

METHODOLOGY

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Study Questions

- Does/in what ways does the MTF program deepen teachers' knowledge of mathematics for teaching?
- Do/in what ways do MTFs' instructional practices change?
- Does/to what extent does the MTF program enable MTFs to be the kinds of leaders envisioned in the proposal?
- Does/to what extent/how does a mathematics culture develop in schools?

Rationale for and Overview of Methods

Respective Roles of Case Study Researchers

A total of five individuals were directly involved in designing and conducting this case study research. The two primary case study researchers were also in the role of external evaluators for FoM. This role provided them substantive knowledge of FoM as well as the ability to draw on evaluation methods and findings in support of the case studies. They collected all data for the study. A research consultant with expertise in qualitative methodology, and research and evaluation experience with other NSF-funded Math and Science Partnerships advised on and contributed directly to the research design, data analyses, and this case study write-up. Two mathematicians involved in FoM participated in the classroom observations (see below). In their FoM roles the mathematicians facilitated study groups, summer institutes and online courses. As such, they had an understanding of KMT (knowledge of math for teaching) and the FoM program goals.

Participants

To develop this understanding researchers asked 6 MTFs to participate in the case study. Their selection was based on the following criteria: (a) different levels of experience/years teaching, (b) different school districts, (c) both genders, (d) middle and high school levels, and (e) representation from both MTF cohorts (one beginning in Summer 2004 and the other beginning in Summer 2005). Each of the six teachers agreed to be subjects of our case studies. One teacher dropped out due to heavy teaching responsibilities; another teacher, not in a classroom teaching role at the time of the study, was dropped due to the researchers' time constraints, resulting in a total of four case study participants. In all, at the start of FoM these four teachers ranged between 2 to 3 years of teaching experience, represented four different school districts (two urban, one with mixed urban and suburban areas and one suburban), included two males and two females, two middle school and two high school teachers, and were from the cohort 1 (two teachers) and cohort 2 (two teachers) MTFs in the BU MMT program. Three of the four teachers had pursued teaching as a second career.

Data Collection and Analysis

For each case study participant, data were collected over a period of either two or three years, depending on when a teacher entered the MMT program.

Data included (a) interviews with the teachers and their principals, (b) classroom observations, (c) observations of program components (PFT, counselors' meetings, MTF meetings, MTF professional development presentations, EDC seminars), and (c) documentation of program activities that reflected teachers' learning processes (PFT counselors' notes regarding teachers, teachers' BU course reflections, email exchanges, and teacher essays about their learning and practice from coursework assignments).

Data collection from the first cohort of teachers began in July 2004 and concluded in late winter 2007. Data was collected from the second cohort between July 2005 and late winter 2007.

Teacher Interviews

Interview protocol and procedures. The case study teachers participated in a series of semi-structured interviews addressing their learning experiences in the FoM program. Cohort 1 teachers were interviewed a total of six times— Fall 2004; Spring and Fall 2005; and Spring, Summer and Fall, 2006. Cohort 2 teachers were interviewed four times—Fall 2005; Spring, Summer, and Fall 2006. Researchers began the case studies in May 2006. However, a significant amount of data had already been collected for the FoM evaluation including observations of PFT and interviews with all cohort 1 and cohort 2 MTFs.

The interviews were conducted by the two primary case study researchers with each researcher interviewing the same two teachers over the course of the study. The researchers recorded the teacher responses into laptop computers during each interview, capturing as much detail in the teachers' own words as possible. The interview topics are described in the table below.

2004: Fall: Cohort 1

Researchers asked teachers to answer a series of questions about their first MMT activity—PFT summer 2004 (See appendix for protocol). Researchers

- Explored teachers' expectations of PFT and if/how they were met, if they had felt prepared for the institute and what might have helped them be more prepared, and what resources and support they had received.
- Asked a series of questions about what teachers had learned about mathematics, themselves as learners, their students as learners, if/to what extent there had been a mathematical community and how the mathematicians contributed to it.

- Questioned teachers about the changes that they (the teachers) anticipated making in their teaching and if they planned to end participation in the MMT program with a certificate of advanced study or continue until completion of the MMT program.

