

***FOCUS ON MATHEMATICS:***

***CREATING LEARNING CULTURES FOR HIGH  
STUDENT ACHIEVEMENT***

**Funded by the National Science Foundation**

**Year Five Evaluation Report**

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## **INTRODUCTION**

Focus on Mathematics (FoM) is a 5-year, grades 5–16 Targeted Math-Science Partnership (MSP), funded by the National Science Foundation (NSF) in September 2003. The partnership includes Boston University (BU); the Education Development Center, Inc. (EDC), a non-profit research and development organization; 5 Massachusetts school districts located in the Greater Boston area (Arlington, Chelsea, Lawrence, Waltham, and Watertown); and, as supporting partners, the University of Massachusetts Lowell (UML); and the Program Evaluation and Research Group (PERG) at Lesley University. Worcester Polytechnic Institute (WPI)—a partner through Year 4—withdraw from the partnership before the start of the fifth year.

The distinctive features of this MSP include:

- A focus that places mathematics at the core of teachers' work;
- A coherently designed, expertly implemented professional development program;
- Research mathematicians' extensive and long-term involvement in the project;
- A Master's of Mathematics degree program created at Boston University;
- A mathematics community comprised of mathematics teachers, students, school and district administrators, mathematicians, and mathematics educators.

## **EVALUATION**

PERG evaluators developed an outcomes-based plan for the fifth and final year of the project, with data collection spread through October 2008. The summative report will be submitted December 1, 2008. This report describes FoM partnership activities from May 1, 2007 (the end of data collection for year 4) through May 15, 2008.

### ***Methodology***

We have employed a combination of quantitative and qualitative data collection methods for this report. We have mined quantitative data from the program-wide database housed at Boston University, and collected descriptive program data from the EDC website. We have also relied on data collected from surveys of mathematicians; focus group meetings with teachers from 3 study groups in 3 districts; observations of mathematicians' meetings, executive council meetings, and meetings related to the establishment of an FoM district consortium; EDC surveys of teachers who participated in FoM summer institutes and district-based seminars; and email exchanges with partners and project staff.

This evaluation report addresses FoM's work in the following areas during summer 2007 through mid-May 2008:

- FoM partnership
- Teacher participation in FoM professional development programs
- Teacher leadership
- District-based math fairs and the FoM Math Expo
- Efforts to sustain the FoM partnership

Outcomes at the institutional level will be addressed in the summative report.

## **THE FOM PARTNERSHIP**

### *Partners*

FoM is a partnership-driven MSP, whose partners in year 5 include:

Boston University: Department of Mathematics and Statistics (CAS) and School of Education (SED)

Education Development Center, Inc.: Division of Mathematics, Teaching and Learning

University of Massachusetts at Lowell: Department of Mathematical Sciences

Arlington Public Schools

Chelsea Public Schools

Lawrence Public Schools

Waltham Public Schools

Watertown Public Schools

The Program Evaluation and Research Group at Lesley University

There have been several changes within the partnership since May 2007:

- Institutional membership: Worcester Polytechnic Institute (WPI) left the partnership: WPI's key representative to the partnership was promoted to a new administrative with increased responsibilities and commitments.
- Boston University: The faculty member who served as SED representative to the Executive Council moved out of state and was replaced by a long-term SED faculty member and provider of FoM professional development.
- District representatives: The Waltham School District lacked a director of mathematics during year 5. The district's Assistant Superintendent represented Waltham on the Executive Committee. A new mathematics director has been hired and will assume the position July 1.
- Project management: BU hired a new FoM project coordinator; EDC hired a new Project Liaison.

Representatives from each partnering institution and district sit on the Executive Council, FoM's decision-making body. Within the districts, the Arlington representative to the Executive Council became the District Assistant Superintendent. She continued to serve as the K-12 mathematics coordinator for the district, and remains committed to FoM. In Chelsea, while the district representative remains the same, an alternate middle school administrator has represented her at all but one of the Executive Council meetings since September 2007.

### ***Executive Council Meetings***

The Executive Council met five times between July 2007 and May 15, 2008. At each meeting district representatives provided updates on FoM activities in their districts. All members of the Council discussed information about and issues related to FoM's professional development programs.

At the first meeting in September, Council members formed a subcommittee to explore how the partnership might form a consortium to extend their work beyond the life of the MSP grant. The subcommittee examined possible structures and sources of funding that might be available to (1) sustain existing FoM programs that were having an impact on teachers and students in grades 6-12, and (2) extend FoM professional development opportunities to teachers of grades 3-5. The committee reported on their discussions with the EDCO Collaborative of 21 districts and their potential relationship with FoM. The BU and EDC PIs also wrote several proposals to secure new resources for the partnership. (A description of the partners' fundraising activities is discussed further in the Sustainability section of this report.)

### ***Mathematicians and the FoM Partnership***

Most of the mathematicians at BU, UML and EDC, remained engaged in FoM activities during Year 5, but the two WPI mathematicians were no longer involved. Overall, about 2/3 of the original group of core mathematicians from Years 1 and 2 remained active in the project.

