

**Perspectives on Deepening
Teachers' Mathematics Content Knowledge:
The Case of the Indiana
University-Indiana Mathematics Initiative Partnership**

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N. Kathryn Essex

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Abstract

Through the Indiana University-Indiana Mathematics Initiative (IMI) Partnership, Indiana University collaborated with nine school districts from across Indiana to provide professional development for teachers of mathematics. In the elementary grades, the goal of the project was to support the implementation of a curriculum program chosen by all partner districts, *Everyday Mathematics*. In the early years of the project, IMI professional development focused on the mathematics content of the curriculum which was closely aligned with the Indiana Academic Standards. In cross-district, grade-level group meetings in the summer and three to four times during the academic year, teachers engaged in key activities from the materials to experience the mathematics content development for their grade level as learners, and then planned together for classroom implementation.

After this first year of support, a subset of teachers from each grade level in each district was invited to join the IMI Select Cadre. Select Cadre teachers continued their professional development in subsequent years with emphases on content development across grade levels, along with leadership training to provide professional development and mentoring support for other teachers. Select Cadre teachers continued to attend annual summer workshops, as well as three to four meetings during each school year. Teachers also engaged in online reflections, through weekly Learning Logs the first year and, for the Select Cadre teachers, through monthly Assessment Logs in subsequent years. In their Learning Log entries, teachers reflected on their progress and challenges implementing the *Everyday Mathematics* curriculum, evidence of their students' learning, and their own mathematical insights. Assessment Log entries were tied to each unit taught. Teachers administered both designated common assessment items and assessment tasks of their own choosing to document, interpret, and report their students' progress with the mathematics learning goals of each unit and continued to reflect in writing on their own mathematical insights. Professional development providers read and responded to each Learning Log and Assessment Log entry as a means of ongoing support for teachers' learning.

Introduction

The Indiana University-Indiana Mathematics Initiative (IMI) Partnership began in the fall of 2002, funded by the National Science Foundation (NSF) as a part of its Math Science Partnership Program. Indiana University partnered with nine school districts from across the state of Indiana to provide professional development for teachers of mathematics. It followed and built upon a smaller NSF-funded Local Systemic Change (LSC) project for middle school mathematics teachers; some of the school districts in the LSC grant continued to be involved with the MSP partnership. The MSP project provided professional development for elementary mathematics teachers, secondary mathematics teachers, and administrators, and also included a pre-service mathematics teacher component. It is the professional development meant to deepen elementary teachers' mathematics content knowledge that is the focus of this paper.

Background and Context of the IMI Project

The original LSC project for middle school teachers centered on the use of reform-minded, NSF-funded mathematics curricula. The leadership of that project believed that it would have

strengthened the professional development if the participating teachers and school districts used common curriculum materials. The district coordinators and other IMI project leaders decided to use *Everyday Mathematics (EM)* as it seemed to align well with both Indiana State Standards and the project’s vision of high quality mathematics instruction.

The proposal submitted for funding noted that one of the goals of the project’s Elementary Grades Action Plan was to provide the participating teachers “with the knowledge of the mathematical content and pedagogy associated with the *Everyday Mathematics* curriculum to effectively pilot this material in their classrooms.” Thus, from the beginning, the focus on content knowledge was related to what was being taught in *Everyday Mathematics* and was closely intertwined with pedagogical knowledge; the goal was to support teachers as they implemented a new, reform-minded curriculum.

What follows are descriptions of the project’s leadership, the elementary teacher participants, the project’s focus on mathematics content knowledge, and the professional development design for the elementary teachers.

Project Leadership

The IMI leadership team consisted of the project’s Principal Investigators who were mathematics professors at Indiana University; another faculty member at Indiana University Purdue University Fort Wayne; and former elementary, middle school or high school teachers (one had also been a building administrator), three of whom had been involved with the previous LSC project. The leadership team also included the Director of Project Operations and the Administrative Coordinator.

During the first three years of the project, much of the professional development was facilitated by consultants from the Everyday Learning Corporation. In addition, there were nine District Coordinators, one from each partner school district, who acted as liaisons between the IMI leadership team and the district personnel and helped planned local professional development.

