

**Sustaining Improvement Efforts to Deepen
Secondary Teachers' Mathematics Content Knowledge:
The Case of the Texas Middle and Secondary Mathematics Project,
Stephen F. Austin State University's MSP**

November 2010

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Prepared for the
Math and Science Partnership Knowledge Management and Dissemination Project
Horizon Research, Inc.
Education Development Center, Inc.
A Math and Science Partnership Research, Evaluation and Technical Assistance project
Funded by the National Science Foundation

Work on the Math and Science Partnership Knowledge Management and Dissemination Project is funded by the National Science Foundation (EHR-0445398). These writings do not necessarily reflect the views of the National Science Foundation.

Introduction

The National Science Foundation's Math and Science Partnerships (MSP) program, established in 2002, involves science, technology, engineering, and mathematics (STEM) disciplinary faculty and K–12 districts in partnerships to improve the quality of mathematics/science education in the participating districts and to add to the knowledge base for education reform more broadly. More than 100 partnership projects were funded between 2002 and 2009, with plans to continue to support additional projects in the future.

The MSP Knowledge Management and Dissemination (MSP KMD) project is charged with synthesizing what the partnerships are learning in each of a number of key areas, and situating those lessons in the broader education improvement knowledge base. Lessons learned about deepening teacher content knowledge have been a particular focus of the MSP KMD work for two reasons. First, the MSPs have devoted a great deal of effort to the professional development of teachers of mathematics and science. Second, professional development is the intervention of choice in many mathematics and science education reform efforts in the United States, with the expectation that enhancing teacher knowledge and skills will lead to improved teaching and learning. Lessons learned about designing and implementing professional development, especially programs that involve STEM faculty, can enable program leaders to be more strategic in their efforts, using resources more efficiently, and addressing challenges more effectively.

In earlier work, the MSP KMD team developed the “Handbook for Enhancing Strategic Leadership in the Math and Science Partnerships” (Weiss, Miller, Heck, & Cress, 2004¹). That document suggests that strategic leadership in mathematics/science education improvement starts with understanding the system one is trying to improve. Strategic leaders then choose interventions that fit with the needs of that system, and are likely to be effective when implemented with the capacity that the partnership either already has or can develop. But capacity is not enough; at the same time, partnerships need to be sure that the system develops the will to improve, which involves getting key stakeholders on board, and ensuring that teachers get a consistent set of messages—from the partnership and from school/district curriculum, instruction, and assessment policies.

MSP KMD has conducted a series of case studies of MSP projects with the strategic leadership handbook in mind as a framework for understanding the partnerships between school districts and institutions of higher education. The goal was to describe how MSP partnerships were designed to foster sustained improvement in mathematics and science education, the nature of the challenges that these partnerships faced, and how those challenges were addressed, to help inform future efforts at system improvement.

This chapter is one of four case reports; it describes the Texas Middle and Secondary Mathematics Project MSP, a partnership between Stephen F. Austin State University and a number of rural independent school districts in the East Texas region. A cross-case analysis can be found [here](#).

¹ Weiss, I. R., Miller, B. A., Heck, D. J., & Cress, K. (2004). *Handbook for enhancing strategic leadership in the math and science partnerships*. Chapel Hill, NC: Horizon Research, Inc., http://www.horizon-research.com/reports/2004/mspta_handbook.pdf.

Vignette

Paula Johnson is a sixth grade mathematics teacher in a small rural middle school in East Texas. Although she's been teaching sixth grade for five years, this year her principal has asked her to move up to eighth grade. With only three credit hours of undergraduate mathematics in her teacher preparation training, Paula lacks sufficient mathematics content knowledge to teach an eighth grade mathematics class; she is considered under-qualified. Fortunately, her district has partnered with Stephen F. Austin State University on a new Math and Science Partnership project. The university is offering graduate-level mathematics education programs for middle and secondary mathematics teachers.

For the next two years, Paula attends weekend and summer immersion classes on campus with a cohort of other middle school teachers; communicates online with university faculty mentors for additional content support; and leads summer math camps with colleagues for at-risk students. In the end, she is a qualified mathematics teacher with a Master's degree (Master of Science Degree: School Mathematics Teaching), and has established herself as a mathematics teacher leader in her school and district.

The Texas Middle and Secondary Mathematics Project

Texas Middle and Secondary Mathematics Project (TxMSMP) was funded by NSF as part of its Math and Science Partnership program. Starting in 2002, the \$3,691,275 grant was a partnership between Stephen F. Austin State University and 12 rural independent school districts in East Texas serving a racially and economically diverse student population of over 40,000 students.² Original supporting partners included a number of mathematics faculty from other institutions of higher education, including both universities and community colleges within Texas.

The overarching mission of TxMSMP was to improve the mathematics learning experiences and achievement of middle and secondary grade students through high quality, content-focused education programs and to upgrade the knowledge and skills of under-qualified in-service teachers of mathematics at these grade levels. The original Principal Investigator for the MSP, now deceased, was the Chair of the Department of Mathematics and Statistics at Stephen F. Austin State University; other faculty within the department served as the project's co-Principal Investigators.