2005: Spring: Cohort 1

Researchers questioned the MTFs about their views of the MMT program as well as changes in their knowledge and practice (See Appendix for protocol):

- One key question about the MMT program asked teachers what they believed the MMT programs' underlying beliefs about teaching and learning were.
- Researchers also asked them to discuss how they attributed specific changes in their practice to their participation in the MMT/FoM programs in terms of 1.) their knowledge of mathematics 2.) their use of instructional materials, 3.) their contributions, if any, to a mathematical community, and 4.) their leadership activities.

2005: Fall: Cohort 1

Researchers asked teachers specifically about mathematics, as well as about their school districts (See Appendix for protocol). First researchers asked

- What teachers had learned about mathematics that they considered critically important, and how their participation in FoM contributed to a broader understanding of what mathematics is of importance to mathematicians;
- To cite a specific example of how their understanding of some aspect of mathematics had changed;
- What they had learned about themselves as adult learners, and their reflections on their students' learning;
- What an observer would see in their classrooms that reflected what they had learned through FoM.

Researchers questioned them about their school districts in relation to

- The alignment between the their beliefs about teaching and learning and those of the district;
- The leadership activities they had been asked to assume or had assumed by themselves;
- Who the members of a mathematical community were, if one existed;

Researchers ended the interview with questions about PFT; what teachers study included, the support they received, and the PFT rubrics the counselors and staff used.

2005: Fall: Cohort 2

This interview protocol was similar to the protocol used in fall 2004 with the cohort 1 teachers. Researchers included three new questions (See appendix for protocol). The first concerned the use of PFT rubrics. In addition researchers asked:

- What do you see as MMT/CMT/FoM's underlying beliefs about teaching and learning mathematics?

- Do FoM's PD practices differ from your past experience learning or teaching mathematics?

2006: Spring: cohort 1

This interview protocol covered several areas (see appendix for protocol). At this time the cohort 1 teachers were taking their last two classes at the School of Education—one a content course and the second, field study. Researchers asked several questions in relation to the course (see protocol for appendix) including:

- To describe the course and what they were learning;
- If they believed that the instructional approach was aligned with that of other FoM professional development activities and programs;
- To describe the professional development workshops they were developing as one component of the course (for field study).

Researchers followed with several other questions:

- Three questions concerned their leadership roles and activities within their districts, and what they would like these to entail.
- Several questions concerned the mathematics community at their schools and their participation in them.
- Several questions concerned their school district: the resources provided to them as MTFs; the ways in which FoM influenced district policies and practices, and district policies and practices they believe should be reconsidered, given their experiences with FoM.

2006: Spring: Cohort 2.

The protocol for this spring was identical to that used with cohort 1.

2006: Spring-Summer: Cohort 1 and Cohort 2 (identical protocol)

This interview protocol focused on the teachers' mathematics backgrounds, including:

- Their earliest memories of math and also how they were taught in school;
- Their attitudes towards mathematics, what interested them about math/when they began to enjoy it;
- The mathematics courses they had taken in high school and college;
- How/why they decided to be mathematics teachers;
- The jobs they had held;
- Their notions about teaching and learning [including the teacher's role] and why they became interested in FoM and the MMT program;
- Changes in their colleagues' learning/teaching/ collaborative work that they would attribute to the FoM program.

2006: December: Cohort 1

The interview questions covered several areas but the focus was teachers' understanding of the design and instructional approach of FoM's professional development program and if/how it had helped them deepen their knowledge of mathematics. The questions fell into the following areas:

- Their knowledge of mathematics: researchers repeated a question posed in 2005, what they had learned about mathematics that they considered critically important.
 - Mathematicians: What had been important about working with mathematicians;
 - Curricular decisions: How FoM helped them make decisions about what is important to emphasize in teaching;
 - Students: How, as a result of the MMT program/FoM they thought about student learning differently, taught their students differently, and whether/what evidence they had that their participation in the program affected student learning.
- Researchers also queried them about their final year in the MMT program.