Elementary Teacher Participants

The plan was to involve a subset of teachers from the entire K–5 spectrum in each of the partner districts in IMI professional development, with the understanding that the participating teachers would subsequently serve as teacher leaders in their districts. In Year 1, the project began with a cohort consisting of selected second- and fifth-grade teachers from each district, representing 10-15 percent of the districts’ teachers at those grade levels. (See Table 1.) In Year 2, a second cohort consisting of third- and fourth-grade teachers joined the project, and in Year 3, a third cohort was made up of pre-kindergarten, kindergarten, and first-grade teachers. The goals of the professional development activities were to support the teachers’ implementation of the standards-based curriculum, to improve their mathematics content knowledge at the student-level, and to promote and develop their abilities as teacher leaders in their own schools and districts.

In each cohort, two to four participants from each school district were identified by their district coordinators as potential teacher leaders. These teachers continued to receive professional development intended to deepen their content and pedagogical knowledge, as well as to provide leadership training, in order to build a strong group of teacher leaders, a “Select Cadre” in each

school district. It was expected that these teacher leaders would then become the means by which professional development in mathematics would be delivered to all elementary teachers in order to improve student learning in mathematics at scale in the nine partner school districts.

Table 1
IMI Teacher Participants

	COHORT I (Grades 2, 5)	COHORT II (Grades 3, 4)	COHORT III (Pre-K – Grade 1)
First year of participation	2002-2003	2003-2004	2004-2005
Number of teacher participants	142	144	168
Number who continued as Select Cadre	2-4 teachers per district	2-4 teachers per district	2-4 teachers per district

Project Focus on Content Knowledge

In keeping with the original goals of the project’s Elementary Action Plan, the IMI leadership remained very conscious of the need to provide teachers with opportunities and experiences to deepen their content knowledge, along with the pedagogical content knowledge needed for teaching with a reform-minded curriculum, and in particular, with *Everyday Mathematics*. Early in the project, participating teachers were given the *Learning Mathematics for Teaching* assessment from the University of Michigan’s Learning Mathematics for Teaching Project (see <http://sitemaker.umich.edu/lmt/home>), which is intended to measure what Ball, Hill, and Bass (2005) refer to as “mathematical knowledge for teaching” (p. 17). This is mathematical content knowledge specific to mathematics classrooms: the content knowledge a mathematics teacher needs to be successful. Thus, the content knowledge development for teachers focused on teachers’ understanding of the mathematics they were teaching at their grade level. However, because they were also acting as teacher leaders and mentors to other teachers in their districts, content development also focused on the bigger picture of articulation and how the mathematical ideals are developed across all the elementary grade levels, as well as understanding the mathematical strands of the Indiana Academic Standards across grades K-6.

Professional Development Design

Table 2, below, shows the timeline and design of the professional development provided for the participants.

Table 2
IMI Elementary Professional Development Timeline

YEAR	COHORT ONE (Grades 2, 5)	COHORT TWO (Grades 3, 4)	COHORT THREE (Pre-K – Grade 1)
Year 1 (2002-2003)	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Learning Logs • Taught with <i>EM</i> for first time 		
Year 2 (2003-2004)	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Mentored Cohort Two teachers • Assessment Logs • Facilitated PD within districts 	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Learning Logs • Taught <i>EM</i> for first time 	
Year 3 (2004-2005) <i>First year EM was used by all teachers in the participating school districts.</i>	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Mentored Cohort Three teachers, along with other teachers in the district • Facilitated PD within districts 	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Mentored Cohort Three teachers, along with other teachers in the district • Assessment Logs • Facilitated PD within districts 	<ul style="list-style-type: none"> • Attended summer and academic year IMI workshops • Learning Logs • Taught <i>EM</i> for first time
Year 4 (2005-2006)	<ul style="list-style-type: none"> • Attended summer 2005 conference: <i>IMI Leaders Make a Splash: IMI Teacher-Leader Institute</i>. Focus was on leadership and mentoring. • Attended 3-4 IMI workshops each academic year • Mentored teachers new to <i>EM</i> • Facilitated PD within districts • Cohort Three teachers completed Assessment Logs 		
Years 5-7 (2006-2009)	<ul style="list-style-type: none"> • Attended summer (2007) conference: <i>Sustaining Success by Supporting Teachers</i>. Focus was on district activities and promoting sustainability within the districts. • Attended 3-4 IMI workshops each academic year • Mentored teachers new to <i>EM</i> • Facilitated PD within districts 		

