

**Preparing Teachers for  
Formal and Informal Leadership Roles:  
The Case of Nebraska's Math in the Middle MSP**

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*It was 10:15 in the morning, and district mathematics coaches Kendra Lucas and Evette Blackman<sup>1</sup> were two hours into leading a half-day mathematics content workshop for all sixth-grade teachers in their district. Lucas and Blackman both completed the two-year Math in the Middle Institute, a graduate program focused on developing their mathematical knowledge for teaching. Recognizing their knowledge and skills, their school district hired them to fill two new mathematics coaching positions created this year. As coaches, Lucas and Blackman are released from classroom teaching responsibilities to work with teachers of mathematics in grades 3-9, using strategies such as helping them plan and lead instruction, modeling and co-teaching, and providing professional development.*

*In the workshop they were leading, Lucas and Blackman put the sixth grade teachers into groups and gave each group a handout called the “Rabbit Fencing” activity. This activity was typical of the problems Lucas and Blackman often worked on in their own Math in the Middle courses: problems designed to help develop mathematical “habits of mind” in which teachers were asked to engage in solving challenging mathematic problems as a mathematician would. Lucas and Blackman facilitated the activity in much the same way that their university instructors had done when they participated in Math in the Middle, asking teachers questions to elicit the techniques they used to solve the problem. In the “Rabbit Fencing” activity, Lucas and Blackman demonstrated the same kinds of questioning strategies that teachers could use with their students to assess their understanding of mathematics. While Lucas and Blackman had been hired into coaching positions in their district, several other Math in the Middle graduates had applied what they had learned through the program as they continued with their full load of classroom teaching responsibilities. They had emerged as informal leaders in their schools, leading team meetings, providing advice and guidance about mathematics instruction to other teachers or working with their principals to create other opportunities to work with their colleagues.*

## **INTRODUCTION**

Nebraska’s Math in the Middle Institute<sup>2</sup> was launched in fall 2004 with funding from the National Science Foundation’s Math and Science Partnership (MSP) initiative. MSP support for Math in the Middle project activities was originally funded through 2009: two supplemental grants support the partnership through summer 2011. Math in the Middle is a partnership of the University of Nebraska-Lincoln (UNL) and several of Nebraska’s Educational Service Units (ESUs)<sup>3</sup> and school districts across the state. Co-principal investigators (PIs) for the project were University of Nebraska-Lincoln faculty members W. J. “Jim” Lewis of the mathematics department (and director of UNL’s Center for Science, Mathematics, & Computer Education), and Ruth Heaton and Tom McGowan from the teacher education department, as well as the curriculum director for Lincoln (NE) Public Schools, Barbara Jacobson.

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<sup>1</sup> Pseudonyms are used in all vignettes, which are based on accounts of Math in the Middle project leaders and participating teachers.

<sup>2</sup> The official title of the project is the Math in the Middle Institute Partnership. Throughout this case, the project is referred to as Math in the Middle.

<sup>3</sup> ESUs are intermediate level school districts that support local schools and districts with services and products such as curriculum support and professional development.

The vision of Math in the Middle was to educate and support mathematics teacher leaders in grades 5-8 to become intellectual leaders in their school, districts, and regions, with a special emphasis on supporting rural schools and districts. Key goals included:

- Enrich participating teachers' mathematical knowledge;
- Assist teachers in transferring mathematical and pedagogical knowledge learned in Math in the Middle into the mathematics courses they teach;
- Create communities of professionals (linking mathematics teachers to each other and to university mathematicians and mathematics educators) who communicate regularly with one another; and,
- Develop intellectual leaders who mentor their colleagues' efforts to strengthen mathematics courses and curricula.

Project leaders who created Math in the Middle envisioned a program that would prepare teachers as intellectual leaders of mathematics by strengthening their knowledge of mathematics and the teaching of mathematics. A key strategy was to develop teachers who possess the "habits of mind of a mathematical thinker" and who would seek to develop similar abilities in the students they taught. Habits of mind refers to a way of thinking about and approaching mathematics as mathematicians do, viewing mathematics as a process rather than a set of procedures and correct answers (Cuoco, Goldenberg, & Mark, 1996). Project leaders believed that this focus would enable teachers to teach challenging mathematics courses and prepare teachers to serve in leadership roles suited to their particular situations, whether as informal leaders within their own classrooms, schools, and districts or as formal mathematics teacher leaders with defined responsibilities. Because many of the teachers with whom the project worked taught in small schools and districts with only a few mathematics teachers, project leaders sought to create a community of skilled middle level mathematics teachers who could serve in a variety of leadership roles. Whether formal leadership roles would be available to Math in the Middle graduates would be determined by individual district partners.

This case describes how the development of the knowledge and skills for teacher leadership in Math in the Middle was applied in formal and informal leadership roles. The case begins by sharing the context for mathematics teacher leadership in Nebraska, followed by a description of the partnership and of the strategies used by Math in the Middle to achieve its goals. This information is followed by a discussion of the key issues identified by the project leaders as shaping the design and implementation of the program, as well as the leadership roles of participants. The case concludes with a discussion of the sustainability of the teacher leader program implemented through Math in the Middle.

