. He has encouraged peers to participate, increasing the size and reach of the sessions and the growing influence it has on teachers at the high school level. .

I think I did a lot of great work with the study group at the HS, advertising it with HS teachers, getting people involved and excited about math. I was able to meet with middle school teachers and get a study group [started] at that end. I feel like I got the [district] community active and participating in seminars.
(MTS, Spring 2011)

In Chelsea, the MTS has worked with FoM mathematicians to attempt to overcome teacher resistance to establishing a middle school study group. In Lawrence, both MTS are regular participants in the high school study group, work closely with the mathematician facilitating the group, encourage colleagues to attend, contribute content to the group's work, and/or occasionally assume the facilitator's role should the mathematician be unable to attend.

· Math Fair participants and advocates.

Most MTS encourage or require students in their classrooms to participate in the school math fair each year. This year, in Framingham, a district in its second year as an FoM partner, the MTS experimented with having a 'math fair' with students in his own classroom, trying out approaches to engaging students, developing strategies for incorporating students' research projects into their coursework, and sharing what he was learning with others at the school. While not a participant in an 'official' FoM school math fair, he used this year to determine best ways the high school might more fully participate in both the FoM Math Fairs and Expo next year.

I don't believe we've ever had a math fair before. I'm kind of getting involved this year. Some honors students are working on explorations, things I was working on for the seminar. After the seminar, I tweaked them. There are 35 questions of great math, stuff you wouldn't normally see covered. The Algebra 2 honors students are pairing off and working on a math paper and are doing a poster. We are done all of the math fair components but without [holding] the fair. It will be self-contained with each class. Some students may come in and present to other classes. Some of the better ones will be asked to present to our study group. I hope to build [the math fair] into the school culture and try to replicate it next year, with the night math fair component. I talked with groups of the students [involved this year] and they are coming up with amazing work. (MTS, Spring 2011)

· Afterschool student math club founder.

In Chelsea, the MTS continued the afterschool student math club for a second year. Interested students attend on a voluntary basis and spend time exploring problems they would not likely encounter nor have sufficient time to work on with peers during the school day.

My main goal was working with students. I am doing now for the second year a math group in my school. I can't say that we did something huge in the school, but it gradually developed. I also do the math competition. Students know about the math group. (MTS Spring 2011)

Other Contributions

Two MTS are serving on Massachusetts Department of Elementary and Secondary Education (DESE) committees to assist with the development of model curricula that meet or are aligned with the Massachusetts Mathematics Frameworks and the Common Core Standards.

In addition, although not specifically related to MTS, but in the spirit of it and what it means to me, I am serving on a committee run by the Department of Elementary and Secondary Education [DESE] on developing model curricula that meets or is synchronized with the Massachusetts Math Frameworks (aka Common Core). My district said go for it—represent us. This will be a 4-year activity with meetings scheduled out over the next 3.5 years.

(MTS, Spring 2010)

I applied and was accepted to the Race to the Top committee with the DOE. We will meet as a committee and develop lesson plans to give teachers ideas about how to implement the Common Core Standards. I'm not clear on all activities we will do. But that's our purpose—to develop units. This will be about 4 years. My committee, which is middle school math, will develop each year 2 new units.

(MTS, Spring 2010)

Program Benefits and Challenges

Learning

When interviewed this year, MTS spoke about what they had learned as a result of their participation in the program. The focus of 'doing' mathematics at each session together, learning from one another, gaining insight into others' perspectives, developing professional development programs for peers, conducting research in preparation for the seminars and institutes they facilitated, and reflecting on what all they were learning and experiencing meant for their own and other teachers' work with students were key responses

One MTS reported that the MTS experience revealed the similarities between student and teacher understanding of mathematics, and spurred new considerations for his/her teaching mathematics to adults and youth.

[I've noticed that] when a math teacher doesn't know an answer to a problem, [it's] similar to students. Now I'm left with wondering if the difference between teachers and students is not that great in terms of understanding the structure of math and being able to solve new and novel questions. I'm looking for a way I can improve people in that arena, teachers in professional development and students in the classroom.

(MTS, Spring 2011)

Another MTS noted that his/her angle of view of mathematics education had broadened.