This paper focuses on Cohort Two’s participation in the project, which began in the second year, after the IMI leadership team and the district coordinators had some experience learning what was needed and expected for all the professional development components. From the beginning of their involvement, team members reported that this was a very enthusiastic group of teachers. They had been hearing about the IMI project and the *Everyday Mathematics* curriculum from the second and fifth-grade teachers at their schools during the previous year, and they were ready to join in the project for themselves.

This cohort began their work in the project in the summer of 2003. They participated in a three-day summer workshop, followed by three two-day workshops during the academic year. During the first year of their participation professional development focused on implementation of the

Everyday Mathematics curriculum, with sessions on working with the curriculum led by *Everyday Mathematics* consultants. However, there were also sessions devoted to content. These sessions were led by the IMI leadership team and focused on the mathematics in the curriculum that was aligned with the Indiana Academic Standards.

Although the workshops were a main focus of the elementary component of the project, the IMI team also felt that, without additional support, these sessions would not be enough to develop teachers' abilities to be reflective about their practices or to develop their capacities as teacher leaders. Thus they decided that teachers would also complete online weekly reflection logs (Learning Logs) during their first year of participation. As a part of the weekly reflection, teachers were asked to comment on their mathematical insights.

The Cohort Two teachers who became members of the Select Cadre began their second year of participation with a one-day summer workshop and continued with four two-day workshops held during the school year, alongside Select Cadre teachers from Cohort One. They continued to participate in online professional development through monthly Assessment Logs, which replaced the weekly Learning Logs. These logs again included a place for teachers to reflect on their mathematical insights.

In addition, they began to be supported in their new work as mentors and as local professional development facilitators. The previous academic year had been the year for mathematics textbook adoption in the state of Indiana, and eight of the nine participating IMI districts had adopted the *Everyday Mathematics* curriculum.¹ Thus, the Select Cadre members in those districts began acting as mentor teachers not only to the teachers that were new to the project, but also to the other teachers in their buildings. (The first cohort of teachers, who had participated as second- and fifth-grade teachers and who had mentored the Cohort Two teachers, shared these mentoring duties.) They also began working with Select Cadre teachers from Cohort One to provide professional development for other teachers in their districts.

The third of year of participation in the IMI project for the Cohort Two Select Cadre teachers began with a two-day summer Leadership Training Workshop, attended by Select Cadre teachers from all three cohorts. From this point on, Select Cadre teachers from all three cohorts began attending four annual workshops held during the academic year. These workshops focused on leadership training and mathematical content. IMI leadership team members led sessions on mathematical content, and then the Select Cadre teachers were expected to lead similar sessions for teachers in their own districts.

Professional Development in Mathematical Content Knowledge

As described above, from the beginning of the project, almost all of the professional development work in mathematics content knowledge was intended to support teachers'

¹ The ninth school district had a dual adoption that did not include *Everyday Mathematics*; the participating IMI teachers, along with other teachers in that district who chose to do so, began using *Math Expressions*, another reform-minded curriculum.

successful implementation of the chosen reform-minded elementary curriculum. During teachers' first year in the project, therefore, the bulk of the work done with the teachers focused on training in the use of a new and different way of teaching mathematics. However, particularly during and after teachers' second year of participation, there was also a deliberate attempt to foster leadership; ultimately it was hoped that the Select Cadre teachers would become the vehicle for delivering the professional development needed for all elementary teachers in their districts.

Professional Development during the First Year of Participation

Cohort Two teachers' first year in the project began with a three-day summer workshop, which was followed by three two-day workshops during the academic year. Teachers also participated in online professional development in the form of Learning Logs.