At BU, one of the PIs continued to lead the project, facilitate a study group, and participate in all aspects of FoM. Most of his colleagues (who were previously involved in FoM) sustained their work in Year 5. In addition to the core mathematicians, one doctoral student co-lead a study group with the PI for the past two years, and worked with the MTFs in PROMYS. (Other BU graduate students also assisted in some FoM activities, such as judging math fairs.)

At UML, two mathematicians continued to lead study groups on a regular basis. Other mathematicians have stayed connected to the project by judging math fairs, assisting their colleagues by 'sitting in' on study groups, and developing teacher resource guides for the Lawrence Public Schools. Several UML students visited classrooms in Lawrence to help students prepare their research projects for the math fairs.

At EDC, three mathematicians remained involved in FoM. One of these is a PI, and continued to lead a study group and examine ways to sustain FoM in the five districts. Another EDC mathematician has joined the faculty of Lesley University and also continued his work in FoM, leading multiple study groups.

The following chart lists the number of active mathematicians in Year 5 at each institution:

**Table 1**  
**FoM Mathematicians by Institution: 2007-08**

<b>Institution</b>	<b>Number of Mathematicians—Year 5</b>
Boston University	7*
University of Massachusetts--Lowell	4
Education Development Center	3**

**Table notes**

\*Includes 1 doctoral student

\*\* Includes 1 mathematician not currently active as of spring 2008

In Year 5, mathematicians served in a variety of key roles within FoM. Mathematicians from the two remaining IHEs—BU and UML—and EDC continued to lead study groups, and participated in FoM events including seminars, colloquia, summer institutes, and work with MTFs and taught in the Promys summer program. Most of the remaining mathematicians were involved in judging math fairs this spring, and several made presentations to teachers and/or worked with students in the partner districts, to assist them in developing student research projects.

The mathematicians reported a high level of satisfaction with their work in FoM, particularly in working with teachers in their study groups, and in several cases, working with the MTFs at Promys and in BU’s graduate program. Several mathematicians also commented on their satisfaction in helping teachers make deeper connections in mathematics and believed that work was having an impact on teachers’ work in the classroom.

As noted in an earlier section of this report, 2/3 of the original, core group of mathematicians (12 of 18) were involved in FoM throughout the year. (Another mathematician was active in fall 2007, but left the project to lead another math-based initiative.) Several mathematicians reported that time spent on FoM activities had decreased in Year 5, since fewer study groups were taking place in the districts. As of May 2008, 6 mathematicians and a BU doctoral student were involved in leading study groups. One EDC-based mathematician took on the facilitation of two additional groups in Year 5, and led a total of four study groups.

FoM mathematicians continued to demonstrate both flexibility in filling project needs and commitment to FoM by taking on new challenges. For example, one mathematician worked with an MTF to plan and co-lead a seminar, and another worked with an MTF on a research project. A third mathematician has been active on the curriculum review committee for several years, where he has worked with district leaders to examine how

teachers at different grade levels introduce linearity in their classrooms and why students continue to struggle with the concept. As a result of the committee’s work, one district established elementary and middle school study groups to further explore this issue. Finally, 11 of the 12 active mathematicians served as judges for the school-based math fairs. The following table outlines mathematicians’ activities from Year 1 through Year 5.

**Table 2**  
**Survey Data: Mathematicians’ Activities 2003-08**  
**Year 5: N=10**

Activities	Year 1 03-04	Year 2 04-05	Year 3 05-06	Year 4 06-07	Year 5 07-08
Colloquia	6	5	4	4	2
Seminars	6	5	6	4	3
Study groups with teachers	9	9	8	8	6
Classroom visits/observations	8	2	2	2	2
Presented math workshops for teachers	1	0	0	0	0
Summer institutes	3	2	2	1	0
Development of on line courses	1	1	1	1	1
PROMYS	4	4	4	5	5
Other	3	3	4	4	4

**Table note**

“Other” includes responses from two mathematicians who said they were involved in “lots of things” or “everything except online courses.”

Outgrowths of Year 5 Activities:

Mathematicians’ efforts within FoM have resulted in a number of new activities and the growth of others this year, including;

- Mathematicians worked with district leaders to deepen the mathematics content in students’ research projects, and to help teachers understand the rationale for the research projects.
- The implementation of a mentoring course at UML involving 2 undergraduate students who received guidance from a mathematician to advise Lawrence high school students on their research projects.
- The inclusion of graduate students from BU and UML to serve as judges for the math fairs.
- The development of a resource guide for Lawrence teachers on fractions; a second guide on data analysis is underway.
- The involvement of several mathematicians in discussions on sustaining FoM. Many are interested in continuing to work within the project beyond Year 5.

## FOM PROFESSIONAL DEVELOPMENT PROGRAMS, JUNE 2007-MAY 2008

In year 5, FoM offered a portfolio of mathematics-focused learning opportunities for teachers in the 5 partner districts—Arlington, Chelsea, Lawrence, Waltham, and Watertown. The project’s effort to improve mathematics teaching and learning in grades 5-12 continues to be a voluntary program. While teachers are encouraged to participate by district leaders, teachers individually select learning opportunities they consider useful or interesting, and that meet at a time and place accessible and convenient to them.