## **Description of the Math in the Middle Partnership**

Math in the Middle is a partnership of the mathematics and teacher education programs at the University of Nebraska-Lincoln (UNL), the Lincoln Public Schools, Nebraska's 14 rural Educational Service Units (ESUs) and the local school districts served by those ESUs. Over 60

local school districts were considered partners by virtue of supporting participation of one or more teachers in Math in the Middle.

In the partnership, the university PIs took leadership in developing and hosting the Math in the Middle Institute which consisted of graduate courses leading to a master's degree. A mathematics leadership team was formed which was comprised largely of UNL faculty from the departments of mathematics, statistics, and teacher education, with some local school district representation. This team planned the graduate curriculum and identified faculty who would develop and teach the institute's courses. Funds from MSP and UNL were used to support this portion of the work.

Among the districts and ESUs involved in the partnership, the Lincoln Public Schools and three of the ESUs were the original core partners in that they were involved from the beginning and provided staff members to serve on various management and planning teams. Teachers who participated in Math in the Middle represented districts with varying student demographics, and included one large urban district (Lincoln Public Schools) and many small, rural districts. The Lincoln Public Schools had approximately 35,000 students, of whom 42% receive free or reduced lunch and 24% of the students were minority. The rural school districts from which teachers were drawn ranged in size from fewer than 100 to almost 9,000 students. While many districts served mostly white students, several served large minority populations (from 50% to 83%), most of whom were Hispanic students; one district was 99% Native American. Lincoln Public Schools was the only partner district with a significant number of African-American students (9% of total enrollment).

The core partners of Lincoln Public Schools and the rural ESUs were intimately involved in identifying and selecting participants for the Math in the Middle Institute from their regions. MSP funds supported teachers' participation in the Institute, although local districts were expected to provide substitute teachers and release time for occasional meetings during the school year.

## **The Context for Mathematics Teacher Leadership in Nebraska**

The decision of Math in the Middle project leaders to focus on middle level mathematics was consistent with a nationwide emphasis on strengthening the quality of mathematics teaching, particularly at the key transition point of the middle grades. Evidence of the need to improve mathematics instruction in those grades had accumulated that led districts to join the MSP proposal. In Nebraska, school district partners in the MSP proposal recognized that over half of their middle grades mathematics teachers possessed an elementary or middle level endorsement rather than mathematics certification. Lincoln Public Schools (LPS), in particular, had concluded that the mathematics knowledge of their typical middle level teacher fell far short of the mathematics specialist designation that is recommended for Grades 5 and above. Moreover, at the time the MSP proposal was written, student performance on the LPS 8<sup>th</sup> grade criterion-referenced test was nine percent lower if the teacher held a middle-level endorsement than if the teacher held a subject-specific endorsement for grades 7-12.

Important contextual issues that shaped Math in the Middle were Nebraska's rural nature and strong tradition of local control. These factors contributed to a setting that included many small, autonomous districts within the state. Nebraska encompasses a large geographic expanse that is relatively sparsely populated, ranking 15<sup>th</sup> among the 50 states in total land area, but 42<sup>nd</sup> in population density. While more than 750,000 live in the metropolitan Omaha area and Lincoln is home to 225,000 residents, only one other Nebraska city has a population of more than 28,000 students.

At the launch of Math in the Middle, Nebraska had over 515 public school districts (this number was reduced in spring 2010 to 262 through a process of school consolidation). The overall student population in Nebraska was concentrated within a few districts, with the two largest districts educating 28 percent of all students in Nebraska public schools (84,000 students) and another 27 percent served by the next 10 largest districts. Of the remaining students, 18 percent were served by districts with student populations between 1,000 and 4,000 students and the remaining 27 percent were spread across 223 districts serving fewer than 1,000 students each and averaging fewer than 360 students per school district. In focusing on rural schools, Math in the Middle leaders hoped to impact mathematics teaching in these last two groups of school districts.

In many of the small rural schools, a single teacher may be responsible for teaching mathematics to all students in the middle grades. Nebraska's Educational Service Units (ESUs) helped meet the needs of these widely scattered rural schools that might not, on their own, be able to access or offer sufficient resources and expertise to support teachers and students. Even so, some ESUs had limited capacity and staff to support mathematics teachers. In 2008, for instance, only three of the 14 rural ESUs had a mathematics staff developer. Math in the Middle then, provided a much needed mathematics professional development opportunity to teachers in rural school districts.

Nebraska's K-12 education system is de-centralized, with districts retaining a large degree of autonomy. When Math in the Middle was launched, there was no statewide mathematics curriculum around which the project might be framed. Given this context, the project was designed to focus on developing teachers' mathematical content knowledge and pedagogical understanding rather than on their implementation of a particular curriculum or on specific leadership roles teachers might play in their schools. Project leaders believed this focus was also responsive to the needs identified on a project survey of rural educators, who listed their top five priorities as expanding opportunities for sharing and collaboration, increasing student engagement with learning, creating professional learning communities, understanding student learning and abilities, and deepening teacher understanding of their content areas.