Professional development workshops in the first year. The primary purpose for the first summer workshop was to provide teachers with the support and training they needed to begin implementing the new curriculum. Approximately half of the workshop consisted of sessions on how to teach using the *Everyday Mathematics* curriculum. These sessions were facilitated by *Everyday Mathematics* consultants; one was a mathematics resource teacher and the others were former classroom teachers, and all had taught with *Everyday Mathematics* for at least three years. IMI leadership team members led the other half of the workshop, which focused on looking at the mathematics content that made up the first six weeks of the curriculum in third and fourth grade (a half day in duration). Time was also spent examining how the mathematics of the curriculum aligned with the mathematics of the Indiana Academic Standards.

Similar two-day workshops were conducted three times throughout the school year. Sessions were much the same, focusing on support for implementation of the curriculum and on the mathematical content being taught across the grade levels, as well as alignment with the state standards.

An example session on mathematics content was one centered on alternative algorithms and computation. The session began with a discussion of the importance of children learning the order of operations and the basic facts, known in *Everyday Mathematics* as "Fact Power." This was followed by a discussion of the definition of an algorithm and how children are not always successful at learning the standard algorithms taught in school. Participants were presented with a variety of addition, subtraction, multiplication, and division algorithms that are used in *Everyday Mathematics*. They then broke up into small, grade-level groups to do the work asked of the students in the introductory lesson for the next algorithm they would be teaching in their classrooms. The session concluded with a discussion of the mathematics content in the algorithm lessons.

Examples of the sort of algorithms presented are those of the Partial Sums method for addition and the Partial Products method for multiplication. The Partial Products method for multiplication is a key focus of *Everyday Mathematics* and it is important that the teachers understand it. The method is based on the simple fact that 87×23 is the same as $(80+7) \times (20+3)$ and this second product is easily computed by adding the terms resulting from the four products: 80×20 , 80×3 , 7×20 , and 7×3 .

Online professional development in the first year. Once a week, participating teachers were expected to complete an online Learning Log entry. In keeping with the professional development goals of the IMI project, teachers were asked to provide responses to the following prompts:

- What were your mathematical learning goals this week? [This referred to the teacher's mathematical goals for her or his students.]
- To what extent do you think your students made progress toward these goals?
- Identify this week's classroom challenges and/or opportunities related to one or more of the following areas: pacing, *EM* [*Everyday Mathematics*] materials, working in groups, and student readiness.
- Your own mathematical insights.

Teachers were asked, therefore, to reflect upon not only what they had been teaching and their students' learning progress, but also upon their own mathematical learning each week. Logs were read and responded to by the same *Everyday Mathematics* consultants who had provided the *Everyday Mathematics* training during the summer workshops. Teachers were assigned to particular readers, so that their logs would be read by the same person each week.

Professional Development during the Second Year of Participation

Two teachers per district in Cohort Two were asked to become members of the IMI Select Cadre. They began their second year of participation with a one-day summer workshop on mentoring, followed by four two-day workshops held during the academic year. They were also asked to participate in online professional development, this time in the form of monthly Assessment Logs. Lastly, along with other Select Cadre teachers, they provided professional development for other teachers in their districts.

Professional development workshops in the second year. As members of the Select Cadre, teachers participated in workshops during the summer and academic year that focused on deepening their mathematics understanding, mentoring, providing their peers with additional support for teaching the curriculum, and further examining alignment of the mathematical ideas in the curriculum with the Indiana Academic Standards.

As these teachers began working as mentors for teachers in their districts, they also began participating in professional development sessions on mathematics content with teachers from grade levels across the elementary years. This arrangement allowed for a greater discussion of articulation of mathematical strands across grade levels, not only in the *Everyday Mathematics* curriculum, but also with the mathematics in the state Standards.

At this point, the Cohort Two Select Cadre teachers were also beginning to serve as facilitators of mathematics professional development in their own districts. In this role, they would first attend professional development content sessions at the project-wide meetings and then would work with IMI leadership team members and their district coordinator to design and facilitate similar sessions for teachers in their own districts.