### *High Schools’ Teacher Participation*

Teacher participation in the FoM professional development program continued to be strong in year 5. Fifty-nine percent (59%) of the five districts’ high school mathematics teachers attended one or more sessions between June 2007 and mid-May 2008.<sup>1</sup> In one high school, more than 75% of the teachers were involved for a total of 288 hours during the past year; in a second, only 50% of the teachers participated, but at a much higher rate, accruing, on average 61 hours each. The total number of professional development hours logged by all fifty-one participating high school teachers was 1598, an average of 31 hours per high school teacher.

**Table 3**

**High School Teacher Participation by District, 2007-08**

FoM Districts	Total HS Mathematics Teachers	Number of Participating HS Teachers	Percent of Participating HS Teachers	Participants PD hrs	Participants with 20+ hrs*	Average PD hours
Arlington	14	7	50%	309*	2	44
Chelsea	17	13	76%	288	5	22
Lawrence	28	14	50%	856*	8	61
Waltham	18	11	61%	71	0	7
Watertown	9	6	66%	74	2	12
<b>Totals</b>	<b>86</b>	<b>51</b>	<b>59%</b>	<b>1598</b>	<b>17</b>	<b>31</b>

#### **Table notes**

- 1. The tables reflect teacher participation through mid-May 2008.*
- 2. We used 20+ hours of participation in FoM professional development programs by May 15 as an estimate for the number of teachers likely to have 30+ hours by August 31, 2008.*
- 3. Teachers, active in either the MMT or PROMYS for Teachers programs during 2007-08, accrue in excess of 100 hours. In those high schools where one or more teachers have enrolled in these programs, the total participant hours distort the average PD hours.*

### *Middle Schools’ Teacher Participation*

Teachers from most middle schools in the five districts (14 out of a total of 16 schools) were involved in FoM professional development activities in 2007-08. Yet, the middle

<sup>1</sup> The exact number of middle and high school mathematics teachers in any given year has been difficult to ascertain in some districts.

school teachers continued to participate at a lower rate than the high school teachers again this year. Nearly half of the 120 teachers at the middle schools in the five districts (49%), attended one or more sessions and together accrued a total of 928 hours. Like in the high schools, some schools and some teachers were more active in Focus on Mathematics than others.

The table below shows middle school teachers' participation by district. In three of the districts, one-half or fewer of the teachers attended sessions. In one of these districts, only one teacher participated this year. In another, two of the three teachers involved in FoM attended only one 2-hour session.

By way of comparison, in a fourth district, almost  $\frac{3}{4}$  of the teachers (a total of 37 out of the 50 middle school teachers in the district) logged 561 hours, an average of 15 hours per teacher. Finally, in the fifth district, just over  $\frac{1}{3}$  of the middle school teachers attended professional development activities, but these teachers participated at a higher rate – on average 27 hours each.

**Table 4**  
**Middle School Teacher Participation by District,\* 2007-08**

FoM Districts	Middle Schools/District	Total MS Mathematics Teachers*	Number of Participating Teachers	Percent of Participating MS Teachers	Participants PD hours	Participants with 20+ hours*	Average PD hours
Arlington	1	12	6	50%	36	0	6
Chelsea	3	35	12	34%	321	3	27
Lawrence	9	50	37	74%	561	4	15
Waltham	2	17	1	6%	3	0	3
Watertown	1	6	3	50%	7	0	2
<b>Totals</b>	<b>16</b>	<b>120</b>	<b>59</b>	<b>49%</b>	<b>928</b>	<b>7</b>	<b>16</b>

**Table notes**

1. District middle schools include different grade levels. Some middle schools serve students in grades 6-8; in others, grades 5-8. Lawrence has several K-8 schools.
2. In Arlington, the middle school includes grades 6-8. However, teachers of grade 4-5 students and a mathematician formed an FoM study group this year.

**Focus on Mathematics Professional Development Programs, June 2007- May 2008**

Focus on Mathematics professional development programs vary in their frequency and intensity. Each year, since the start of the MSP program, the following types of learning opportunities have been offered:

- The Master's in Mathematics for Teaching Program at Boston University
- PROMYS for Teachers at Boston University (6 weeks, 200+ hours of study during the summer)
- Summer Institutes held at district schools or EDC (one week, 30 hours)



- On-line courses developed and offered by the University of Massachusetts at Lowell (75 hours)
- Study groups held in district schools (2–3 hours per after-school session; varied number of sessions held throughout the year at the discretion of the groups’ members.)
- Seminars hosted by the districts, 2-3 hours per seminar, after school, 5 times a year. (Each district offered one seminar each year.)
- Colloquia, held in the fall and spring of each academic year, are gatherings organized for the broader Focus on Mathematics community to hear prominent mathematicians or mathematics educators speak on issues of importance to the field.

***Teacher Participation by Type of Professional Development Activity***

Many teachers attend more than one type of professional development activity each year. Some focus almost exclusively on one type of activity and attend multiple sessions throughout the year. The two tables below demonstrate the extent of middle and high school mathematics teachers’ participation in the varied Focus on Mathematics professional development programs during year 5. Participants are listed by district and type of activity.