Math in the Middle developed out of existing partnerships within the University of Nebraska-Lincoln and partnerships between UNL, the Lincoln Public Schools, and the three ESUs that were core partners in the project. Within the university, the work done under earlier NSF grants helped develop a relationship between the mathematics and teacher education departments that focused on integrating mathematics content courses with coursework on curriculum and pedagogy. Through UNL's Center for Science, Mathematics & Computer Education, one project leader had worked with Lincoln Public Schools to offer professional development in

mathematics to elementary and middle school teachers. A focus on developing teachers' mathematics content knowledge and pedagogical skills was at the heart of these prior efforts.

## **MSP Strategies**

The Math in the Middle project had two main strategies for preparing teacher leaders: (1) The multi-year Math in the Middle Institute, which offered participants a program of study to deepen their mathematical knowledge for teaching and develop their leadership skills; and (2) mathematics learning teams led by Math in the Middle participants and intended to develop collegiality, help teachers align their instruction with state standards, and assist teachers in examining their practice. The responsibilities for implementing these strategies were divided between the university, which would be primarily responsible for the Institute, and Lincoln Public Schools and the ESUs, which would take the lead on the mathematics learning teams. Representatives from all partners, however, were involved with all MSP activities on some level.

### **Math in the Middle Institute: Developing mathematical knowledge for teaching**

Project leaders who developed the Math in the Middle Institute reported that they were strongly influenced by the Vermont Mathematics Initiative (VMI), a statewide, graduate-degree program established in 1999 to better prepare elementary and middle school teachers for the demands of the contemporary mathematics classroom. A project leader noted that the philosophy and approach of VMI was compelling in its focus on developing teachers as intellectual leaders in mathematics. VMI's slogan "Competence leads to confidence" was adopted by the Math in the Middle Institute to convey the idea that as teachers develop knowledge of mathematics concepts, processes, and pedagogy, they become more confident in their classroom teaching and in sharing what they know with their colleagues. With this philosophy as a basis, university leaders developed the Math in the Middle Institute as a series of summer institutes and school-year courses that helped participants explore deeply such topics as algebra, geometry, number theory, statistics, and calculus, as well as processes such as experimentation, conjecture, reasoning and communicating mathematics. The Institute also helped participants consider pedagogy related to issues of equity, assessment, and problem-solving.

The Math in the Middle Institute was a 25-month graduate degree program. Four cohorts of between 32 and 35 teachers participated in the program over the course of the original MSP grant, with one cohort beginning the program each year. The recent supplements from the National Science Foundation provided funding to work with an additional cohort of 32 teachers from the Omaha Public Schools, which had not participated in the original MSP. The Institute consisted of 12 courses, developed and taught by university faculty in various departments. Seven of the courses were offered through the mathematics department, three courses were available through the department of teacher education, and a single course was taught through the statistics department. A required capstone course on action research titled "Integrating the Learning and Teaching of Mathematics" could be taken in either the mathematics or teacher education departments. Upon completing the coursework, participants received a master's degree from UNL. The MSP grant supported teacher participation in the Institute, including stipends, a

waiver of tuition and fees, textbooks and calculators, as well as room, board, and travel expenses for teachers who live outside Lincoln.

Courses were offered as residential summer institutes and as online courses taken during the school year. There were two types of summer courses. In one, participants enrolled in two courses over a two-week period. The first half of each day was spent in a mathematics course and the afternoon in a pedagogy course. The two courses were purposely paired so that instructors for the pedagogy and mathematics courses could work together to offer teachers an integrated learning experience. The other type of summer institute course consisted of a single course, taught for five full days over a single week. In both cases, teachers were expected to do substantial homework each evening (3-4 hours per night). Members of the instructional team were always available to provide help as teachers worked on assignments. Distance courses, offered during the school year, began with a two-day kick-off session in Lincoln. This session was followed by on-line experiences for the duration of the course. Math in the Middle Institute participants typically took three courses during the summer and one distance course each semester during the school year.

The core idea of the Math in the Middle Institute was to deepen teachers' knowledge of mathematics for teaching while developing teachers' mathematical habits of mind, a variation on the VMI concept of developing intellectual leadership in mathematics. Math in the Middle participants were encouraged to work on a mathematics problem not simply to find the answer, but to engage with the mathematics as a mathematician might – struggling with it, providing complete reasoning to explain solutions, and developing the ability to discuss mathematics with others. The title of one Math in the Middle course, "Experimentation, Conjecture and Reasoning," exemplified the emphasis on the cycle of doing mathematics. Project leaders anticipated that as teachers developed these habits of mind, they would develop confidence in their own ability to do mathematics and to work with and communicate with others about mathematics.

Another feature of Math in the Middle Institute courses was that participants were placed in the role of student and given challenging mathematical problems and tasks to work through, with support from course instructors and graduate students from the mathematics department. During the courses, participants worked in small groups to solve mathematics problems. Work on a single problem might extend several hours or even days. During this time, mathematicians, master teachers, and the mathematics graduate students were available to provide guidance and encouragement to the participants, helping participants when they became stuck or frustrated. This process demonstrated to participants the benefit of group work and the importance of giving students time to work through the problem-solving process rather than rushing to a solution. One unanticipated benefit was that teachers developed empathy for their students (and fellow teachers) who struggle with mathematics.