An example of the content preparation in which Select Cadre teachers participated focused on algebra throughout the *Everyday Mathematics* curriculum and the state standards. This workshop

began with a discussion of the algebra standards for each grade level, beginning with kindergarten and working through eighth grade. The participants then played a series of algebra-focused games from *Everyday Mathematics*. The stage had been set for this activity by the work of Donna McLeish, who had earlier produced a detailed list of the connections between Everyday Mathematics activities and the Indiana Mathematics Standards. The teachers worked on many activities such as “What’s My Rule?” for numbers out of sequence and then discussed the related ideas in algebra and functions. The activity is then connected to the Indiana Standard on Algebra and Functions. These sessions were reinforced by lectures of Paul Kehle from Indiana University, who showed how the same settings could be used from grades 2 to 10 to build up knowledge and intuition about algebra.

In these grade-level appropriate games, the goal is for participants to make predictions and identify a rule used by the teacher or a fellow student. For example, in the Kindergarten game “What’s my rule? Fishing” the teacher uses a rule to “fish” for students in the classroom. An example rule might be students wearing blue. The teacher would pull out students wearing blue, one by one, until someone determined the rule.

Other games included “Magic Bag,” “What’s My Attribute Rule?,” and “What’s My Rule? Function Machine.” In “Magic Bag,” the leader used a bag and several identical items to demonstrate a rule. For example, the facilitator put one stick in a bag and then pulled out two sticks. She then put in two sticks and pulled out three. This action was repeated several times as the group described the rule being used. In “What’s My Attribute Rule?,” a player used attribute blocks to provide examples and non-examples that fit a rule shown on a hidden card, while other players tried to determine the rule. The game “What’s My Rule? Function Machine” was similar; participants predicted responses and determine functions based on given “in” and “out” numbers. The session ended with a discussion of the mathematics content, and specifically the algebra, that was involved in working on the tasks in the games.

Online professional development in the second year. During their second year in the project, participants completed Assessment Logs at the end of their own teaching of each *Everyday Mathematics* unit, approximately once a month during the school year. Either the IMI leadership member in charge of the online professional development component of the project (a university mathematics faculty member), or one of the original Learning Log readers responded to each Assessment Log entry.

The Log readers had chosen particular assessments from each unit to be used as common assessments by all Select Cadre teachers at the same grade level. As a basis for the Assessment Log entries, each teacher was expected to use the unit assessments and at least one other assessment of her or his choice. The mathematical learning goals for the unit were listed at the beginning of each log, and for each assessment administered the teacher responded to the following prompts:

- Goal(s) assessed.
- Number of students who reached the appropriate level of expectation.
- Comments about the assessment and the plan of attack. (Here teachers were to write about what they learned from the assessment about their students’ mathematical learning and understanding, and then what they planned to do next for the named learning goal.)

- Other reflections about the unit.
- Your own mathematical insights.

As with the Learning Logs, teachers were expected to reflect upon their students' learning and understanding and their own mathematical learning. By having teachers write explicitly and specifically about their students' understanding, it was expected that teachers would be engaged in thinking more deeply about the mathematics content in the unit.

Professional Development during the Third Year of Participation and Beyond

The project began to shift its focus from providing professional development for teacher leaders to supporting teacher leaders as they conducted professional development in their own school districts. In addition, the project continued to provide Select Cadre teachers with sessions on mathematics content.

Select Cadre teachers from all three cohorts of participants began the year by participating in a two-day summer workshop that focused on leadership training. While most sessions at this workshop focused on other aspects of leadership training, there was one breakout session for participants entitled "Leadership in Mathematics through Content Training."