Although TxMSMP graduate programs focused on both teacher content and leadership development, this case focuses on TxMSMP's efforts to deepen teachers' mathematics content knowledge. The case begins with a description of the context for mathematics education reform in Texas, and provides details regarding the project's goals and plans for the work, and how those plans played out over time. A summary of key factors in the implementation of TxMSMP work on deepening teacher content knowledge, and a discussion of the likelihood of lasting impacts conclude the case.

² Due to the movement of participating teachers to new districts throughout the course of the project, 28 additional districts in East Texas became affiliated with TxMSMP.

The Context for Mathematics Education Reform

When the MSP grant proposal was written, the state of Texas was facing many education challenges, especially in the area of mathematics. Data from statewide testing, district assessments, and course rosters indicated that few students were mastering mathematics concepts and few were pursuing advanced mathematics at the secondary and post-secondary levels. Also, there was an acute shortage of qualified middle and high school mathematics teachers throughout the state; over 40 percent of middle school and 20 percent of high school mathematics teachers in Texas were not certified to teach secondary mathematics. The situation was much the same for districts in East Texas; the teacher workforce there included many teachers who had completed only minimum content requirements to teach mathematics.

Numerous state and national policy changes had been enacted the years preceding the MSP award. College readiness policies were placing new demands on schools and post-secondary institutions. State-level accountability policies for teachers and students were being modified in response to demands of the No Child Left Behind legislation. Revisions to state-mandated curriculum standards and student assessment instruments were in the works, and changes in teacher certification standards and exams meant that some teachers who were certified to teach middle-level mathematics were now considered not qualified according to state and national recommendations for teacher preparation.

Stephen F. Austin State University: A Mission to Prepare Teachers

Stephen F. Austin State University (SFASU), located in Nacogdoches, Texas was founded in the early 1920's with a primary mission of preparing K–12 teachers. Now a teaching university with a broader mission, including both undergraduate and graduate education programs, SFASU has an active and supportive community of administrators and faculty dedicated to providing high quality instruction.

With a long history in teacher training, curriculum development, and providing outreach mathematics services to teachers in the neighbor districts, the faculty in the Department of Mathematics and Statistics share a common interest in mathematics education reform, in particular developing, revising, and teaching rigorous mathematics courses using a range of pedagogies.

Vignette

What may at first glance seem like a typical mathematics department working environment with faculty busy planning for their next class and grading assignments, is actually quite extraordinary. There's a team mentality and cohesiveness here; faculty collaborate in working toward a common goal of providing high quality instruction. Even those faculty members who may lack an interest or desire to participate in a particular program or initiative still show their support for their colleagues and the work to be done because they understand the importance of that work on a broader scale.

What makes this department work so well as a whole? It's the attitudes and expertise of its individuals, and the stability of the group over time. Carrying a passion for their work and an eye on the horizon, the department's leadership abilities and collegial working relationships encourage and enable the transparent collaborative structures and family atmosphere. Working together, they are champions for the cause.

TxMSMP was built on a number of prior mathematics education reform efforts conducted through the Mathematics and Statistics Department, including projects supported by federal Eisenhower and teacher quality programs. The Texas State Middle School Mathematics Project involving SFASU and two other universities overlapped with the early years of the MSP grant. Using a 36 credit hour graduate program in mathematics education as its intervention, the middle school project focused on recruiting elementary teachers to become middle level mathematics content specialists, providing a growth opportunity and an incentive for these teachers to remain in their districts.

The MSP's original PI had been instrumental in previous mathematics education reform work at SFASU. Serving as the Chair of the Department of Mathematics and Statistics, he was described as being "highly influential with mathematics department administration across the state." His résumé included participation in the development of the joint statement regarding the mathematical preparation of teachers from the Texas Association of Academic Administrators in Mathematical Sciences and the Texas Association of Colleges of Teacher Education organization. Two associate professors within the Department of Mathematics and Statistics, both with extensive prior experience in the K–12 arena, would help coordinate the work of the MSP.

Focus, Goals, and Plans for the TxMSMP Work

To ensure district support for the MSP work, the project planned to capitalize on the history of working relationships between SFASU and districts in the East Texas region, and the recognition of a state-wide need for more qualified middle/secondary mathematics teachers. The target population for the MSP was middle and high school mathematics teachers who were under-qualified to teach either middle or secondary mathematics, lacking sufficient mathematics content knowledge to be effective mathematics teachers. Working with this teacher population addressed an important need in the region; it was a natural extension of SFASU's work with elementary teachers, and would bring in a new set of graduate students to the university.