2006: December: cohort 2

Researchers asked the same questions that appeared on the protocol for cohort 1, fall 2005.

Analysis. Working with their case study consultant researchers developed initial codes for data analysis based on the data and the FoM logic model. Then each researcher independently coded the same teacher interview, followed by discussions to establish inter-rater reliability. The codes that emerged from the data included:

AP = Ability to Participate

Challenges to MTFs' participation in the MMT program

CT = Classroom transfer

How teachers were using what they were learning in their classrooms and/or their reflections on their instructional practices and their observations of student learning in their classrooms.

DC = District context

District support or challenges to MTFs' involvement in the MMT program, what they were learning, how that was affecting their thinking, their work in their classrooms, etc.

LR = Leadership role

Examples of how MTFs assumed leadership roles within their schools, districts, FoM, or the larger mathematics community including roles they were asked to assume and hoped to assume; what roles they feel prepared to assume and those they had taken on, on their own.

MB = Math background

MTFs prior educational background in mathematics. The degrees they held in mathematics, their perception of their assets/deficits in terms mathematics knowledge as needed for the MMT program, their reflections on how they learned mathematics.

MC = Math community

Mathematics community has a broad meaning and can be 'located' at different levels

PD = Masters in Mathematics Teaching program and other Focus on Mathematics programs

SC = School culture

School culture including beliefs about teaching and learning held those within the school; organizational structures and school day schedules that influence teaching and learning; time for/or the lack time for teaching mathematics and support for teacher collaboration.

SL = Student learning

MTFs thoughts about how students learn mathematics, their reflections on changes in student learning given changes they make in their instructional practices, evidence of students' learning

TL = Teacher learning/attitudes/beliefs

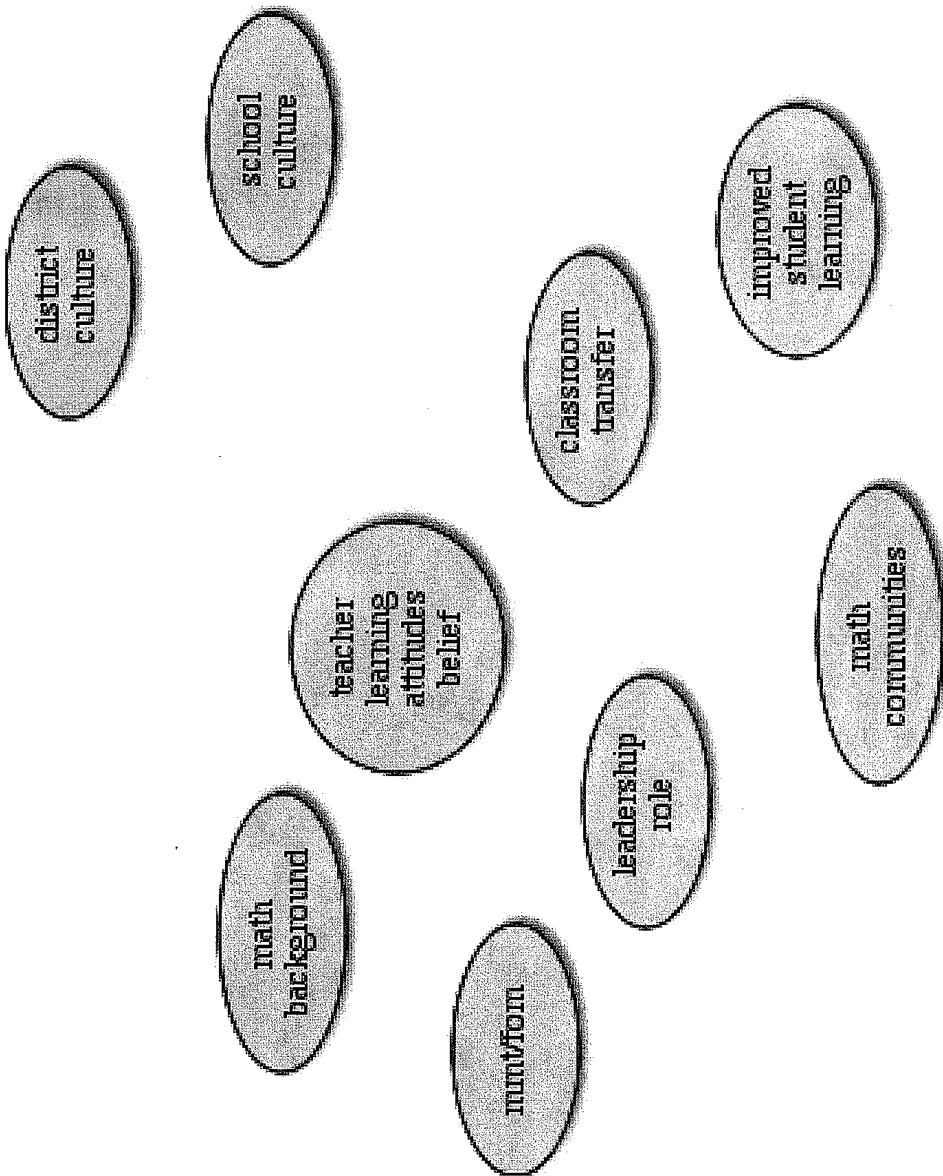
Teachers' beliefs about learning mathematics, changes in their beliefs about and the role of understanding concepts, excitement and joy of learning/knowing mathematics, experience struggling with difficult mathematics