This session was intended not only to provide some content development in mathematics for the participants but also to work as a model for how professional development in mathematics content could be presented in the teachers' home districts. Led by an IMI leadership member, the content used for this model session was in geometry. The session began with participants doing a second-grade activity from *Everyday Mathematics*. They were asked to feel a cutout shape that was hidden in a paper bag, to find the matching shape on their tables, and then to explain how they knew that was the matching shape. Next, they were asked to discuss the mathematics involved in the task. The facilitator then focused on articulation, using several released items on geometry from the most recent state achievement tests in grades 3-10, as well as the accompanying Indiana Academic Standards. After this activity, the group shifted to addressing the mathematics content itself, through a discussion of the classification of quadrilaterals, using a chart with names, descriptions and examples, and a diagram of overlapping classifications. Some specific items mentioned were the concepts of lines, segments, rays, and polygons, as well as the notions of reflection, symmetry, perimeter, area, and volume. The study of all of these ideas originates in the elementary grades. There were also discussions of ideas such as slope, parallel lines, perpendicular lines, and equations of lines, connecting geometry to algebra, and illustrating connections between topics studied in the elementary grades and more advanced and formalized ideas students encounter in the middle and secondary grades. Participants then concluded their mathematical work by completing another *Everyday Mathematics* task from fourth grade, in which they were asked to decide which of a list of characteristics was true for two given drawings of parallelograms and to add an additional characteristic for each. They were also asked to consider the question, "Is a kite a parallelogram? Please explain." The session ended with the presentation of an outline template that that could be used by the Select Cadre members for content sessions with the teachers in their own districts.

The leadership training itself was an important component of the project. It was through the work of the Select Cadre teachers that support for implementation of *Everyday Mathematics* and development of the mathematical knowledge needed for teaching this reform-minded curriculum

would reach all of the teachers in the participating school districts. After the leadership conference, in order to continue supporting the teacher leaders in their district work and to help them continue to deepen their mathematics content knowledge, three to four day-long project-wide meetings were held for Select Cadre teachers during each of the next three academic years. IMI leadership members would facilitate sessions on mathematics content, and the teacher leaders were then expected to provide content sessions in their own districts, which might or might not be similar to the project meeting sessions.

An example session used during the Cohort Two teachers' third year was on problem solving. The session began with a discussion of how using problems in the classroom can help provide differentiated learning and that in using problems in the classroom the focus needs to be on the mathematics and on the students. The accompanying PowerPoint slide directed the teachers to:

- Focus on the mathematics
 - What are the mathematical goals?
 - What are the tasks?
 - What is MOST important for all students to learn?

- Focus on the students
 - What are their strengths?
 - What are their weaknesses?

Participants then worked on several story problems and discussed the strategies students might use to solve the problems.

Evidence of Impact

Evidence of the impact from the professional development designed to deepen teachers' content knowledge can be found in three different forms. First, teacher participants were given both a pre- and post-test version of the *Learning Mathematics for Teaching* assessment. Second, teachers who participated in the project were given several opportunities and means to discuss and report upon their content knowledge learning, including conversations with the project evaluator and anonymous evaluation surveys given at different times during the project. Third, the sustainability of the project, including the individual districts' plans and ongoing work to continue to implement professional development in mathematical content knowledge, provides evidence of the effectiveness of the project's work.

Learning Mathematics for Teaching Assessments

As mentioned above, participants were given the *Learning Mathematics for Teaching* Assessment as both a pre- and posttest. It was reported in the project's 2005-2006 annual report that teachers who had taken the pre-test one year earlier had shown modest but significant gains of about six percentage points.

Teacher Comments and Self-Reported Gains in Content Knowledge

During the final year of the project, Select Cadre teachers in almost every district made unsolicited comments to the evaluator (the author of this paper) about how they felt they

understood mathematics so much better than they had before teaching the *Everyday Mathematics* curriculum. Some stated that it was when they were teaching that they learned the most; others reported that it was the Learning Logs and the Assessment Logs that pushed them to think more deeply about the mathematics.

Indeed, these statements were supported by comments made in two different surveys given to participants, one during the project and one at the end.

As part of the outside evaluation conducted by Horizon Research, Inc., Heck, Wickwire, and Smith (2007) wrote that “Overall, participating teachers reported increases to their content preparedness between a retrospective baseline questionnaire administered at the end of each teacher’s initial year of involvement and a follow-up questionnaire randomly administered two, three, or four years after each teacher’s initial involvement” (p.15).

In the survey given at the end of the IMI project by the author of this paper, teachers were asked, “How has your mathematical content knowledge changed or grown since you began participating in the IMI project?” Eighty-percent of the elementary teachers who responded to this question indicated that they felt their content knowledge had grown or deepened in some way during their time in the project.