The goals of the MSP grant were to deepen teachers' understanding of targeted core mathematical ideas; why that knowledge is important for their mathematics teaching; and how that knowledge applies to their mathematics instruction, with the ultimate purpose of improved

student performance in mathematics. Three primary intervention strategies were planned for meeting these goals: (1) graduate degree programs consisting of a series of mathematics courses, leadership and mentoring courses, projects, portfolios, and exams; (2) mentoring by university mathematics faculty; and (3) teacher involvement in summer mathematics enrichment opportunities for middle and high school students in their respective school districts. Opportunities for individualized remediation would also be provided to participating teachers on an as-needed basis in order to ensure their successful completion of the program.

TxMSMP funds would cover the cost of participant tuition at the rate of \$800 per course for 12 courses, travel expenses, and a summer stipend of \$70 per day for the 2½- or 3- week summer coursework. Salaries for staff to facilitate the graduate courses, serve as mentors, and assist with summer enrichment institutes would also be covered. Other incentives for faculty would include either release time (25 percent) or additional compensation for course development. Furthermore, to compensate for Saturday courses, participating mathematics faculty would be encouraged to take one day off during the Monday through Friday regular weekly schedule.

The plan was to serve 60 middle-level mathematics teachers (two cohorts of 30 teachers) and 30 secondary-level mathematics teachers (one cohort), with the idea that the teachers who completed the programs could provide mathematics leadership to others back in their school districts. In each participating district, a district coordinator was identified to work with the project by nominating and recruiting candidates for the degree programs. Across the districts, a variety of administrators, mathematics/curriculum coordinators, and department chairs might serve in this role. By involving the district coordinators in recruitment, an anticipated benefit was that at least one decision-maker in the district was aware of the experiences participating teachers would have throughout the degree program to develop expertise and leadership, so that these teachers could be tapped for new responsibilities in their school and districts.

In addition, stakeholder support would be built by involving key district administrators in professional development seminars held on the SFASU campus twice a year, providing progress updates and information regarding best practices in mathematics teaching. It was anticipated that the district coordinators would take advantage of these opportunities, and other school and district administrators would also be invited to participate.

Graduate Degree Programs

The mathematics graduate programs at Stephen F. Austin State University were designed for under-qualified in-service middle and high school mathematics teachers. Teacher participants seeking middle grades qualification (grades 4–8) would complete a two-year program, including 27 credit hours of mathematics content and 9 credit hours of educational leadership and mentoring. Secondary teacher participants seeking grades 8–12 qualification would complete a three-year, 36 credit hour program, which included a 6 credit hour capstone sequence addressing leadership and mentoring.

The graduate programs were developed in the College of Sciences and Mathematics, in cooperation with the Department of Secondary Education in the College of Education at SFASU, and following the recommendations set forth by the Texas Association of Academic

Administrators in Mathematical Sciences and the Texas Association of Colleges of Teacher Education.

The design of TxMSMP's graduate degree programs was based on the project team's beliefs about effective professional development: an on-going program of study that provided in-depth and connected experiences with mathematics content was a more effective model than one built on isolated workshops. Explained a co-PI:

[The PI] and I began to team teach under [the previous] funding opportunities, the Eisenhower and the teacher quality, working with K–12 teachers. We realized that what [teachers] needed was sustained experiences. They needed more than just workshops. They needed more than just three weeks in the summer. They needed a sustained program of study. So what we as higher education mathematics faculty began to build were courses that...would address the [mathematics] content deficiencies.

Courses would focus on topics such as number concepts, algebra, geometry, statistics, pre-calculus, and logic and proof. Both the middle and secondary level programs would also require the completion of a teaching portfolio designed to help teachers apply their mathematics learning to classroom practice, and demonstrate mastery of the teaching standards for master mathematics teachers. Each portfolio was to include a selection of artifacts of teachers' mathematics work and classroom instruction (e.g., lesson plans, student work), as well as reflections on their teaching. A final component demonstrating growth in mentoring and leadership skills would also be included in the portfolio.

The graduate programs were to be implemented on SFASU's campus using a cohort design structure. During an academic semester, participating teachers would be required to attend classes for 4–5 weekends, referred to as immersion weekends; they would also participate for 2–3 weeks during the summer sessions. This immersion schedule was planned for three reasons: (1) SFASU wanted to offer the courses on campus as part of a structured program of study; (2) some teachers saw it as appealing to come to campus; and (3) it played to the strengths of the cohort design to have the teachers together periodically for the intensive mathematics experiences.

In order to develop and execute the graduate degree programs, the project team planned to engage SFASU mathematics faculty in a team teaching model. Mathematics faculty participating in the MSP would be assigned to teach the graduate courses as part of their regular teaching load within the department, working closely with the PI and co-PIs in course development and instruction for both graduate programs. The project team also planned to recruit faculty from the College of Education to develop, oversee, and implement the teacher leadership and mentoring component of the degree programs. To help foster a cohesive partnership between the mathematics and secondary education department, the project PI planned for ongoing collaborative project meetings. During these meetings, faculty would have opportunities to share their expertise and ideas about program revisions.