I've become very familiar with standards-based math education. I've become much more knowledgeable about teaching and learning of math, in addition to my experience in the classroom as teacher. Also about how different school districts and teachers approach teaching and learning of math. As a potential educational leader, I have gained some really valuable insights into how school districts adopt and support math curricula, both the topics that are taught, the pedagogy involved in teaching them, and the actual teaching of them.

(MTS, Spring 2011)

Teaching

MTS experiences in the immersive PROMYS for Teachers summer program and EDC workshops during the academic year, the Masters of Mathematics for Teaching graduate program, and/or continued work in FoM professional development sessions – seminars, study groups, summer institutes, and importantly the research, design and facilitation of programs for peers – had considerable impact on teachers’ beliefs about teaching and learning, their relationships with students, and how they conduct their classroom work.

We asked MTS in spring 2011 to discuss what impact their involvement in FoM, and more specifically the Teaching Scholars program, had on their teaching. Their responses were thoughtful.

The work I’ve done this year, what the title encouraged me to do is to think about the math I teach and how I teach it. I feel like the kids this year, more so than years past, are realizing that I’m pushing them to think about the issues at large and the culminating threads and the structures of systems. That this is what drives the conversation and math work, and not just devolving into doing problems. One student verbalized exactly what I wanted them to think about—she said, “You’re not like most teachers, because other teachers told me what to do and I just did it. You’re making me think about what I want to do.” That made me happy. Something I’ve been trying to do, but being in the program has given me the motivation to put the time and energy and really focus on those ideas and try to bring them into the classroom. I’m very excited about next year. I’ve learned a lot this year. I’m starting to think about culturally what can I change in classroom, and mathematically, what can I change in terms of pacing. I’m already real excited for next year. (MTS, Spring 2011)

I really feel that my work this year has been driven by thinking about math, especially now in light of the Common Core. How will we develop student’s thinking about practices? And developing support in not feeling overwhelmed by such a daunting task. (MTS, Spring 2011)

I’ve been teaching geometry 8 years. Kids have no concept what the word proof means. One of the things the Common Core looks at is explicitly asking, ‘how do you know that you know?’ You are more likely to remember if you remember why or how it works. In my own experience, participating in PROMYS where we learned a lot of number theory proof, and thought more deeply about what proof is, but at some point, how do you know? I do really think that kids would understand math better if we took more of an approach like PROMYS, where you have a set of tools, and what can you figure out using these tools. (MTS, Spring 2011)

I see a few things more clearly about where my students are coming from. Figuring how things fit together is not such an easy task. I see my role as a teacher is changing to how can I help best, whereas 8 years ago, it was about how to take shortcuts with algorithms. Most kids say they don’t know how to do this, but if you talk to them a little, they do know what they’re doing. Kids know more than they think they know. Teaching is about helping them to make connections. (MTS, Spring 2011)

All the things we are learning in math are connected—the more I grasp that, the more I'll be able to understand the meaning of [students'] mistakes.

(MTS, Spring 2011)

Community of Mathematics

A central goal for Focus on Mathematics since the program was first funded in 2003 has been to create and support a mathematics community – one that encompassed students, teachers, graduate students, and university mathematicians and educators involved in the project, but also one that reaches out to others beyond the region's border. A community dedicated to learning mathematics. The MTS felt strongly that they were a core part of that community and valued the advantages it provided to them.

I think the people who lead the program, the program topics, doing scholarship, both mathematical and pedagogical, helped me to learn these things. The people doing them in the company of other people. At this point, I think my peers, Chris, Stefka, Bob, and the MfA people as well. I've learned a lot from seeing how they see these things.

(MTS, Spring 2011)

I think it's useful working in this team of educators, graduate students, BU professors—it's a great team to work with. We accomplished many things. I strengthened my math knowledge, my leadership role—it's a great experience to work with such a team this year.

(MTS, Spring 2011)

I like doing the seminars. I like my work with students also, in the math club and the competitions. The other thing I like is that I have the opportunity to participate in different activities, different seminars, to know about different math events that happen in the area, and to be in touch with my colleagues and professors. All this work is exciting, I like it, and I learn a lot.

(MTS, Spring 2011)

Challenges

Time

Not surprisingly, given the teaching and leadership roles they were responsible for, MTS most often said having enough time to do it all well was the greatest challenge they faced.