As participants engaged in these mathematical tasks, they were asked to present, explain, and justify their work publicly within the context of the courses. The goal of these experiences was to further develop teachers' thinking around mathematics as they articulated what they had done. A related goal was to develop their confidence to communicate publicly about mathematics,

which would become important later on as participants assumed formal or informal teacher leader roles.

Math in the Middle Institute coursework culminated with a capstone action research project which required participants to connect their work in the courses to classroom instruction. Project leaders believed that conducting action research contributed to the development of teacher leadership because it helped teachers take on and be successful in a demanding effort: identifying a topic relevant to their own teaching practice, conducting research on that topic, writing a scholarly paper, and exploring mathematical and pedagogical topics that may have been foreign to them previously. One project leader spoke of how the action research project bolstered teachers' confidence:

*I think that course has a pretty significant impact on teachers. It fits into the "competence leads to confidence." Once they have done [the action research project], it makes a really big difference in who they are and what they are capable of doing.*

An important part of developing teacher leaders as mathematical thinkers was to offer strong support throughout the coursework, another idea borrowed from VMI. For most courses, five instructors were available during the summer institutes to help anyone who was struggling so that teachers did not become frustrated and give up. Project leaders believed it was critical that substantial support be provided if teachers were to persevere when work was challenging and thus, over time develop the mathematical habits of mind needed for teachers to change their own practice and become leaders who could influence the practices of other teachers.

### **Math in the Middle Institute: Developing teacher leadership**

With a focus on developing teachers as mathematical thinkers, most of the Math in the Middle Institute courses were not about developing leadership skills per se, nor were they geared to preparing teachers for specific leadership roles. Project leaders believed, however, that the activities in these courses prepared participants for leadership. In addition, activities near the end of Institute coursework were designed specifically to help participants think about how they might act as leaders. During the capstone course, teachers developed individual leadership plans, drawing on case studies of teacher leadership. These leadership activities were especially important for participants from the Lincoln Public Schools, which was developing formal mathematics leadership roles for teachers.

The expectation that Math in the Middle graduates would function as teacher leaders was also addressed in the selection process, in which leadership potential and the support of one's peers were criteria for admittance into the program. On the application, teachers were asked to list their previous leadership experience, such as heading a committee. Applicants were also asked to provide letters of recommendation from a peer and a principal or administrator that addressed their leadership potential. In effect, the project selected teachers with leadership experience or potential and provided them with content and pedagogical expertise that would equip them to move more readily into leadership roles.

In evaluating the applications from teachers for the Math in the Middle Institute, reviewers also considered the amount of experience teachers had leading instruction. While all teachers needed to have reasonable mathematics background (for their current teaching duties) and a positive attitude towards learning more mathematics, it was not necessary for applicants to demonstrate special strengths in mathematics prior to selection for the program. The selection process was carried out collaboratively between UNL faculty and district or ESU administrators. Four people (two project staff from UNL and two people from school districts or ESUs) assessed each application on 0-100 scale. Negotiation around the ratings of candidates almost always resulted in consensus between university and school district/ESU staff on who to enroll in the graduate program. However, in cases where a district or ESU had a special interest in a teacher's selection for the program, university project leaders deferred to district/ESU staff, recognizing that graduates of the Math in the Middle Institute would need the support of their school administrators to become teacher leaders. Said one project leader, "We need to take [the applicants recommended by districts/ESUs] if it is who they want to support."

### **Mathematics Learning Communities**

Math in the Middle teachers were expected to meet and engage in mathematics learning communities during and continuing after their participation in the Institute. Each district in the partnership was charged with supporting the development of mathematics learning communities, which took on a variety of forms. One learning community was conducted through organized distance learning in which teachers participating in the Math in the Middle Institute met as homework groups. Another activity modeled on the Japanese Lesson Study approach, in which a Math in the Middle teacher taught a mathematics lesson while other Institute participants, university faculty, and teachers from the participant's school observed and critiqued. The lesson was revised, and then another Math in the Middle teacher taught the revised lesson. Another example was a monthly "Teachers' Math Circle" in which Math in the Middle Institute participants, UNL faculty, and school district and ESU leaders were invited to meet over dinner and engage in mathematics activities and discussions. Different Teachers' Circle participants, including many Math in the Middle teachers, planned and led the activities each month.

The learning communities focused on developing and solidifying collegiality among participants of the Math in the Middle Institute. The activities underscored the premise of the Institute coursework, that engaging in mathematics publicly and for the sake of solving challenging problem were core principles for being a leader in mathematics. Learning communities regularly consisted of teachers who had completed their Math in the Middle coursework as well as other project leaders and teachers just enrolled in the Institute.

The learning communities emerged out of a strategy that was originally conceived as "mathematics learning teams" led by Math in the Middle graduates and composed of teachers from their schools that did not attend the Math in the Middle Institute. The learning teams were intended to provide Math in the Middle teachers with a venue for sharing their knowledge of mathematics developed through the Institute with other teachers in their schools. The mathematics learning team component of the project unfolded differently than was envisioned. Ultimately, this notion of mathematics learning teams was altered to focus solely on developing

collegiality and extending the experience of Math in the Middle teachers, rather than a form of outreach across schools. Project leaders pointed to the lack of sufficient resources to fully implement and sustain the original vision for the school-based learning teams as primary reason for reconfiguring this strategy.