University Mathematics Faculty Mentoring

The program design for both graduate programs included a university mathematics faculty mentoring component to provide additional mathematics content support for teachers beyond what they experienced in their coursework. To staff this mentoring piece, the MSP leadership team intended to recruit faculty members from other institutions of higher education in Texas in order to educate and influence science, technology, engineering, and mathematics (STEM) disciplinary faculty state-wide. Their training would include conferences and seminars focused on key issues in mathematics education.

The mentors would be assigned groups of 10 participating teachers from each graduate program, middle and secondary. Their responsibilities would include corresponding with their mentees via email and web-based course tools; facilitating interactions with participants between sessions on the university campus; and attending course sessions as often as possible in order to engage in face-to-face discussions with groups. Said a co-PI about the intent of the mentoring component:

[The university mathematics faculty mentoring component] really was to get university faculty who were content-rich in their background both to lend support to the program, but also to get a window into the secondary and middle school issues with which university faculty are often unfamiliar.

Summer Enrichment Institutes

To further help participating teachers translate their mathematics learning to their instruction, and to develop their leadership capacity, the project planned to sponsor optional one-week summer enrichment institutes—referred to as math camps—for mathematically at-risk middle and high school students in the partner districts. The camp materials would be co-designed by a team of project leaders and participating master teachers and based on an investigative approach. Teachers in the programs would be trained to lead the math camps using the developed materials and then paired with a non-MSP mathematics teacher to implement them. Said a co-PI about the goals of the summer camps:

Not only did we want [the participating teachers] to be able to work with kids in that...nonthreatening, no-risk environment with discovery learning activities, we wanted [the participating teachers] to mentor [other] teachers who had been in the pipeline or in the teaching field for a while and let them see the kinds of things that could bring about the mathematical ideas without hammering it into the students. We also wanted [the teachers] to take those pieces [from the summer camp material] and infuse those tasks into their daily instruction. In other words, we wanted that to become routine for [the teachers].

TxMSMP in Action

The three planned interventions—graduate degree programs, faculty mentoring, and summer enrichment institutes—were developed and implemented over the course of the five-year funding period and a one year no-cost extension. Various modifications were made to the interventions

as they were implemented in order to meet the participating teachers' content knowledge needs and in preparation for transitioning to the degree programs as the grant funding ended.

Descriptions of how each intervention played out over time are provided in the sections below. The detailed information included about the graduate degree programs reflects the fact that those programs served as the primary strategy for deepening teachers' mathematics content knowledge in TxMSMP.

Developing the Graduate Degree Programs: The Power of Creativity

Work on the development of the degree programs and course syllabi began in the fall of 2002. The coursework that had been used in the NSF-funded Texas State Middle School Mathematics Project served as the starting point for TxMSMP's middle level curriculum, with modifications made in order to align the courses with recent policy changes, capitalizing on newly-available resources. The resulting curriculum for the middle-level degree program focused on number and operations, quantitative reasoning, algebra, geometry and measurement, and probability and statistics content. At the secondary level, the focus was on pre-calculus, advanced calculus, advanced algebra, geometry, probability and statistics, and logic and proof.

During the development of the middle and secondary level coursework, the project team encountered some concerns from the Department of Mathematics and Statistics regarding the labeling of the mathematics courses. Mathematics faculty resisted using a mathematics prefix (MTH) for graduate-level courses that didn't target the same advanced level of mathematics content addressed in other graduate-level mathematics courses in the department. To resolve this issue, mathematics faculty, in cooperation with SFASU's College of Education, decided to deliver the courses under a graduate-level mathematics education prefix (MTE) instead. This decision was based on the belief that "although the mathematics presented is not graduate-level mathematics, the students (in-service teachers) are graduate students."

Once the courses were developed, the next step was to work with the university and the Texas Higher Education Coordinating Board to establish the Master of Science Degree: School Mathematics Teaching programs at SFASU. Rather than creating a totally new degree program, with the extensive approval process that would be required, the project team resurrected an existing inactive degree program—Master of Science in Teaching—swapped out the courses on a one-to-one basis, and renamed it. Said a co-PI about this plan:

The [Master of Science in Teaching] was a program that was on the books, but it was not being utilized. We negotiated with the coordinating board to trade in the Master of Science in Teaching for this Master of Science in School Mathematics Teaching. We renamed it and then made it pertinent to middle or secondary levels...It was a good trade.

After a year of development work, the programs were approved by the Texas Higher Education Coordinating Board. As a result, teachers taking part in the MSP would pursue their Master's degrees through a graduate major in School Mathematics Teaching at the Middle or Secondary Level at SFASU.

Implementation of TxMSMP's degree programs began in 2003. As planned, the project leadership team worked closely with the rest of the faculty to co-plan and co-instruct the middle/secondary content courses. Integrating content and pedagogy and modeling effective mathematics instruction were key components of course implementation. Mathematics and education faculty also met on a regular basis to discuss the status of the programs, necessary revisions for improvements, and next steps.