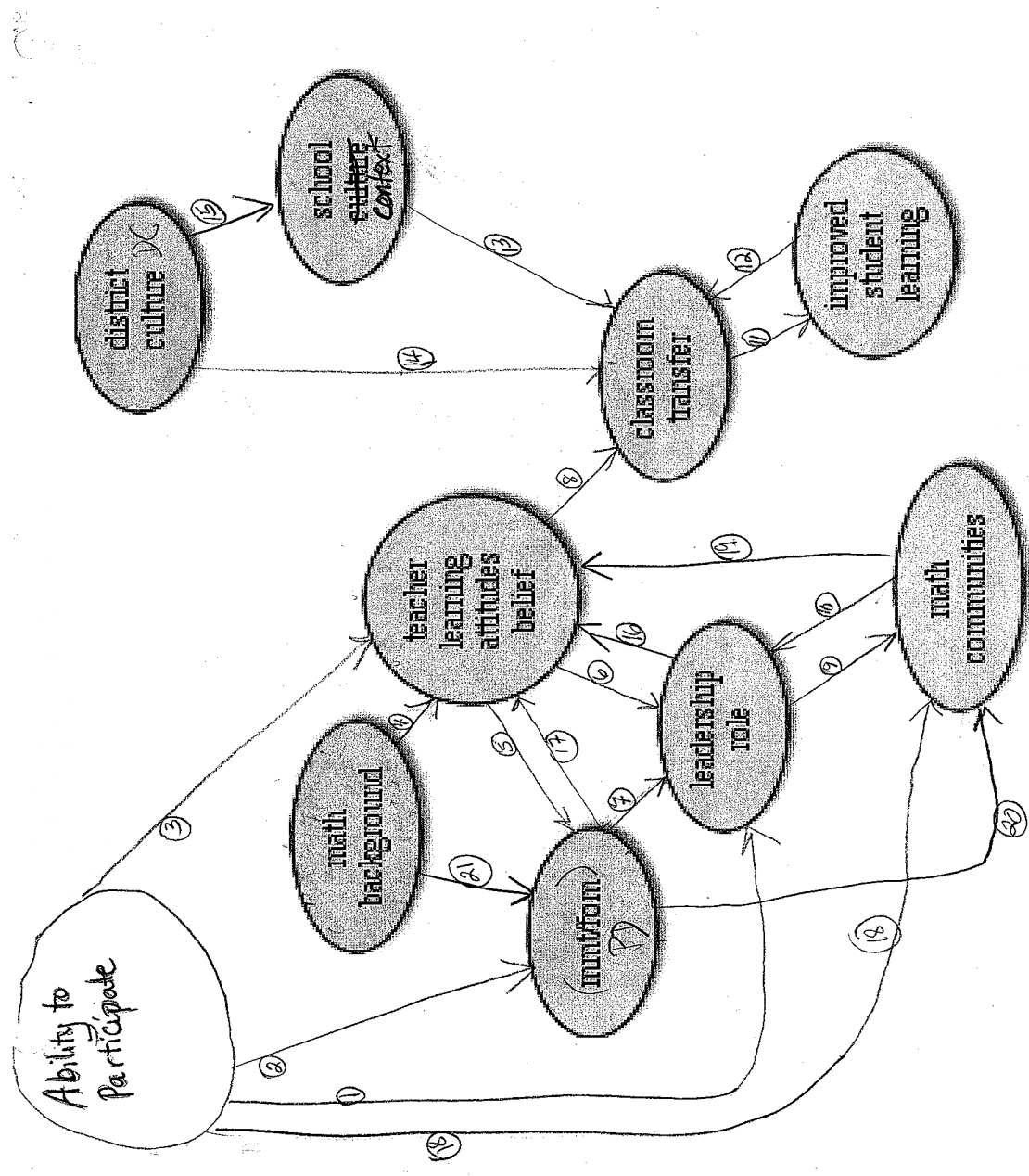
Researchers coded the data in chronological order using Hyper Research. Each researcher coded data relevant to the teachers she had interviewed, plus other data pertinent to that teacher. Reviewing the results, researchers realized the necessity of refining the coding process so that they could disaggregate each code at a finer level.