This is a very easy answer. Time is the ultimate constraint. I coach hockey in the winter, along with teaching. The hardest part about being an MTS is there are not enough hours in the day to get everything done.

(MTS, Fall 2010)

The only challenge I've felt so far is scheduling. I missed one of the meetings, which isn't catastrophic. But I enjoy them, so I was disappointed. We've all got different school and personal schedules.

(MTS, Fall 2010)

Designing Professional Development Programs for Peers

Some said that designing and organizing professional development sessions for peers, and motivating them to come, was challenging. They researched their areas of study for seminars and institutes, consulted with their colleagues at their schools and among the

MTS team, and met or communicated with one or more mathematicians as their ideas for their sessions took shape. They wanted their programs to be as successful as the mathematicians' who first led seminars and institutes in the early years of FoM and who continue to facilitate the study groups. They wanted a large turnout for their efforts.

I found some good problems that were used in different studies in middle and high schools in the US and UK. I had lots of good discussions about what would a good proof would be, and what were we expecting from the kids. I had some good active discussion about several of the problems. (MTS, Spring 2011)

It's always challenging to make a seminar, starting from picking a topic, making it interesting. Different teachers [attend], some are from high schools, some from middle schools. You have to keep it interesting for everyone. It was hard to find problems to intrigue everyone in the seminar. (MTS, Spring 2011)

I think it's pretty tough, in the sense that teaching is tough. I can go in to teach a lesson on rational functions and plan it thoughtfully, but I gotta deliver and sell it to them, so that they know it as well as I. The (MTS) program involves me trying to get people fired up about it. I need to get other people just as excited. That is a lot like teaching is on a daily basis. (MTS, Spring 2011)

I guess one thing that surprised me—I feel I was fairly successful motivating people at my school to come to events. I'm surprised at just how hard it is to motivate people to attend events. It's tough to convince a large amount of people to go. (MTS, Spring 2011)

One of the challenges was just getting [the seminar] organized; getting a space to hold the seminar. The high school gets kind of crazy. On the day of the seminar, the principal double booked the room. Logistically, organizing things at the high school is difficult because it's such a big district and not a lot of space. (MTS, Spring 2011)

District Support

The role of the district leaders, their understanding of and support for the Math Teaching Scholars program, their own and their district's position on teacher leadership, and how they viewed the importance of the work of Focus on Mathematics for their schools and district, strongly influenced what MTS were able to accomplish.

District and school administrative support was crucial if MTS wanted to attend FoM professional development sessions, especially those that required them to leave school early to drive to the meeting place, or their being absent from the classroom for a day.

If I am an MTS next year, I hope to be able to attend more seminars or activities that FOM offers. Because sometimes I can't attend everything. (MTS, Spring 2011)

Some district leaders took an active role in communicating with math teachers about upcoming FoM programs and encouraged their attendance. One district leader regularly

attended the sessions along with teachers. Others delegated that role to the MTS. The MTS position in the district, especially the district's view of teacher autonomy and the importance of the professional development FoM offered, influenced the success of the MTS' efforts to get the word out and have it heeded by colleagues.

I don't know how popular this program is among administrators in my district. My principal doesn't know much. It may be my fault, but I inform them. I'm not sure if my colleagues know much more about this program. I have no idea. They should know more. If they did, maybe they could look for some kind of help from the (MTS) group. (MTS, Fall, 2010)

I send materials or let teachers know about things that happen, so it's not difficult or impossible. It's a bit more difficult to communicate with the district. I try to update them if something has to be done in the district. It's easier in my school, since I am already in the math leader role, but I'm not sure how other teachers accept what I send or tell them. So I mainly try to work with the math coaches and math lead teachers. I have a good relationship with them. I believe they can take this from me. (MTS, Spring 2011)

How they met the challenges they faced was best explained by one MTS.

Suck it up. Juggle. (MTS, Spring 2011)

Next Steps: MTS look forward to next year

Three of the four Math Teaching Scholars in cohort 2 are hoping to continue as leaders in the program next year. Some MTS have a particular project or area of study s/he would like to have the opportunity to work on next year. A common theme is to explore and master the use of technology in the classroom.