## **Key Issues that Shaped the Design and Implementation of Math in the Middle**

Leaders of Math in the Middle identified several key issues that shaped the design and implementation of the work. These issues reflected conditions that influenced the project's structure and focus, as well as decisions made by project leaders that contributed to the project's success. Discussion of each of these issues highlights strategic thinking as well as reflections in hindsight by project leaders, and offers insights for other designers of teacher leader programs.

- Earlier collaborations involving the MSP partners eliminated obstacles that could have challenged implementation of Math in the Middle.
- The use of a model program supported the Math in the Middle Institute in delivering high-quality coursework to teachers.
- Providing intensive support to teachers as part of the Math in the Middle Institute was critical to creating an environment that supported teachers as they developed mathematical knowledge for teaching and mathematical habits of mind.
- Responsibility for developing the knowledge of the Math in the Middle teachers and for placing teachers into leadership positions was clearly delineated between the university and district partners.

### **Earlier collaborations involving the MSP partners eliminated obstacles that could have challenged implementation of the Math in the Middle.**

Project leaders reported that Math in the Middle proceeded relatively smoothly because of many years of groundwork laid through prior partnerships at the university through work on earlier grants. When the MSP grant was awarded, partnerships had already been established between the mathematics and teacher education departments at the university and between the university and school district. Project leaders believed the presence of these pre-existing partnerships made it easier for the Math in the Middle work to move ahead efficiently as the university and school partners had established a shared trust and willingness to collaborate.

During implementation of prior grants, a strong relationship was forged between the UNL mathematics and teacher education departments. The mathematics department at UNL had been working with teachers since at least the mid-1980s through various grants the university had obtained. Faculty members who would become project leaders of Math in the Middle worked together on earlier grants to foster cooperation across departmental and budget lines, an undertaking one project leader described as “incredibly difficult.” At times, entrenched departmental structures were also difficult to alter. A project leader noted that, at that time, even convincing the people in charge of room assignments to schedule courses from different departments back-to-back in the same classroom met with initial resistance.

NSF funding for this prior grant provided leverage to encourage the departments and faculties to work together. In addition, the teacher education program had begun to rethink its teacher preparation sequence in the face of budget cuts, so became more receptive to a restructuring. An additional boost came from the university chancellor, who valued the work that was being done and reallocated money to create a science and mathematics education center that became the locus of the MSP and similar efforts. All of these efforts smoothed the way for Math in the Middle so that project leaders did not have to spend time creating relationships within the university. As a project leader remarked, “Now having laid this foundation, many people are willing to support us and work with us.”

Similarly, prior partnerships between the university and Lincoln Public Schools and ESUs set the stage for collaboration in the context of Math in the Middle. LPS and several ESUs had been partners in an earlier NSF grant and through the undergraduate teacher education program. A project leader remarked, “LPS trusted us because of our past relationship with them. They knew that we would not go in and tell teachers what they should be doing.” A different project leader added:

*At the time we wanted to write the MSP proposal, we had recent success built out of a partnership. NSF was making partnerships important, and [the mathematics and teacher education departments] had a partnership...so we had a good internal foundation. Then we had a partnership with LPS and experience offering math professional development courses, and a more distant partnership through [a prior NSF grant] that allowed us to initiate partnerships out across the state with ESUs... The partnerships we had established were part of the foundation that gave us a chance to get in an MSP here.*

### **The use of a model program supported the Math in the Middle Institute in delivering high-quality coursework to teachers.**

Project leaders of the Math in the Middle Institute made clear that modeling their project after a successful teacher leadership program, the Vermont Mathematics Initiative (VMI), helped focus the project and ensure its effectiveness. Similar to Math in the Middle, VMI was a multi-year graduate degree program based at a large university, led by a collaborative of mathematicians and educators. VMI was designed for practicing elementary and middle grades teachers of mathematics and consisted of summer institutes and coursework during the school year. A project leader of Math in the Middle had heard about VMI through professional networks. Prior to developing the MSP proposal, this project leader held lengthy conversations with the VMI director. In these conversations, the Math in the Middle project leader was particularly interested in how VMI provided professional development for rural teachers, given Nebraska’s rural nature. He also believed that VMI’s focus on mathematics content and pedagogy, as opposed to a specific teacher leadership model, was well-suited to Nebraska’s context, given that a single leadership model would not be appropriate for the diverse districts served by Math in the Middle.

In order to identify a suitable model program, Math in the Middle project leaders needed a clear understanding of how features from the VMI program could be applied to the particular needs and conditions they faced for implementing Math in the Middle. Project leaders envisioned a program that would help develop middle grades teacher leaders with outstanding knowledge of

mathematics for teaching, and who were working in urban or rural school systems. VMI had served a similar teacher population and had designed a mathematics program with a similar goal.

The experience of VMI project leaders provided guidance for Math in the Middle project leaders that informed the strategies for supporting these teachers to succeed. From VMI, Math in the Middle project leaders emphasized the importance of coordinating communication and distance courses for rural teachers and designing courses with mathematic content appropriate to middle grade teachers. Math in the Middle project leaders also recognized resources that they had available which matched those present in VMI. Math in the Middle, like VMI, capitalized on the expertise of, and collaboration between, mathematicians and teacher education faculty members. Math in the Middle project leaders also employed master teachers and graduate students in mathematics to support teachers in the Math in the Middle courses, a strategy based on one developed in VMI. Any leadership roles held by VMI and Math in the Middle graduates were developed by the district and not directly connected to the preparation program.