They began with a visualization of the codes with one per circle, professional development [PD] in the center. (See Figure 1)

Searching for a more systematic way to work with the coded data researchers decided to add arrows to link the circles/codes for one teacher. They revised their method to allow them to describe the interconnections between the codes for a particular teacher, as represented by arrows from one circle to another. Researchers realized that in some cases the arrows went in one direction, while others were bi-directional. While an arrow could represent a negative or a positive link/causality, most were positive. (See Figure 2)

The arrows identified strings of codes with the first code in the string determined by the starting point for the direction of change. For example, a specific data point with arrows from TL to CL to SL indicates that what the teacher learned had an impact on her/his classroom teaching and, subsequently, student learning. Researchers re-coded the Hyper Research report using the strings of codes. The following page represents the first teacher's map.





Classroom Observations

Observation protocol. After reviewing the FoM proposal and several articles authored by the PIs, researchers developed a list of indicators of effective classroom practice. At the same time they reviewed MMTs responses to the interview question, *What would an observer see in your classroom that reflects what you have learned through FoM?* There was substantial overlap between what the PIs wrote and teachers reported, and researchers developed a final list of indicators based on these two sources.

At the same time researchers searched for an observation protocol that was aligned with the project. They reviewed several classroom observation protocols and identified four that were relevant to the work of FoM. Ultimately they made adaptations to, and used the Reformed Teaching Observation Protocol (RTOP) developed by the Arizona Collaborative for Excellence in the Preparation of Teachers at Arizona State University. Researchers modified this instrument by adding selected items from other instruments (the Gates Foundation observation protocol, the Distributed Leadership observation protocol, the Mathematical ACTS Observation Protocol, and the Horizon Research Inc observation protocol for mathematics teachers) based on the information from the PIs and teachers described above. They selected questions that were consistent with FoM's program design and intent, and added three questions of their own. They piloted the initial version in three teachers' classrooms in spring 2006 with a mathematics educator working with FoM. Based on how well each item captured what they felt was aligned with the indicators, researchers subsequently eliminated, revised, and added several items. The final version of the instrument (see Appendix A) included items that addressed lesson design and implementation, content (propositional and procedural knowledge), and classroom culture.

Procedures. Classroom observations of each of the five case study teachers were conducted during mid-winter of 2007. One of the case study researchers and one of two mathematicians involved with FoM observed each classroom (see section above on "Respective Roles of Case Study Researchers"). Researchers prepared observation guidelines for the mathematicians (see Appendix). Each teacher's class (of the same students) was observed for three consecutive days at the beginning of which the teacher introduced a new unit or concept. For each teacher the set of observations was supplemented with pre- and post-observation interviews. When possible, the mathematicians participated in the post-observation interview: This was only possible in those instances when the teacher was available during the following period. At this time the researcher followed the standard post observation interview protocol while the mathematician shared his observations with the teacher and posed questions.