The content and leadership and mentoring curriculum for the graduate programs remained fairly stable over the life of the MSP project, with the exception of one preparatory content course from each program. After analyzing the mathematics content pre-assessment scores from the first middle and secondary cohorts, and taking stock of students' experience in their initial courses, the project leaders recognized that the level of content knowledge of the in-coming middle/secondary grades teachers was lower than originally anticipated. To meet these unexpected content needs, the project team modified both plans of study to include more preparatory work at the front end. Explained one project leader:

With the first group [of secondary teacher participants], we realized that one pre-calculus course, one semester, was not enough. They needed to go further back...so we plugged the holes where we could with the first group. With the second group, we spread out the pre-calculus content over two semesters. Now, what that meant was that something else had to go. So we did some creative consolidating of content within existing courses and stayed within the required number of hours.

Realizing early on that some of the teachers accepted into the two graduate programs were not sufficiently prepared to successfully complete their program, the project leaders tightened the selection criteria for the second round of program applicants. Although the changes might mean that the project would end up accepting fewer teachers into the program, it was expected to reduce the number of teachers dropping out of the program. Described one of the co-PIs:

One thing we've learned is that there can be a teacher who is so under-qualified, that we can't help them in this type of program. And we did have some of those. We had to take them off of degree-seeking status. It was difficult to do, but the lesson learned was that we had to tighten our selection criteria.

The need for another content-related program modification was highlighted in 2005 when fewer than 50 percent of the first cohort of middle grades teachers passed the Texas Master Mathematics Teacher Certification exam. Rather than making further changes to the coursework, the project leaders focused on improving remediation efforts for teacher participants who chose to take the exam. Specifically, teachers had to: (1) attend a series of review and study sessions during the last two semesters of their coursework to help fill gaps in their understanding of the targeted content; (2) take a practice exam; and (3) score at least 80 percent on their comprehensive exam. The project team offered additional remediation sessions in the summer to teachers who did not make the comprehensive exam cut-off score.

As the MSP progressed, project leaders made the decision to change the coursework delivery schedule from immersion weekends that consisted of Friday and Saturday six-hour sessions once

a month to an all day Saturday delivery every third Saturday of the month. The rationale for this alteration was two-fold. First, it was a way for the project to cut expenses on lodging, travel, and child care. Second, having courses solely on Saturday eliminated the need for teachers to be absent from their classrooms.

As the five-year funding period was coming to an end, the project saw a continued interest and need for TxMSMP's work and took a one year no-cost extension to work with additional cohorts of teachers. During this time, course materials were also packaged and made transportable for broader scale implementation outside of SFASU. Furthermore, the PI began networking with other universities within the state with the hopes of partnering with them on similar mathematics education efforts.

Around the same time, a new Provost and a new Dean of the College of Sciences and Mathematics were appointed at SFASU. Both had prior connections with the university, knew the PI, and were familiar with the project goals. As a means to "research, develop, implement and disseminate best practices in STEM education," the administration and project PIs proposed a STEM Research and Learning Center for the SFASU campus. The assumption was that this center would serve as a structure for housing the continuation of TXMSMP's work as well as other mathematics and science education reform efforts in the future.

With the death of the project's PI in 2007, the leadership team had to reorganize in order to continue TxMSMP's work. One of the project's co-PIs became the new PI of the project. In 2008, she also took on the roles of Associate Dean of the College of Sciences and Mathematics and director of SFASU's STEM Research and Learning Center. The other co-PI was unanimously voted by the Department of Mathematics and Statistics faculty to become the department's Chair. To further ensure capacity of the department to carry out the mathematics education graduate program work, the university hired another mathematics faculty member who became a co-PI of the project. This new faculty member was familiar with the MSP through her earlier participation as one of the non-SFASU university faculty mentors and came into the department well-respected by her faculty peers.

University Faculty Mentoring: A Long Distance Relationship

Recruitment of mathematics faculty to serve as content mentors for the participating teachers engaged 32 faculty members from a number of Texas colleges and universities; 24 of those also supported the summer enrichment institutes. Orientation for the content mentors included conferences and seminars focused on professional development; they also examined curriculum and certification standards for teachers, national and state recommendations for teacher preparation, and current best practices in mathematics education. As planned, university faculty mentors worked with participating teachers during the first year of the program to provide additional content support. Interactions consisted of some face-to-face discussions during course sessions on campus as well as online correspondence.

After the first year of implementation it was determined that the faculty mentors were not being utilized by the participating teachers as much as the project had originally anticipated. As one former mathematics faculty mentor explained, "The secondary group never needed me... They were more cohort dependent and mentor independent."