One thing that I really wanted to work on, which I haven't been able to, but it's a reason I hope to come back and participate another year or two—I'm a big advocate for technology in the classroom, and particularly technology for math inquiry. I'm very interested in data analysis and statistics and there's a really good application that explores this, called FATHOM. It does for data analysis and stats what sketchpad does for geometry. I would really like to do some scholarly work on this next year. I feel there's a need for some well-done thought leadership in this area. (MTS, Spring 2011)

I need to find more succinct ways of evaluating how kids are learning things. What's a quick way to give a formative assessment? I can easily give a good summative assessment, but I'm looking for ways to check in with students along the way. Can I narrow it down to 1-2 problems that capture what they understand and also keep the class moving? Part of me thinks it could be with technology. (MTS, Spring 2011)

My school next year will become a science and technology academy. That will change the name and direction of teaching. So I plan to have more technology in my lessons. (MTS, Spring 2011)

Another MTS mentioned s/he was interested in returning to the program next year because of the impending changes stemming from the state's adoption of the Common Core standards.

These next few years are going to be really big in terms of implementing the new standards. So I just want to keep doing more. (MTS, Spring 2011)

One scholar has decided to take the next year off from the program to focus on his/her work in the classroom.

I am not applying for next year. I really feel I need to take the summer and next year and really focus on taking everything I've done and trying to deliver it in the classroom. In the past 2 years, I've been learning so much, but the time constraint has made it hard to bring it to the classroom. I'm sure that I will jump back into the fray and be very involved with people at BU the year after that. Next year I want to focus just on the implementation. (MTS, Spring 2011)

MTS recommendations for the program

The Math Teaching Scholars were asked to offer their recommendations for the program. Participants reported that they were pleased with the program design, structure, and expectations and had no suggestions for its improvement in these areas.

Instead, some teaching scholars suggested that the program be expanded. This included expanding the number of scholars in the program. ...

I think one thing would be to expand it a little bit; have a few more teachers from a wider area. Now we're meeting with Math for America (MfA) scholars too, so that's good. The MfA people are in some different schools. (MTS, Fall 2010)

Maybe we need more people. We're only 4 or 5. We have more districts [in FoM], we probably need more MTS to participate. (MTS, Spring 2011)

I would love to see the program get a little bit bigger, not a lot bigger, because I really enjoy learning from my peers. (MTS, Spring 2011)

As well expanding the program's reach by increasing the number of events, districts, and teachers participating in the professional development programs.

I am really enjoying being part of this group and the opportunity to work with teachers. It would be great if we could replicate this in other areas. I think a lot of teachers in a lot of schools are on their own. Having more local things that are still connecting you more broadly than just within your own school or district would be good. (MTS, Fall 2010)

I feel it would be better to expand as much as possible on this seminar model—teachers from FOM hosting them. It would be great if we could expand that model forward. FOM is only a couple of districts. It would be great if some of the seminars could be tweaked and offered to other schools. That would be awesome. It would put us in touch with other math educators. With Common Core Standards implementation, there will need to be a lot more communication with

other teachers. How can we use our expertise to bring it to scale? We have a great group of people—it could be used as a platform to do something bigger and target more communities. FOM could think about going there.

(MTS, Spring 2011)

I like the ideas that FOM has in place. In the long term, I'd like to see these opportunities expanded to more districts. The seminars in Chelsea and Lawrence had great attendance. I think it would be great to extend it to districts beyond the FOM umbrella. People say there is a problem of scale. I feel like the way you do that is just to get it out to more people. We've just got to get it out to more districts. I have no idea how! I think that's a realistic goal of this program.

(MTS, Spring 2011)

One MTS suggested that an expansion of the work might be accomplished by working with those at the district level responsible for planning the local professional development programs that will need to address the instructional and curricula changes connected to the Common Core.

I know that Glenn Stevens said there are a lot of programs at BU, and they are getting bigger. More people are coming to PROMYS and to BU. You can't have 700 people in the program. What happens after? Maybe MTS could focus work on how to harness all these teachers—make the web bigger than what FOM covers. An expansion of the idea, pushing outwards, getting more people involved. I guess the push would really have to be on the people that coordinate and plan professional development time. I think there are a lot of teachers who would want to be involved. Teachers don't choose their professional development. An effort would need to be focused on district coordinators and math coaches. I know it would be well received by teachers. (It's a matter of) convincing the people that plan professional development time. The Common Core could drive that sales pitch because a lot of the seminars are about math practices and the Common Core. That could be a small course for PDPs. We'd need to find time and money to make all that happen.