**Providing intensive support to teachers as part of the Math in the Middle Institute was critical to creating an environment that supported teachers as they developed mathematical knowledge for teaching and mathematical habits of mind.**

Project leaders believed it was critical to the project's success to provide support to middle school teachers as they engaged in the challenging mathematical courses that comprised the Math in the Middle Institute. They noted that many teachers lacked experience with the kinds of mathematics they encountered in the Institute and could become frustrated. To motivate teachers to persist, the project provided a great deal of support—a notion borrowed from VMI. As a project leader stated, “One thing [the VMI director] stressed to me was the idea of support and having 4-5 instructors in the room at one time.” The abundance of support for the teachers was connected to developing mathematical habits of mind, which required that teachers' time was spent reasoning through and often struggling with complex mathematic problems. It was important that Math in the Middle project leaders were aware that teachers could feel overmatched in these situations and that adequate guidance and scaffolding needed to be available to them.

During summer institutes, teachers were supported by the instructional team, which often consisted of two university faculty members, a master teacher and two graduate assistants, paid for by the MSP grant. Through the use of teams to provide instruction, help was always available for teachers as they worked through problems during class and as teachers worked on their homework each evening. During the school-year distance courses a graduate assistant, along with the course instructors, was available to assist teachers online. The project organized study groups to support teacher participants, with teachers in Lincoln meeting face-to-face and rural teachers meeting through online study groups arranged by Math in the Middle. The graduate assistants answered teachers' questions about mathematics and helped teachers consider alternative mathematical approaches when the teachers became stuck while solving problems, consistent with the development of teachers' mathematics habits of mind. A mathematics professor who taught one of the distance courses commented on the need to develop teachers' confidence:

*I mostly teach senior-level, applied mathematics courses, so I get [math majors... who] are 22 years old and invincible, extremely confident, bullet-proof. I find it is a real shift to work with the teachers: it is a totally different mindset [from mathematics majors] because a lot of [teachers] are really not confident. They have not done these kinds of problems before... They need to learn that it doesn't hurt to try these sorts of things and if it doesn't work, you abandon it and try something else.*

Project leaders believed the support provided during the Math in the Middle Institute developed participants' commitment to seeing the coursework through to the end, contributing to the high retention rate: 125 out of 136 participants in the MSP earned their master's degree through the program. A project leader remarked:

*We treated them with respect and first-class and gave them incredible support, but in turn, we would have incredible expectations. They did not want to let us down. So the biggest variable [in the high retention rate], I think, is this sense of support.*

**Responsibility for developing the knowledge of the Math in the Middle teachers and for placing teachers into leadership positions was clearly delineated between the university and district partners.**

In Math in the Middle, the Institute coursework was designed around the concept of developing teachers' mathematical knowledge for teaching with a special emphasis on developing mathematical habits of mind, as opposed to implementing a particular district curriculum or preparing for a specific teacher leadership position. This meant it was up to the districts, ESUs, and the participants themselves to find appropriate outlets for utilizing participants' new knowledge and skills to impact the mathematics instruction of other teachers in their schools.

Project leaders at the university explained the rationale for this division of responsibilities: universities in general have expertise in preparing students academically and intellectually, not in preparing them to play specific roles. Project leaders believed this same approach applied within the context of the MSP, that a sensible strategy was for the university to develop teacher leaders intellectually and academically and then for school districts or even participants themselves to determine how to make use of the knowledge and skills learned in the university-led coursework. A university project leader explained:

*When students take our courses, you don't know what job they are going to have. Similarly, because of the diversity of curricula materials used across the state, we can't educate teachers to teach a particular curriculum like Math Investigations. Instead, we educate people to be as well-rounded as possible. That is the essence of an arts-and-sciences philosophy; you educate people for jobs that may not exist yet.... We make a big investment in teachers' competence and thus their confidence. In an informal setting, leaders emerge, and smart districts build on that by providing opportunity.*

Not only did the focus on developing teachers' mathematics knowledge for teaching fit well with university expertise, project leaders also believed this approach was well-suited to the nature of Nebraska's de-centralized and diverse K-12 education system. There was no statewide

mathematics curriculum around which the Math in the Middle Institute could be framed and Nebraska's school districts had very different needs relative to teacher leadership. Larger districts had the capacity to create formal leadership roles for teachers, but small, rural districts might have only one middle school mathematics teacher. In this context, university leaders felt, it would not have been appropriate to prepare teachers for specific kinds of mathematics leadership roles.

As a result, leadership opportunities for Math in the Middle graduates varied widely, with the expectation that some graduates would emerge as informal leaders in their schools and others would fill formal leadership positions, depending on the opportunities available to the teachers. Lincoln Public Schools (LPS), the largest district in the partnership, created six district-supported mathematics coaching positions that were filled by Math in the Middle graduates. In the fall semester, the coaches worked with teachers at other schools, at the invitation of those teachers, through activities such as co-teaching, lesson planning or conducting demonstration lessons on mathematics topics. In the spring, two coaches also led a series of mathematics workshops for sixth-grade teachers.