At this point, the project believed that it had made good progress toward its goal of influencing higher education faculty. The team leaders decided to discontinue the use of mathematics faculty mentors, and instead opted to involve their own mathematics graduate students, who would be asked to communicate with the teachers on a weekly basis. The project leaders believed that by involving graduate students in TxMSMP, they would be able to extend the project's impact on mathematics teaching and learning at the post-secondary level, and understanding of issues at the middle and secondary levels, by helping to prepare the next generation of college and university mathematics faculty.

Summer Enrichment Institutes: A Connection to Practice

As planned, summer enrichment institute materials were developed by project leaders and participating master teachers using various existing resources. Over the course of the project, the curriculum for the summer institutes went through multiple iterations, including the development of student materials at the middle and secondary levels, the inclusion of the Texas Essential Knowledge and Skills objectives; and the development of facilitator and teacher materials and adaptations for classroom use.

Implementation of the summer enrichment institutes, commonly called math camps, began in 2004, involving roughly half of the teachers who were enrolled in TxMSMP's graduate programs. Teachers who volunteered to conduct a summer enrichment institute in their schools/districts participated in an intensive two-day training experience focused on mathematics content and pedagogical issues. This training consisted of an overview of the summer enrichment institute philosophy, schedule, and method of operation, and a grade-level specific orientation and discussion of the curriculum goals and activities. Each teacher was given materials and supplies for planning the camp experience, with on-site assistance and on-going support from the project personnel. Participating teachers were also encouraged to engage a mathematics teacher colleague from their school or district who was not participating in TxMSMP's degree programs to collaborate in planning and implementing the math camp. Project leaders and district representatives reported that teacher and student participants across the board considered the math camps "a worthwhile and rewarding experience."

Despite this initial success, over the course of two years the level of high school student participation declined, reportedly due to conflicting schedules and commitments (e.g., summer jobs, athletics). According to a co-PI, the summer enrichment institutes for the secondary students were "not practical" so the project discontinued them. The project was able to continue to offer math camp opportunities for participating secondary teachers by adjusting their institute curriculum to an 8th grade level and pairing the secondary teachers with middle level teachers. Opportunities for high school teachers to connect their learning to practice were also maintained through the modeling and discussion of effective mathematics instruction offered during coursework and the creation of a teacher portfolio as a requirement of the degree programs.

In 2007, after multiple revisions, the middle-grades summer enrichment curriculum materials were finalized for publication and dissemination.

Key Factors in the Implementation of TxMSMP

Capitalizing on a the prestige of an NSF award; the opportunity to make a fundamental impact on mathematics teacher preparation and student learning; and existing partnerships, structures and resources; TxMSMP project staff worked diligently to create high quality graduate degree programs in mathematics aimed at deepening teacher content knowledge. The following specific factors were key in TxMSMP's experience:

- Attending to the clear need for more qualified mathematics teachers ensured initial buy-in and ongoing stakeholder support at multiple levels.
- Both the prestige of the grant and the fact that it built on prior working relationships were essential for maintaining ongoing efforts to deepen teachers' mathematics content knowledge.
- Efforts to anticipate and address university/faculty resistance from the get-go were essential for the institutionalization of the mathematics courses and degree programs.
- The cohesive nature and team work mentality of the mathematics department, along with the collaborative partnership fostered between the mathematics and education departments facilitated the development and maintenance of high quality programs to deepen teachers' mathematics content knowledge.

Attending to the clear need for more certified and qualified mathematics teachers ensured initial buy-in and ongoing stakeholder support at multiple levels.

Securing initial support of key players and maintaining that support is critical for the success of any large-scale reform. By attending to the need for more qualified mathematics teachers, TxMSMP succeeded early in getting the commitment of state-, university-, and district-level stakeholders, and maintaining their support over time. Motivating factors for proposing the grant were changes in state-level accountability policies for teachers and students, including new teacher certification standards and exams and state mandated curriculum standards and assessment instruments for students. The MSP's graduate program model lent itself to providing middle and secondary mathematics teachers with the sustained, in-depth mathematics content experiences necessary to achieve these new standards.

Not surprisingly, the state curriculum standards, revised assessments, teacher certification standards, and college readiness guidelines continue to drive the mathematics education reform efforts in Texas, which in turn, continues to drive TxMSMP's work with teachers.

Garnering district support for participation in TxMSMP was also necessary, although not a difficult task in this case. The need was there; many, if not all, of the partner districts suffered from a shortage of qualified middle/secondary grades mathematics teachers, and reported low student performance on state-mandated mathematics assessments. Building school/district teacher leadership capacity was yet another need of districts within the East Texas region.

Some partner districts provided release time and substitute coverage as incentives for teachers to participate in the grant. In one case, a district paid teachers an extra \$300 per year for having a Master's degree. However, other partner districts disengaged from the project, reportedly due to

“a severe lack of commitment within the district at both the administrative and instructional levels.”

Both the prestige of the grant and the fact that it built on prior working relationships were essential for maintaining ongoing efforts to deepen teachers’ mathematics content knowledge.