**Table 5  
High School Mathematics Teachers’ Participation in FoM Programs, 2007-08**

FoM Districts	Total MTs/ district	Summer Institutes*		On-line Courses*		Study Groups		Seminars		Colloquia*		BU Courses*	
		MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess
Arlington	14	3	3	0	0	1	2	6	13	2	1	1	5
Chelsea	17	6	14	0	0	8	9	12	28	2	1	0	0
Lawrence	28	8	17	0	0	14	13	10	19	1	1	4	14
Waltham	18	2	3	0	0	0	0	11	24	2	1	2	6
Watertown	9	0	0	0	0	3	4	6	12	0	1	1	2
<b>Total</b>	<b>86</b>	<b>19</b>	<b>37</b>	<b>0</b>	<b>0</b>	<b>26</b>	<b>28</b>	<b>44</b>	<b>96</b>	<b>7</b>	<b>1</b>	<b>8</b>	<b>27</b>

**Table notes**

1. Summer Institute 2007 participants are listed above. Summer Institutes for 2008 have not yet begun.
2. No On-line courses were offered during the 2007-08 academic year. A summer course started in May.
3. The first Colloquium was held October 2007. The second Colloquium is scheduled for June 9, 2008.
4. In the BU Courses column, participants have either attended only the summer 2007 PROMYS for Teachers program (PfT) or were enrolled in the MMT Program June 2007 - May 2008, and attended the 2007 PfT program as well as one or two BU graduate courses during the 2007-08 academic year.

**Table 6**  
**Middle School Mathematics Teachers' Participation in FoM Programs 2007-08**

FoM Districts	Total MT/ district	2007 Summer Institutes*		On-line Courses		Study Groups		Seminars		Colloquia*		BU Courses*	
		MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess	MTs	Sess
Arlington	12	2	3	0	0	3	2	5	8	2	1	0	0
Chelsea	35	7	9	0	0	13	13	6	12	3	1	2	6
Lawrence	50	3	7	0	0	15	17	12	17	11	1	1	5
Waltham	17	1	3	0	0	0	0	1	1	0	1	1	2
Watertown	6	0	0	0	0	3	1	1	1	2	0	0	0
<b>Total</b>	<b>120</b>	<b>13</b>	<b>22</b>	<b>0</b>	<b>0</b>	<b>34</b>	<b>33</b>	<b>25</b>	<b>39</b>	<b>18</b>	<b>1</b>	<b>4</b>	<b>13</b>

**Table Notes**

*Same notes as Table 5.*

Discussion

Each of the Focus on Mathematics professional development programs, offered June 2007-May 2008, is described individually and participation rates by activity are discussed below in more detail. Plans for the 2008 summer programs, and projections for the number of teachers attending, where available, are included as well.

***Master in Mathematics for Teaching Program (MMT)***

The MMT is a Master's degree program offered jointly by Boston University's School of Education and the College of Arts and Sciences. Teachers must apply to the program and compete for the limited number of spaces available each year. Once admitted to the program, teachers take an intensive course of study over 2 academic years and 3 summers for a total of 38 credits—20 in the College of Arts and Sciences, and 18 in the School of Education. An optional set of 5 all-day seminars per year is held at EDC on Fridays. They also continue to carry a full teaching load in their districts. The MMT courses include:

*College of Arts and Sciences (20 credits total)*

- The PROMYS for Teachers summer program. An immersion experience of mathematical exploration (PfT):  
 MA 547-548: Topics in Number Theory/Problem Solving in Number Theory
- 2 courses selected from the following:  
 MA 511-512: Real Analysis  
 MA 541-542: Abstract Algebra  
 MA 528: Modern Geometry  
 MA 549: Geometry and Symmetry  
 MA 563: Differential Geometry  
 MA 671: Dynamical Systems

- Research experience in mathematics:  
MA 647: Research Methods in Mathematics I  
MA 648: Research Methods in Mathematics II

*School of Education (18 credits total)*

- 2 courses focusing on the connections and relevance of the immersion experience to their classrooms:  
ME 581, which connects abstract algebra with school mathematics  
ME 580, geometry and symmetry to the classroom
- 2 courses in the mathematics curriculum, and mathematics for students with special needs  
ME 558 (curriculum)  
ME 551 (special needs and advanced students)
- Both a course in professional development and field study in mathematics, preparing teachers to assume leadership roles in professional development  
ME 589 (needs assessment and design of a professional development sequence)  
ME 590 (implementation of PD designed in ME 589)

Since the start of FoM, teachers have either applied to the MMT program before taking the first PROMYS for Teachers summer program, or attended PfT and then decided whether to apply for acceptance into the full Masters degree program.

***PROMYS for Teachers***

The intensive, 6-week summer program, PROMYS for teachers (PFT) grew out of the Program in Mathematics for Young Scientists (PROMYS) at Boston University, as a collaboration of Boston University’s Department of Mathematics with the Education Development Center in Newton, Massachusetts. PFT includes middle and high school mathematics teachers.