LPS district leaders also re-designed an existing teacher leadership role that was present at each school, to capitalize on the expertise of Math in the Middle graduates in their district. Prior to Math in the Middle, the math liaison position at each school had largely been an administrative role, serving as a line of communication between the district curriculum director and school mathematics teachers. The LPS district curriculum director, a leader in Math in the Middle, urged principals to assign the math liaison role to Math in the Middle graduates, which resulted in seven graduates among the ten math liaison positions. The curriculum director noted that, with this change, meetings with the math liaisons were focused more deeply on identifying and addressing instructional issues than before.

In many rural districts, formal leadership opportunities were not readily available within schools or districts, although some Math in the Middle graduates sought out opportunities on their own. For example, Math in the Middle graduates assumed leadership roles in state associations for teachers of mathematics. In another example, one teacher participated in selecting the mathematics curriculum at her school and serving on a district committee to write assessments based on the curriculum. An ESU mathematics consultant described how Math in the Middle Institute participants from rural areas might assume leadership roles:

*One teacher who lives about 70 miles from Lincoln is the only teacher in the high school. As part of the assessment system, some of the small schools got together and wrote assessments as a group, and she led that group to write the assessments. In a second example, [a Math in the Middle Institute graduate] and I have been working with his school on textbook selection. Through this process, he has developed confidence about math and sharing where math should be, and that has influenced textbook selection and curriculum at that school. Those are places where those teachers serve as role models for other teachers on staff.*

While the Math in the Middle Institute was not geared to creating leadership positions for participants, university leaders helped some individual participants continue to develop their

knowledge and leadership abilities beyond the Math in the Middle Institute coursework. Thirty-six Math in the Middle teachers worked side-by-side with university faculty to teach Math in the Middle courses or other professional development courses organized by project leaders. Rural Math in the Middle teachers have been invited to speak at a rural educator's conference and at a regional conference for teachers of mathematics. In addition, two Math in the Middle Institute participants were able to exert their leadership within the professional mathematics community after MSP funding supported their attendance at a workshop (along with UNL faculty) on Math Circles. This group returned and created the monthly Math Circles in Lincoln, which brought together middle level mathematics teachers, university faculty, and others over dinner to do mathematics together. Graduates of the Institute were often asked to facilitate the Math Circles. Math in the Middle leaders also invited institute graduates to speak at seminars at the University.

### **The Sustainability of Math in the Middle to Prepare Teachers for Formal and Informal Teacher Leadership Roles**

During its initial five years of funding, Math in the Middle provided 125 middle school mathematics teachers from across the state with an intensive, two-year, graduate degree program with the aim of developing their mathematical content knowledge for teaching. In addition to these graduates, 32 teachers from the Omaha Public Schools will earn their master's degree in 2010 or 2011 through a supplement to the original MSP grant. Due to the success enjoyed by Math in the Middle, project leaders were able to convince university leaders to authorize reduced tuition for teachers who take mathematics, education or science courses that are part of a new program, the Nebraska Math and Science Summer Institutes. Courses developed as part of Math in the Middle have been offered through this program as have other courses for math and science teachers. While most of the courses are offered on the UNL campus in Lincoln, courses have also been offered at several other Nebraska universities. The sustained presence of Math in the Middle was also anticipated in the partnering districts through the emergence of informal leaders in the rural districts and the continuation of formal teacher leader positions in the Lincoln Public Schools filled by Math in the Middle graduates.

This section of the case highlights the strategies of project leaders that contributed to the sustainability of Math in the Middle teacher leadership program. This discussion expands on the MSP strategies and the key issues identified by the leadership team as influential in the design and implementation of their programs. Strategies that contributed to sustainability were identified through the use of a theoretical framework from the Handbook for Enhancing Strategic Leadership in the Math and Science Partnership (Weiss, Miller, Heck & Crest, 2004). In the framework, four components were identified as critical to enacting and sustaining change through school reform efforts: 1) designing and implementing interventions, 2) garnering support from key stakeholders, 3) aligning policy and 4) developing capacity and infrastructure to scale up interventions.

Strategies that contributed to the sustainability of the Math in the Middle teacher leadership program:

- School districts, particularly LPS, built upon the momentum created by Math in the Middle to design and sustain new teacher leadership positions.
- The courses of the Institute were sustained through the university and district partnerships that were central to Math in the Middle.