When the teacher was *not* available after class, researchers held debriefing sessions with the mathematicians at the school. The mathematicians suggested specific questions to add to the teacher interview protocol based on their observations. In these situations researchers interviewed teachers at a later time, by phone.

The pre-observation interviews were conducted prior to the first observation day either via telephone or by email. The interviews included questions concerning the lesson to be taught, how it was developed and how it related to the curriculum as a whole.

Researchers asked what, if anything, the teacher had added to the curriculum and why, as well as what the teacher anticipated students would have difficulty understanding. They also asked about the students themselves and any particular instructional strategies the teacher planned to use.

Post-observation interviews occurred following each observation as well as at the end of the set of three observations. The interview protocols that followed observations on days one and two asked the teacher for his or her reflections on the lesson, including perceptions of what the students had learned and what struggles students had encountered understanding concepts. Researcher also asked what changes the teacher had made in the lesson while teaching, and why. Finally they asked how the teacher might teach the same lesson differently in the future. These interviews took place in person immediately after an observation or, when necessary, at a later time via telephone.

The interview following all *three* observations probed a similar variety of topics, as follows, adding others unique to each teacher:

- Did/how did your work with the students differ from what you had planned? What challenges did you face?
- What did you change or do differently than you planned and why?
- What seemed most difficult for the students? What did you do to help students who were struggling with the content?
- What do you think students gained from the three lessons? How can you tell?
- Based on what happened today, what is your plan for tomorrow?
- Is there anything you would do differently the next time you taught this lesson?

The classrooms that were observed ranged from 8 to 27 students who had diverse ethnic backgrounds and understanding of mathematics. In one class the 8 seniors represented 4 different ethnic backgrounds and were taking 2 calculus courses simultaneously. The teacher of another, middle school class described it as a “regular education class” with “no high level thinkers”. Likewise, teachers described their students across a range, from “bright/sharp” to those who struggled to understand new ideas/concepts.

Recording and integration of observation and interview data.

Running notes were taken during each observation to record as accurately as possible the teachers’ and students’ words and actions, including the setting and context of the lesson, materials and instructional strategies used, and student responses and evidence of their learning. These notes were then used to write a summary of the observation relative to each item on the observation scale.

Then, these data were incorporated into an observation series write-up for each teacher, which also drew on the pre- and post-observation interviews. The write-ups described (a)

the lessons to be taught and how they related to the curriculum, (b) the students in each classroom, (c) the classroom setting, (d) challenges anticipated by the teacher, (d) the teacher's strategy for teaching each lesson and any adaptations made, and (e) detailed notes from each of the three days of observation. The mathematician's comments that followed each class as well as the teacher's reflections on how the lesson played out were also included.

Finally, researchers added the rest of the data that accompanied each observation (principal interviews, etc.) to each teacher's protocol and rated it. The mathematicians met with the researchers in order to rate each teacher on those observation protocol items that addressed propositional mathematics content.

Analysis. A preliminary summary rating of each teacher's observation series (that is, based on all three days observed) was made according to the rating scheme in the observation protocol (see Appendix A). Each observation series write-up (see above) was then coded using as codes: (a) the items of the observation instrument, and (b) the codes used for interview data described above. The results of this coding process were used to refine the written descriptions and ratings for each item of the observation instrument. Initially the two primary case study researchers and the research consultant independently coded the same observation series in order to compare codes, discuss their understanding of the items, and establish inter-rater reliability. The two primary case study researchers and the research consultant made final observation ratings. To further assure the validity of the rating process, the remaining three cases were coded by the research consultant and the primary researcher who had not conducted the observation for the teacher in question. These two individuals then compared, discussed, and agreed upon the final ratings.