The program

... is built around three major components—(1) immersion in an experience of mathematical exploration for six weeks in the first summer; (2) reflection on the relevance of this experience for classroom practice during the intervening academic year; and (3) more immersion in mathematics in the second summer. PFT summer activities combine three tightly interlocking components: (1) problem-solving activities shared by all first-year participants; (2) independent team projects carried out by all participants in groups of four; (3) advanced activities (seminars, and projects) for returning participants. These components are supported by discussions and independent problem-solving activities with the counselor staff. *(from BU’s website description of program)*

The number of middle and high school teachers who attended last summer’s PFT program is listed in the table below by district. The 6 teachers, identified as ‘1<sup>st</sup> year’ participants, started the program in summer 2007. Of these, three plan to or have already enrolled in the MMT program, and will attend PFT for a second summer in 2008. The three teachers listed as ‘2<sup>nd</sup> year’ in summer 2007 are MMT candidates, as are the three ‘3<sup>rd</sup> year’ teachers. Most teachers who attend PFT for a 3<sup>rd</sup> year complete their coursework for the Masters degree program by the end of the third summer.

**Table 7**

**Teacher Participation in PROMYS for Teachers, Summer 2007**

District	High Sschool MTs			Middle School MTs			Total MTs
	1 <sup>st</sup> year	2 <sup>nd</sup> year	3 <sup>rd</sup> year	1 <sup>st</sup> year	2 <sup>nd</sup> year	3 <sup>rd</sup> year	
Arlington		1					1
Chelsea				2			2
Lawrence	2	1	1		1		5
Waltham	1		1	1			3
Watertown			1				1
<b>Totals</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>1</b>		<b>12</b>

Since Focus on Mathematics was funded, 4 middle school and 4 high school mathematics teachers have earned their degree from BU’s MMT program. Three teachers are due to graduate from the program by end of summer 2008; another 3 have enrolled in the MMT program after successfully completing last summer’s PROMYS program. As of mid-May, five new teachers have registered for the 2008 summer PfT program.

***Summer Institutes***

Summer 2007

Each summer, FoM has offered a set of three intensive, one-week, 30-hour mathematics courses for teachers.

*Each institute looks at core ideas within a foundational topic in mathematics, and reflects on the development of these big ideas throughout the curriculum. Teachers will be able to see how mathematical ideas arise at their grade level, and how those ideas develop as students move through the grades. Little by way of background is assumed, but we promise new and elegant results every day!*

*FoM Summer Institute Brochure*

In summer 2007, institute topics were:

- Session 1: Geometric Thinking [June], facilitated by two Boston University doctoral students in the mathematics department
- Session 2: Number Theory [July], offered by a mathematician from EDC
- Session 3: Algebraic Reasoning [August], organized by two EDC mathematicians.

Nineteen (19) or 22% of the high school teachers and 13 or 11% of the middle school teachers attended one or more of these summer sessions. Not shown in the table is the attendance of two teachers working at the elementary school level. One attended all three sessions; the second attended one.

## Findings from 2007 SI surveys

FoM offered 3 summer institutes during 2007 and participants submitted 39 post-institute surveys. The institutes were rated as highly successful along several dimensions by all of the middle and high school teachers who answered each question. Teachers found the institutes interesting, learned mathematics, and found them valuable professionally.

**Table 8**  
**Survey Results for Summer Institutes**

**Middle School Teachers: N=14**

Survey questions	Strongly agree # (%)	Somewhat agree # (%)	Somewhat disagree	Strongly disagree
This institute met my expectations	12 (86%)	2		
This institute addressed issues of interest	12 (86%)	2		
I learned mathematics	12 (86%)	2		
The mathematics presented was valuable to me as a teacher	9 (64%)	5		

**Table 9**  
**Survey Results for Summer Institutes**

**High School Teachers: N=25**

Survey questions	Strongly agree # (%)	Somewhat agree # (%)	Somewhat disagree	Strongly disagree	N/A
This institute met my expectations	19 (76%)	6 (24%)			
This institute addressed issues of interest	20 (80%)	5			
I learned mathematics	22 (88%)	1			2
The mathematics presented was valuable to me as a teacher	19 (76%)	4			2

## 2008 Summer Institutes

Three institutes are planned for the Focus on Mathematics teachers this summer.

- Session 1: Problem Solving in Number Theory and Algebra [June], facilitated by a retired district mathematics leader from Waltham, closely involved in FoM for the past four years
- Session 2: Algebraic Reasoning [July], led by a coordinator of middle school mathematics from Chelsea and a high school mathematics teacher [and MTF] from Watertown
- Session 3: Exploring Topics in Statistics, Probability and Finance [August], offered by a high school mathematics teacher in Watertown.

In a departure from past summers, the design and facilitation of these courses has been assumed by district mathematics educators, all of whom have participated in Focus on Mathematics professional development programs. As of late May, 46 teachers had

registered for these three institutes, 5 K-5 teachers, 19 middle school teachers, and 22 high school teachers.

### New 2008 Summer Institute for teachers, grades 3-8.

To address the persistent requests of the district partners, FoM will offer a newly designed course for upper elementary and middle school teachers, grades 3-8, in August. The course, *Uncovering Fundamental Concepts of Arithmetic*, will be designed and jointly facilitated by a Boston University faculty member in the Mathematics Education program and a mathematician at EDC.

*This course provides an immersion experience in exploring the mathematics you teach.  
Explorations will extend whole number arithmetic to algebra and to decimals and fractions.  
Emphasis will be on understanding fundamental concepts of arithmetic, algebra, and geometry  
and figuring out how these concepts fit together.*

*FoM Brochure*

The enrollment period ends in late June; the number of participants is not available at this time.