Sustainability: District Plans for Deepening Teachers’ Content Knowledge

A third indicator of the impact of the IMI project on teachers’ content knowledge is the fact that most of the participating district coordinators reported that they planned to continue work in content knowledge for teachers once the project had ended.

During the final thirteen months of formal project activities, the main focus was on building the capacity within each of the partnership school districts to sustain the momentum of the work that was begun by IMI. This included developing and supporting a structure that would enable each individual school district to continue to provide teachers with relevant mathematics content training. This effort centered on moving the leadership and the decision making of the project from the team leadership members to the district coordinators and the teacher leaders in each of the partnership districts, by having them identify and prepare written proposals for activities they would conduct in their own districts to be funded with IMI monies. One of the requirements for proposals was that there would be sessions on content training for teachers. Each district did, indeed, provide sessions on content training, led by the districts’ IMI-trained teacher leaders.

A district coordinator wrote about the ongoing impact of the IMI project on professional development in her school district, and, in particular, about deepening teachers’ content knowledge:

One of the goals of IMI was to increase the mathematical content knowledge of elementary teachers. As a district [we] had not previously taken this variable into consideration in planning professional development in mathematics. One positive result that occurred at the elementary level . . . was a natural increase in mathematical knowledge of teachers with the implementation a standards-based program. . . . We often heard teachers talking about their own mathematical learning, as they were teaching the standards-based program. Through our work with the IMI collaborative, the select cadre

was also expected to organize and implement mathematical content sessions for elementary teachers in the district. . . . Our feedback forms from the after-school sessions indicated an increase in their knowledge base for math content. [We have] now also included content work in the implementation professional development sessions, where teachers actually do the math work that is expected of the students and explain it to a colleague. This has become a vital part of the planning process of a standards-based program. (Maddox, 2009, p. 5)

Lessons Learned

While there were many lessons learned about working with elementary teachers during the six years of the IMI project, there are six that stand out. Each of these is described below.

Teachers Need to See Value Added for their Classrooms

Because the long term success and sustainability of the project was dependent upon the teacher leaders and because active and enthusiastic teacher involvement in the content sessions was a critical project goal, project leadership remained highly sensitive to participants' needs. Teachers were provided with evaluation forms at all workshops, conferences, and similar sessions. Teachers were given opportunities to write about questions, concerns, and areas in which they needed support in every online Learning Log and Assessment Log. In addition, teacher leaders developed strong relationships with district coordinators and often with the project staff and were able to voice their own and their colleagues' concerns and perceived needs. When district coordinators met with the IMI leadership members, they were able to discuss teachers' needs and concerns.

Responses on the session evaluations were mostly positive when teachers perceived the mathematics to be directly connected with their *Everyday Mathematics* classrooms and generally neutral or negative when they felt such connections were weak or missing. Comments made by teachers, Select Cadre members, and district coordinators echoed these feelings. In other words, for work on developing teachers' content knowledge to be effective, teachers had to see that it clearly related to what they needed to be successful at teaching mathematics with the students in their own classrooms.

An early example of this was when the IMI leadership chose to focus sessions on assessment using the Balanced Assessment materials from the Mathematics Assessment Resource Service (see <http://www.balancedassessment.org/> and <http://www.nottingham.ac.uk/~ttzedweb/MARS>). Teachers reported that they did not see any connections between the Balanced Assessment materials and their classroom mathematics work. After discussing this reaction, the IMI project leadership decided that this experience was not beneficial for the project, and they did not continue using the materials. Later, the leadership members reported that they realized the teachers needed to first learn the curriculum and how formative assessment plays a role in instruction before they were ready to see the connections between the use of assessment in *Everyday Mathematics* and in the Balanced Assessment materials. This experience was also influential in the decision to have the online professional development focus on assessment in the curriculum during the Select Cadre teachers' second year in the project.

Thus, in the early years, as a project goal and in continued response to feedback from the teachers, almost all of the professional development in content knowledge was closely tied with pedagogical content knowledge and with support for teaching the *Everyday Mathematics* curriculum. In many ways, this approach proved to be a great strength of the project. Teachers were deepening their “mathematical knowledge for teaching,” which Ball and her colleagues (2005) have found to be correlated with students’ gain scores in mathematics.