The rating scheme included two sets of rubrics for rating: one for instances when what was observed matched a protocol item description; and the second, for when it approximated the item. The rating scale included not at all/no evidence of item; some evidence/occurred at least once; occurred about 50% of the time; occurred more than 50%; and item very descriptive/occurred all or almost all of the time.

Principal Interviews

Interview protocol. The principals' interview protocol was based on several two major considerations: prior evaluation data and additional information needed for the case study. As part of the FoM program evaluation the group of MTFs had been interviewed about the leadership roles they envisioned for themselves within their schools and districts. A total of seven principals were also interviewed about (a) teacher leadership within their schools in general, (b) the leadership roles of the MTFs in particular, and (c) the support they provided the MTFs.

By the time researchers interviewed the principals for a second time they had identified additional information needed for the case studies but had not asked previously, in particular in relation to the school context and policies. In addition they wanted to ask

principals again for their perceptions of the case study teachers' teaching and if/how it had changed over time in ways that they attributed to participation in FoM. The final set of interview questions covered: (a) teacher/principal participation in FoM, (b) the principals' observation-based perceptions of each teacher's classroom teaching including any changes over the 2003-2007 period, (c) the teacher's role in school and district leadership, (d) school policies, and (e) the role of the visiting mathematicians from FoM, and (e) the role of the visiting mathematicians from FoM.

Procedures and Recording. The classroom observer interviewed the principal before or following one of the three observations. These interviews took place in the principal's office or a meeting room at the school s/he selected. Researchers recorded the principals' responses on laptop computers during each interview, capturing as much detail in the principals' own words as possible.

Analysis. The principal interview data were coded using the same codes and procedures as were used for the teacher interviews (see above).

Observations of Program Components

PfT counselors' meetings.

During each day of PfT the PfT counselors met as a group and discussed individual teachers including what teachers were doing well, as well as struggling with mathematically. During the first two PfT summers researchers observed these meetings on the days when they observed PfT, and scripted the conversations.

MTF meetings.

PfT and FoM staff held these meetings in order to collect feedback from MTFs participating in the MMT program about a range of issues current at that time. Researchers observed some of these meetings and scripted the conversations on computers, later selecting those comments specific to each case study MTF for analysis.

MTF professional development presentations.

The MTFs presented their research to each other during the PfT seminars at EDC, as well as at colloquia and FoM seminars. When researchers observed these events they took notes.

EDC seminars

Participants in the PfT summer institutes were given the option of attending any or all of 5 all-day seminars held at EDC. Teachers worked on mathematics problems, and listened to visiting mathematicians' presentation as well as each others'. Researchers record group and table-specific conversations on laptops.

Analysis.

All of the observations listed above were coded in Hyper Research, using the same set of codes as described above.

Documentation of Program Activities that Reflected Teachers' Learning Processes

PfT counselors' notes regarding teachers.

During the second and third summers of PfT the counselors wrote notes about individual teachers based on their meetings, and sent them to researchers.

Teachers' BU course reflections.

While taking an Algebra 1 course in CAS, the MTFs simultaneously participated in an SED course that linked the CAS course to the course participants' classroom instruction. One SED course assignment asked MTFs to reflect on the ways in which Algebra 1 informed or would inform their instruction.

Email exchanges.

From time to time the PIs, district leaders or other FoM staff copied the researchers on emails that concerned specific MTFs. The topics ranged from concerns about teachers to comments about a seminar, presentation, or other activity provided by the MTF.

Analysis.

All written materials were coded in Hyper Research along with all other data, using the same set of codes described above.

Integrative Data Analysis and Case Reports

Researchers developed a matrix for each teacher, listing each data source along one dimension and the code strings along the other. Researchers recorded the number of data points for each string as it appeared in the analysis as an indicator of the central themes relevant to each teacher. Finally one researcher wrote the first draft of each study based on the analysis to date. At a later point researchers added observation data.

In the first step of writing the studies each researcher wrote the case concerning the teachers she had not interviewed, observed, or coded in order to assure validity. The researcher who had made classroom observations, however, completed the observation protocols. Initially observations were analyzed and written as separate reports that included all data related to the observations, including interviews. Information from observation reports and completed protocols was incorporated into the final case report as appropriate.