(MTS, Spring 2011)

As an alternative to 'growing the program outwards,' some MTS recommended that FoM strengthen its relationship to the existing districts in the partnership.

I'm thinking about somehow connecting things back to our district more. In terms of my district, what they want to get out of [the program] isn't so tightly tied into anything. Some of things we are working on now [seminars/institutes/Common Core] could be a source for professional development that goes on in the schools. We have monthly half-day in schools for PD. So we could be more of a resource for that professional development for math teachers in our districts. That's one way to give something more directly back to our districts. FOM seminars are good and interesting, but don't always focus of pedagogy, but on math. We can focus on both.

(MTS, Spring 2011)

One MTS, frustrated with the lack of district interest and teacher participation, struggled to understand how the relationship might be improved given that there was a perceived, shared interest in supporting teachers' ability to teach mathematics well.

I don't know if the district knows enough about what we do. I don't know if I have to actually inform them about everything, or if FOM has to inform them. This relationship is not clear for me. Of course they know about the seminars. But maybe they don't know enough about it. Maybe FOM could advertise, focus on a bit more. I don't know what they know, or if they expect something. One of the purposes of this program is to help with professional development, and I think we are doing something like that—designing summer institutes and other activities. This actually helps improve the quality of teaching math. I think we need to develop in this direction. That's probably the purpose of this program.
(MTS, Spring 2011)

Summary and Discussion

It is clear, from the evidence discussed in this report, that the participants in the MTS program this year viewed their experiences in a very positive light. FoM leaders had intentionally and effectively made many of the changes recommended in last year's report. They clarified expectations for teachers' participation in the program at the start of the year, held a set of regularly scheduled meetings on a monthly basis, encouraged the agenda for those meetings to evolve from participant interests, strengths, and perceptions of district needs – while keeping close the broader purposes of the MTS program, and ensured that MTS had sufficient support, on an as-needed basis, as they developed seminars and institutes for the FoM community. MTS are so pleased they would not like to expand the program!

The MTS highlight the depth of their learning as a result of their participation in the program and as members in the FoM mathematics community. One MTS is stepping out of the leadership group to focus on translating what he has learned to his work in the classroom. This in itself seems to be a critical leadership role. How can his explorations and discoveries be part of the Math Teaching Scholars work and/or area of study next year, without placing an undue burden on this teacher and thereby preventing him from pursuing his work? Can/how can the MTS community remain a 'sounding board' for his investigations?

We offer a few more ideas for further consideration.

1. The remaining difficult and still unresolved issue is FoM's and the districts' relationships. The reasons seem to vary, although it is unclear whether project and district leaders have met recently to explore them. Some program-district relationships are either not fully formed, as is true with the new districts as well as those original members whose leadership has changed, or relations appear strained due to a belief that the district's and program's goals, as well as strategies for achieving them, are not in close alignment.
 - What can FoM do to forge stronger relationships with district decision-makers in Cambridge and Framingham, the two newer districts, and with Waltham, where most top administrators were new this year, and little institutional memory of

FoM remains? A partnership needs to think about the administrative transitions as well as new additions -- how can those folks be brought in comfortably and feel like part of the crowd?

- What are Chelsea's goals for their involvement in FoM? Can FoM programs be or how can they be better supported internally?
- Arlington and Watertown are struggling financially and internal district relationships remain frayed. What's possible for FoM in districts undergoing considerable turmoil?
- Lawrence heartily supports FoM programs. What plans can be made to build upon their successes and work to sustain the leadership efforts underway? The MTS from Lawrence express an interest in bridging their work as teacher leaders to more closely address the needs in the district.

2. The MTS have created a wealth of well-designed, finely honed professional development programs. What strategies does FoM have for collecting, vetting, and making these programs accessible to others?

3. Several MTS have discussed their interest in using technology to enhance their classroom instruction. What role can this interest play in next year's work?

4. In Chelsea, the afterschool math club is slowly taking root, growing from one middle school to perhaps others. Concurrently, there is growing interest and funds for afterschool programming that is less formal than the school day, but that provides for more extended, in-depth and inquiry-based learning. Could FoM explore Chelsea's early work in this area to learn the extent to which it might support student research projects?