### ***On-line Courses***

No on-line courses were offered during the 2007-08 academic year. In the past, most teachers who enrolled in the courses struggled to commit sufficient time (75 hours) to complete the work required for these rigorous courses while teaching a full load.

However, this summer, the on-line course entitled *Mathematical Problem Solving* is being offered to interested FoM teachers and to University of Massachusetts at Lowell students. The goals for this course are to: make participants aware of the role of problem solving in mathematics and mathematics education, improve participants' problem solving ability through working on problems, and help participants investigate ways in which their students' problem solving abilities can be enhanced using their curriculum. Five (5) FoM teachers and 14 University of Massachusetts/Lowell graduate and undergraduate students have enrolled in the course.

### ***Study Groups***

Teachers of mathematics at the districts' schools and FoM mathematicians organize the study groups each year. Study groups are designed so participants, both teachers and mathematicians, learn from each other by working together on topics of mutual interest. In the past years, examples of the topics middle school study groups have explored are *Pascal's Triangle, Number Games, Methods of Logical Thinking, Linearity, Geometry Measurement, Math Fair Projects, Factoring, and Math Explorations using Technology*. High school study group topics have included *Geometry Area Algorithms, Algebra, Spreadsheets, AP Calculus, Differential Equations without Calculus, Geometry of Voting, and TI-89 Calculator Applications*.

Study groups meet face-to-face, after school for 2-3 hours once or twice a month. Meeting schedules and locations were determined by the groups' members. High school teachers and middle school teachers in two districts held their study group meetings in their own schools. In one district, middle school teachers formed a somewhat loosely organized study group that met in each of the 3 middle schools on a rotating basis. In a second district, three middle schools formed separate study groups.

From September 2007 to May 2008, six mathematicians and teachers in four of the five districts formed 10 study groups that met for a total of 73 sessions; three were high school groups, six were middle school groups, and one was an elementary school study group. The groups varied widely both by the number of teachers that attended relatively consistency and the frequency of the groups' meetings.

The table below shows the number of elementary, middle, and high school study groups that formed this year, by district, and the total number of sessions each group met. By the May 2008, 8 groups remained active in three of the five districts.

**Table 10**  
**Study Group Sessions by District and School Level, 2007-08**

District	High School Number of SGs (sessions)	Middle School Number of SGs (sessions)	Elementary School Number of SGs (sessions)	Totals
Arlington	0	1 (9)	1 (4)	2 (13)
Chelsea	1 (10)	1 (17)	0	2 (27)
Lawrence	1 (13)	1 (8) 1 (7) 1 (2)	0	4 (30)
Waltham	0	0	0	0
Watertown	1 (2)	1 (1)	0	2 (3)
<b>Totals</b>	<b>3 (25)</b>	<b>6 (44)</b>	<b>1 (4)</b>	<b>10 (73)</b>

In April and May, PERG evaluators conducted focus groups with teachers involved in three of the longest-running study groups in FoM districts—two at the middle school, and one at the high-school level. We chose these groups specifically because they had a high level of teacher participation over the life of the project. Each of these groups has been running since Year 1, though the membership of the groups has changed somewhat over time. The following scenarios summarize the experience of teachers in these study groups.

### Scenario 1: A High School Study Group

This high school study group, in an urban high-needs district, met once or twice a month over the past 5 years. During Year 5, this group of 4-8 teachers discussed a number of topics including: Geo-board geometry and Pick's theorem, puzzles and games, fitting polynomials to discrete data, the simplex lock problem, and an examination of challenging Algebra problems aimed at high school students.

In the focus group interview, teachers emphasized the importance and value of having a mathematician lead the group. Several teachers commented that it wasn't a specific area or topics studied within the group that was most valuable for their work, but rather FoM's integrated approach to the understanding and teaching of mathematics. This approach was modeled by the mathematician. He facilitated the group but also encouraged teachers to take ownership for the direction of the group's sessions. Teachers also said the mathematician helped create an environment that was conducive to learning, asking questions, and exploring new topics.

Several teachers discussed FoM's broader impact—from attending the study group, summer institutes, and seminars—on their teaching style. They are now more willing to experiment in their teaching, and to allow students to approach topics in a number of ways. They tried to integrate the FoM approach of questioning and looking for multiple connections and points of entry into their teaching. Finally, teachers felt that the group members had become more active over time, so that they sometimes came to the board to demonstrate their approaches, led group discussions, and suggested topics to investigate.

### Scenario 2: A Middle School Study Group

This middle school group consisted of teachers from approximately six schools in another urban district. The FoM mathematician worked closely with the math coaches from two middle schools and the district mathematics principal to develop a plan for the study group for Year 5. The group focused on various aspects of geometry, particularly area, perimeter, and volume. The group met on a monthly basis during the school year.

Many of the attending teachers were elementary or special education teachers, and were not math specialists. In the focus group interview, the teachers emphasized the collegial nature of the group and the encouragement they received from the math coaches and the mathematician. Group members stressed the interactive nature of their sessions where the mathematician usually presented the group with a problem which they then explored. The teachers often took turns presenting their solutions to the group. Teachers said that the group was useful, both in terms of modeling pedagogy and in building mathematical content. As one teacher said, "I have more strategies, more ways to approach a problem, and the confidence to use unfamiliar ways of approaching a math problem."