**School districts, particularly LPS, built upon the momentum created by Math in the Middle to design and sustain new teacher leadership positions.**

Even as the Math in the Middle Institute was being developed, Lincoln Public Schools was interested in strengthening the capacity of its teacher staff to fill existing and newly created teacher leader roles. Mathematics liaisons in each LPS school had historically played an administrative role, but district leaders hoped the liaisons would become more influential in instructional matters if those positions could be filled with graduates of the Math in the Middle Institute. The district also hoped to create district-level mathematics coaching positions using Institute graduates. A district administrator remarked that the Institute offered an opportunity to develop a cadre of teachers to provide mathematics leadership within the district:

*We had math liaisons in the middle schools. One math person in each school comes to the district office once per month; they're the go-between for the district and the school. We saw that it was the same person forever, no matter what their skills were... If we had a person with the right knowledge, then it became a way for us to come to the principals and say, "Shouldn't this person be the math liaison?" Also, at the time we had no math coaches at all. We saw this as a way to help with that process. We had people now who could be in that role.*

The presence of the Math in the Middle Institute helped LPS leaders ensure that the new teacher leadership positions were filled by qualified teachers who could advance mathematics instruction. A project leader reported that, with the placement of Math in the Middle graduates into the mathematics liaison positions, the tenor of the district meetings with the liaisons had changed to include a deeper examination of the mathematics curriculum. This project leader hoped that this indicated that the liaisons had helped a similar shift occur in conversations among teachers in the schools.

The district mathematics coaching positions served as a venue for a limited number of Math in the Middle graduates to work with other teachers in the district to deepen their knowledge of mathematics for teaching. The coaches work directly with middle grades teachers of mathematics, providing demonstration lessons, co-teaching, helping to plan lessons and other activities to support mathematics instruction. The coaches also utilized their experience in Math in the Middle to lead district-wide workshops with sixth grade teachers that were based on the Math in the Middle principles of deepening teachers' mathematics content knowledge through developing their habits of mind. In addition to these roles, LPS administrators indicated that at least 15 Math in the Middle graduates have led staff development, curriculum writing, or participated on a school improvement committee.

The majority of Math in the Middle graduates in LPS were not placed in formal teacher leadership positions. LPS saw these teachers as exerting informal leadership through their grade-

level and school leadership teams. These teachers also became a strong pool of candidates that allowed the district to expand its program of mathematics coaches to add more coaches or replace coaches if the positions were vacated.

By the end of MSP funding, the initial success of the mathematics coaching program in the district led to its expansion. Originally, prior to Math in the Middle, LPS had a single district math coach who worked with elementary grade teachers. During Math in the Middle, LPS initially created two new, part-time math coach positions to work with middle grades teachers and staffed these positions with Math in the Middle teachers. The coaching program continued to expand based on the positive feedback the district received, and eventually six district-wide math coaching positions were created, five of which were filled by graduates of Math in the Middle. All but one of the coaching positions is fully released from classroom teaching responsibilities, with the sixth position released half-time.

For Math in the Middle participants outside Lincoln, formal teacher leadership opportunities were less common, as was expected by project leaders. Math in the Middle graduates in rural districts demonstrated leadership through assuming governing positions of the state association of teachers of mathematics. Other Math in the Middle graduates from rural districts have become instructors of Math in the Middle courses and have been hired to lead courses offered through their ESU or local community college.

**The courses of the Institute were sustained through the university and district partnerships that were central to Math in the Middle.**

With the end of MSP funding, the courses of the Math in the Middle Institute and its approach for deepening teachers' mathematical content knowledge continued to be offered without NSF funding through the Nebraska Math and Science Summer Institutes at UNL and other sites across the state. During the MSP, partnerships that had been cemented between mathematics and teacher education faculty at UNL and between the school districts and the university had formed the foundation for Math in the Middle. These partnerships continue to be essential for the sustainability of the programs begun by Math in the Middle.

The partnership between teacher education and mathematics faculty created support for continuing to offer the Math in the Middle courses as part of a graduate degree program at UNL. Faculty members who had designed and taught the Math in the Middle courses during MSP worked with university administrators to arrange for reduced tuition charges for Math in the Middle courses so that the courses would remain affordable and available to teachers.

As they approached the end of the MSP grant, Math in the Middle project leaders expanded upon the partnership between districts and the university in a new project. A \$9.2 million grant was obtained from NSF to support NebraskaMATH, a new project that works with primary grade and high school algebra teachers. This new project expanded on the partnership established by Math in the Middle and included faculty from UNL and a number of Nebraska school districts, including Lincoln Public Schools and all of Nebraska's ESUs. Launched in January 2009, the NebraskaMATH program includes the Nebraska Math and Science Summer Institutes which is

supported by local funds and which continues to offer the coursework created during Math in the Middle.

## Conclusion

The case of Math in the Middle documented a program to develop teacher leadership which drew teachers from a variety of school districts across the state. A challenge for the designers of the Math in the Middle Institute was to create a single program that prepared teachers to lead in urban and rural school districts where different leadership opportunities, formal and informal, were available. In order to bridge a possible gap between the preparation of Math in the Middle graduates and the lack of leadership roles, project leaders utilized the partnership between the university and school district administration and the education service units serving rural districts. In Lincoln Public Schools, the involvement of a district administrator was critical to launch mathematics coaching positions and to advocate for Math in the Middle graduates to fill leadership roles in the district. In rural school districts with support from project leaders and local education service units, Math in the Middle graduates assumed a range of leadership responsibilities while retaining their teaching workload. The sustainability of Math in the Middle is most clearly evident in the continuation of formal teacher leadership roles that have been filled by Math in the Middle graduates. Less obvious, though still present, is the continued presence of Math in the Middle through the creation of a network of informal leaders who serve as a pipeline for future leadership positions and who have deepened the overall capacity of their schools in teaching mathematics.

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