Stakeholder and policy support at the university level was already fairly well established prior to TXMSMP. SFASU’s history and mission as a teacher’s college, and mathematics faculty’s experience with, and commitment to, teacher preparation, made the university well-suited for leading the efforts to deepen teachers’ mathematics content knowledge. As one university administrator described, “it was a match made in heaven.”

The prestige of being awarded federal grant money to conduct work in line with the university’s mission was a major factor in gaining university-level support. Through this grant, the university was able to expand its services and attract a new pool of graduate students.

SFASU administrators and faculty were supportive of the project’s continued efforts to better prepare mathematics teachers, seeing it as necessary for meeting new demands such as those of the state college readiness initiative. As the Mathematics and Statistics Department Chair, the PI of TxMSMP was able to offer faculty time to work on the grant as well as merit pay and credit toward tenure and promotion for working on the grant, support that his successors have continued. The recently-appointed Dean of the College of Sciences and Mathematics was an influential proponent of the project, seeing the MSP as a building block for future mathematics and science education reform efforts at SFASU.

Prior to TxMSMP, some of the partner districts had a history of working with SFASU and viewed the university as a valuable professional development resource for their teachers. One co-PI of the project had also served as a mathematics consultant with several nearby rural school districts, conducting in-service teacher training, and developing K–12 mathematics curriculum.

From the start, TxMSMP project leaders strengthened the established partnerships with the districts and gained additional district level support through bi-annual administrator professional development seminars focused on best practices in mathematics teaching and classroom evaluation. In general, administrators viewed the improvement of mathematics teaching and learning as a top priority on their district agendas.

Efforts to anticipate and address university/faculty resistance from the get-go were essential for the institutionalization of the mathematics courses and degree programs.

The institutionalization of the mathematics degree programs and mathematics courses as official components of SFASU’s graduate program curriculum was a critical step in facilitating future efforts to deepen teachers’ mathematics content knowledge. Early on, the project team avoided potential barriers by refining an existing curriculum, changing course prefixes from mathematics (MTH) to mathematics education (MTE), and replacing a defunct degree program with the new program. In addition, course adjustments were made to better meet the participating teachers’ content needs.

The cohesive nature and team work mentality of the mathematics department, along with the collaborative partnership fostered between the mathematics and education departments facilitated the development and maintenance of high quality programs to deepen teachers' mathematics content knowledge.

The Department of Mathematics and Statistics' cohesive nature and active support formed the foundation for developing the capacity to conduct TxMSMP's work. The stability, cohesiveness, and expertise of the department enabled sustained mathematics education reform efforts at the university.

As planned, project leaders used a team teaching approach to train SFASU mathematics faculty in course development and facilitation. As the chair of the department, the project PI had the ability to adjust faculty loads and use the financial support from the grant to accommodate this approach. Pairing with other faculty members, the project leaders worked to create, plan, and deliver the middle and secondary content courses. As the grant funding became more limited, the team-teaching model was eventually eliminated. However, there was sufficient capacity developed by that time so that individual faculty members would be able to continue to teach the courses well.

Another factor that contributed to the development of high quality programs was the positive working relationship that was fostered between the Department of Mathematics and Statistics and the Department of Secondary Education and Educational Leadership at SFASU. Mathematics and education faculty shared a common vision and commitment to improving mathematics teaching and learning. With a clear goal in mind, the division of responsibilities established from the beginning, and a mutual respect for each other's ideas, faculty from the two departments worked together on an ongoing basis to develop and revise the graduate programs.

According to the chair of the secondary education department, it was the project's leadership abilities that encouraged and enabled the collaborative structures that were formed throughout the life of the project:

So, I think the first thing for [the project] to [be] sustained and keep going, you just have to have that leadership all the way up and down the road. And we have that. I think for any partnership you have to continue to have the collaborative structures. Now that's part of that leadership, but [it's also] putting those structures in place where people are meeting on a regular basis to talk about "what do we do next and how do we make this happen".

Likelihood of Lasting Impact

TxMSMP's legacy continues. Over six years, the project created a solid infrastructure and developed the necessary capacity to continue its graduate degree programs to deepen the mathematics content knowledge of teachers in East Texas. TxMSMP's leaders and participants described their hopes for the work beyond the funding period; their views, as well as initial evidence of what is likely to be sustained are shared below.

Graduate Degree Programs at SFASU

As noted earlier, critical steps were taken during the grant to institutionalize the middle and secondary courses and degree programs at SFASU in hopes of continuing to serve additional in-service middle and secondary mathematics teachers. Said the co-PI:

We have institutionalized each course... they are all on the books. I think that is a great sustainability issue in that the courses and degree programs are in place.

The commitment and personal motivation of the mathematics faculty to continue work on the project is evident. However, despite having the courses in place and the faculty to deliver them, it is unclear whether enrollment in those courses would be maintained without additional funding to pay tuition costs. As the grant was ending, the PI looked into a number of external funding sources.