Several teachers stressed the value of building relationships with their colleagues from their own and other schools, and developing more confidence in teaching math. Their



work in the study group has given them greater willingness to explore topics in depth and bring their knowledge into the classroom.

### Scenario 3: Another Middle School Study Group

The second middle school group we interviewed met on a monthly basis, alternating between two schools in an urban district. This group was facilitated jointly by a mathematician and a doctoral student from Boston University. There were usually 4-8 attendees. Rather than focusing on a single topic, the group chose to explore a range of topics related to the district curriculum. Year 5 topics included geometric mathematics: square numbers, triangle numbers, and quadratics.

Group members found the study group to be a rich experience. They appreciated having the time to explore mathematics, to work with their colleagues and to see different approaches and problem-solving strategies. The group included teachers from grades 5-8, but most of those active during the 2007-08 school year were 7<sup>th</sup> and 8<sup>th</sup> grade math specialists. Those who attended the group regularly liked FoM's "exploration way," which enables students to find different ways to approach mathematics problems. Group members said that having time set aside to talk about and think about mathematics and work with two mathematicians was very valuable and stimulated their teaching.

Teachers stressed the importance of building connections with colleagues; many felt isolated in their schools, since they were the only math teacher at their grade level. One participant [a district math leader] expressed some disappointment that few 5<sup>th</sup> and 6<sup>th</sup> grade teachers came to the group sessions. She felt that the relatively high level of mathematics in the group intimidated some of those teachers. Several members of this group have been very active in Focus on Math activities; two have completed BU's master's degree program.

### *Seminars*

Each district in the Focus on Mathematics Partnership hosted an afternoon seminar during the 2007-08 school year. Seminars provide middle and high school teachers with relaxed, after-school venues where they can work together with colleagues—within or across schools and districts—to explore mathematical problems and discuss classroom applications.

This year, four out of the five sessions were designed and facilitated by one or two of the host districts' high school mathematics teachers; in the fifth district, a high school teacher teamed up with the Boston University mathematician who had worked closely with that district, leading study groups for the past 4 years.

The five seminars offered in 2007-08 were:

- *Modular Arithmetic*, presented by 2 Mathematics, Science, and Technology High School teachers from Lawrence
- *Seeing the Whole Elephant, Slope from 4<sup>th</sup> Grade through Calculus*, presented by Chelsea High School teacher
- *Close Enough: Solving Equations Iteratively*, presented by a Waltham High School teacher and Boston University Mathematician
- *Problematizing Your Curriculum*, presented by 2 Arlington High School teachers
- Solving Problems in Statistics and Finance with the TI 83/84, presented by a Watertown High School teacher.

A total of 69 mathematics teachers, 25 from the middle schools and 44 from the high schools, attended a total of 135 seminars, an average of 2 seminars per teacher this year.

### Findings from Seminar Surveys

One hundred ninety-nine (199) participants (*not* individual teachers) attended the five district-based seminars, submitting 145 post-seminar surveys. Participants reported that the seminars were interesting, that they learned mathematics and that the mathematics was professionally valuable.

**Table 11**

#### **Survey Results for Year 5 Seminars**

##### **Middle School Teachers: N=39**

<b>Survey questions</b>	<b>% Strongly agree and agree</b>
This institute met my expectations	93
This institute addressed issues of interest	90
I learned mathematics	90
The mathematics presented was valuable to me as a teacher	87

**Table 12**

#### **Survey Results for Year 5 Seminars**

##### **High School Teachers: N=79**

<b>Survey questions</b>	<b>% Strongly agree and agree</b>
This seminar met my expectations	86
This seminar addressed issues of interest	98
I learned mathematics	97
The mathematics presented was valuable to me as a teacher	91

## ***Colloquia***

FoM invited Heather C. Hill, an associate professor at the Harvard Graduate School of Education, to speak at the first FoM Colloquium, held October 17, 2007 at Boston University. Dr. Hill's talk, *'Knowing Mathematics Well Enough to Teach It, What More Does that Take?'*, described her work as the principal investigator for Learning Mathematics for Teaching (LMT), a project funded by the National Science Foundation to investigate the mathematical knowledge needed for teaching and how such knowledge develops as a result of experience and professional learning. Twenty-five middle and high school teachers, district leaders, and mathematicians from Boston University, University of Massachusetts at Lowell, and EDC attended.

A second colloquium is planned for June 9, 2008. The featured speaker will be Philip Uri Treisman, professor of mathematics and executive director of the Charles A. Dana Center for Mathematics and Science Education at the University Texas at Austin. The title of his talk is *The Mathematics Achievement Gap*.

*Dr. Treisman is a leading expert on the development of programs aimed at increasing minority participation in mathematics. His seminal research in this area provided a foundation for his Emerging Scholars Programs (ESP). Now a workshop model used by colleges and universities nationwide, ESP builds student success through collaborative group work on rigorous mathematical problems... In all his work, he is an advocate for equity and excellence in education for all children.*  
*FoM Colloquium Brochure*

## **TEACHER LEADERSHIP**

Teachers continued to assume responsibility for providing professional development for their peers throughout the 2007-2008 academic year working individually, with other teachers and/or with a mathematician.

- Eight teachers presented/co-presented the 5 district-wide seminars during 2007-2008. One teacher co-facilitated one of the 5 seminars with a mathematician.
- Three of the 4 summer institute instructors for the three 2008 institutes will be teachers: No teachers were instructors for the 2007 summer institutes.

Presenters at district seminars included 2 MTFs and 6 other teachers. Two of the 4 summer 2008 institute facilitators are MTFs, and one is a middle school administrator (formerly in the MMT program).

In addition, 2 teachers wrote and published an article and 3 presented at conferences:

- Two (non-MTF) teachers and one mathematician published an article in Mathematics Teacher and have submitted a second article for publication.
- Three teachers presented at conferences [2 MTFs and 1 other teacher]:
  - One teacher made a presentation, *Investigating The Simplex Lock*, at The Annual Discrete Mathematics Conference for K - 12 Teachers at Boston College;
  - One teacher made a presentation, (*title unavailable at this time*), at the Spring Meeting of the Southeastern Section of the American Mathematical Society, Louisiana State University;
  - One teacher co-presented *Focus on Mathematics in MA* with a mathematician at The Secondary Teacher Preparation in Mathematics Workshop, Institute for Mathematics and Education, University of Arizona.

## STUDENT RESEARCH: MATH FAIRS AND MATH EXPO

### *Math Fairs*

Math Fairs continued to be an FoM activity heavily embraced by the districts. Data from the 2006- 07 math fairs and all but one of the 2008 fairs are represented below. Data from the final math fair was unavailable at the time of this report. The number of students and math research projects cited in the table includes students from all districts and both middle and high schools.

**Table 13**  
**FoM District Math Fairs**

Year	Schools hosting math fairs*	Research Projects	Students
2007	21	1,568	2,762
2008	18	1,370	2,314

**Table note**

Data from the final 2008 math fair were not available for this report.

In addition to judges from the FoM IHEs, volunteer judges came from 7 corporations in 2007 and from 2 corporations in 2008.

EDC has posted resources on the FoM website for both students and teachers to use in the development of research projects. Resources include guidelines for projects and posters, and a link to a ‘mentoring website’ for project development.

## ***Math EXPO***

The fourth Math Expo took place June 9, 2007. One hundred fifty seven (157) projects, developed by 302 students working in teams, were selected from the district math fairs and shown at the Expo. The fifth annual Math Expo will take place June 14, 2008 at the Boston Museum of Science. To date FoM has secured corporate support for the 2008 Expo from Google, Alkermes, Eureka!, Exxon Mobil and Foster- Miller.

## **SUSTAINABILITY**

During Year 5, FoM followed several strategies for sustaining FoM professional development activities post NSF-funding. The PIs submitted two proposals, which have been funded, two others, which have been submitted, and a fifth proposal is under development at this time. Corporate sponsorship for the Math EXPO has been sought, and the formation of a possible district Consortium, first described in the Year 4 evaluation report, has progressed.

### 1. Two proposals have been funded.

- From NSF: The Robert Noyce Fellowship Program proposal, submitted March 2007, was funded by the NSF, with additional funds supplied by BU's SED. A joint collaboration between SED and CAS, it will provide scholarships to up to 13 college mathematics majors per year to prepare to become mathematics teachers.
- From MA DOE: MA STEM Pipeline Fund: A proposal for *Inquiring Minds* was funded. This program will engage science teachers grades 3-8 in a summer institute on *Green Energy*, with academic year follow-up activities over a period of three years. This proposal was developed by BU, Northeastern University and Wheelock College. While this project is not attached to FoM, it will serve the 5 FoM districts and four others. As FoM partners, teachers from the 5 districts will be given priority in selection for the program.

### 2. FoM has submitted two proposals for additional funding.

- To the NSF: The PIs submitted a MSP Phase II proposal, *FoM: Phase II*, to extend and strengthen FoM's mathematical communities by increasing the capacity of current expert teachers, increasing teacher participation in study groups, accepting new districts into FoM mathematics communities and conducting research "that will detail the distinctive features and outcomes of the *Focus on Mathematics* mathematical learning communities" (from proposal). This is a three-year proposal.

- To the MA DOE: BU and UML submitted a Title 2-B, 3-year proposal, *Mathematical Experiences*, to develop a new program for mathematics teachers of grades 3-8. This program would provide teacher participants a 2-week summer institute, year-long study groups, and leadership development through the BU PFT program. This project would serve all 5 FoM districts.
3. To the NSF: The PIs are currently developing a proposal for an MSP supplement.
  4. Fundraising: FoM continued to actively seek corporate funds to support the Math EXPO and secured them from both Exxon Mobil and Foster- Miller. A similar proposal to Raytheon Corporation was not funded.
  5. The Consortium: FoM partners have discussed the development of a consortium since the beginning of Year 4. The consortium committee met three times during the fall to discuss the consortium—its infrastructure, governance, decision-making processes, accountability, fee structures, and potential professional development programs. Consortium meetings ended with the last of three meetings in November.