In June 2009, SFASU leveraged additional funding from the Texas Higher Education Coordinating Board, merging it with the Colleges of Science and Mathematics graduate assistant funding to provide a track for teachers who not only wanted to become Master Math Teachers, but also wanted to transition into a M.S. in Natural Sciences. The track was 18 credit hours of TxMSMP's graduate mathematics education coursework combined with 18 graduate mathematics hours. Since both secondary mathematics and science teachers were recruited in this effort, SFASU science faculty designed a parallel track in science education courses, followed by graduate science courses in discipline, giving teachers the opportunity to receive a Master Math or Science Teacher status and deliver dual credit instruction within their districts. Funding to support a second cohort of teachers was secured in 2010.

The original TxMSMP graduate courses were still offered at SFASU in 2009–10, reaching middle and high school teachers across approximately 40 districts in the East Texas region. According to the PI, the courses in highest demand were those of a capstone nature, aimed at preparing teachers for the Master Math Teacher Certification. Additionally, 10 teachers were receiving instruction and support in further development of leadership abilities as master teaching fellows at SFASU.

Broader Scale Implementation and Impacts

In addition to having the graduate courses take root at SFASU, TXMSMP had initial intentions of creating an infrastructure that increased the likelihood that future mathematics education reform efforts would be initiated beyond the university. Although the attempt to develop university faculty capacity beyond SFASU did not take hold during the grant, the course materials were packaged and made accessible to other faculty outside of SFASU for more broad scale use. According to the co-PI, places such as the Region 7 Service Center, Sam Houston State University, Texas State University, University of Texas Tyler, and Abilene Christian University have been utilizing these materials.

Impacts on Pre-service Education

The project's recognition of the need for better prepared mathematics teachers elicited additional discussions among administrators and faculty within the Department of Secondary Education about adopting the UTeach model for pre-service teacher education, an innovative, widely-

respected teacher preparation program based on national standards and education research. Conversations between the Department of Secondary Education and the Department of Mathematics and Statistics about adopting the UTeach model are continuing as elements of the model are already being introduced. For example, in order to connect students' pre-service preparation more closely to secondary mathematics classrooms, students enrolled in the teacher preparation program are participating in professional development experiences led by graduates of TXMSMP that are continuing their leadership development as Master Teaching Fellows.

On-going Impacts on Teachers and Teaching

Meeting a state-wide need, TxMSMP provided quality graduate degree programs for over 100 under-qualified in-service middle and high school mathematics teachers using a cohort design structure that included in-depth and connected experiences with mathematics content. The program also focused on developing teachers' leadership capacity so they could serve as mathematics teacher leaders in their schools/districts after the grant funding ended.

Project leaders were able to point to evidence that TxMSMP had a positive impact on its participating teachers' mathematics content knowledge and instructional practices. For example, near the end of the grant, participants reported gaining a more in-depth understanding of mathematics content, a better understanding of where they want their students to go with that content, and the knowledge of how best to structure and facilitate that learning. In addition, data from observations and portfolios suggested that teachers internalized master's mathematics teaching standards, and were incorporating both content and pedagogical recommendations in their mathematics classrooms.

In some cases, district representatives noted that their districts were seeing substantial benefits from the leadership provided by the teachers who had participated in TxMSMP. In other districts, teacher mobility had limited the extent to which the districts were able to capitalize on the capacity built through the project. However, according to a project leader, even though teachers are moving out of their respective districts, they are generally staying within the East Texas region, including parts of the Dallas and Houston areas. Overall, it is believed that approximately 90 percent of teachers who participated in TxMSMP have remained in East Texas.

Districts in the East Texas region continue to value their partnership with SFASU and remain interested in further collaborations with the university. Unfortunately, without financial means to cover tuition costs and supplies, continued district involvement of teachers in the Master's program is uncertain.

Closing Thoughts

Fulfilling a state-wide need, capitalizing on a university's rich history and reputation in teacher preparation, and strengthening the capacity and infrastructure already established through prior mathematics education reform efforts, the Texas Middle and Secondary Mathematics Project created, refined, and is implementing potentially powerful graduate degree programs to deepen teachers' mathematics content knowledge and improve classroom practice. Critical steps were

taken early on to design the coursework and eliminate possible barriers, and negotiations were made with key stakeholders to help ensure the institutionalization of the degree programs at Stephen F. Austin State University. Additionally, further capacities at the university were developed through a team-teaching approach, course materials were codified, and structures were proposed and set in motion for sustaining the work in the future. Districts have seen promising impacts from participating in TxMSMP and continue to seek out similar opportunities to improve mathematics teaching and learning in their schools.

Despite meeting a growing need and having capacity, incentives, and a physical location in which to house the mathematics professional development opportunities for teachers, the lack of funds to continue mathematics education reform efforts is a major obstacle to sustainability of TxMSMP's efforts. Clearly, the continuation and success of at least part of TxMSMP's legacy will depend on continued funding from external sources.