Supporting Teachers—in the Classroom and as Leaders—Fosters the Development of Content Knowledge

Many Select Cadre members reported that as they gained experience in teaching *Everyday Mathematics*, they began to see the value of deepening their own understanding of the mathematics in the lessons they taught. Others stated that they deepened their mathematical understanding not only by participating in the IMI project’s professional development sessions on content, but also by the actual classroom experience of teaching with *Everyday Mathematics*; by the reflecting that they did in the Learning and Assessment Logs, as they were required to stop and think about their students’ mathematical understanding; and by the work they did with their colleagues as mentors and leaders of professional development.

Thus it became obvious to the IMI leadership team that the support they were providing for the implementation of the curriculum was another way that they were helping teachers to deepen their mathematics understanding. The support was deep and ongoing and was based on a strong relationship between teachers, district coordinators, and leadership members.

One reason this strong support for teachers was possible was the use of a single curriculum project-wide. As noted, it was felt that the use of one curriculum by all the project participants would strengthen the likelihood of the project’s success, and, indeed, this appears to have been the case. The ability to provide support specifically related to one curriculum enabled the leadership members to work simultaneously with groups of teachers from all partner districts. At the same time, participating teachers from across the state could support one another, through online forums and at the project-wide meetings. Teachers from the same grade level in different districts were working on and discussing the same mathematical ideas at the same time, and teachers from across the project and across grade levels were able to see the importance of the articulation of the mathematical ideas from kindergarten through sixth grade.

Provide Credible Project Leadership and Local Administrative Support

Another strength of the IMI partnership was the leadership provided for the project, as well as its inclusion of local administrative support and professional development. The project leadership team was composed of individuals whose insights were seen as valuable by the teacher participants; they were former teachers and most had experience with instructional coordination and supervision responsibilities. Thus, they brought both leadership and credibility to the project.

At the same time, local administrators from each of the school districts were supportive of the project from its inception and were provided with professional development tailored to their needs and interests. Indeed, administrative commitment was essential to district participation in the project. Teachers not only had administrative support from the beginning, which can be essential in allowing teachers to try new ideas and methods on their classrooms, but they also

knew that their local administration was eager to see the successes in their classrooms. This provided additional motivation for the teachers to become fully invested in the project.

Make Deeper Mathematical Connections Within and Beyond the Elementary Curriculum

While increasing teachers' content knowledge was an important component of the project from its inception, the IMI project staff believe it would have been more effective if from the beginning they would have made a greater effort to be explicit about the value of deepening teachers' mathematics understanding. In retrospect, the project leadership believes that activities focused on identifying and developing connections between mathematical ideas treated separately in the elementary curriculum—connections that might go a bit beyond what is actually taught but which (if done well) will provide insight and context for the teachers—would have been valuable. Along with the discussion about where the mathematical concepts fit into the curriculum and the state standards, there could have been activities and discussions about connections between various mathematical ideas and topics, both within a single elementary grade, across several elementary grades, and between the elementary grades and the immediately following middle school grades. For example, the leadership team could have been more careful to explicitly discuss the connections between number and geometry through measurement, the connection between algebra and geometry through formulas for areas, and the ways in which algebra and geometry come together in the middle school grades through the graphs of functions.

Include Discussions on Data Collection and Sustainability from the Start

During the later years of the project, IMI staff saw that many opportunities to collect data and to document project activities and successes and failures had been missed. Thus, if the project were to start over, two important components to the project's foci would be added. First, the staff would add a focus on documentation and data collection, to be used for a variety of purposes. They would spend time with the project leadership before the work with teachers began, to make decisions in advance about what it was they were interested in measuring and, thus, what data needed to be collected. Quantitative information could be used to support the evaluation of the project, to conduct research on the effectiveness of different components of the project, and to provide data for both formative and summative assessment of the students' and the teachers' learning.

At the same time, the IMI staff would add a much earlier focus on sustainability. This was a part of the final years of the project, but it would have been very helpful to have launched an explicit consideration of the topic much sooner. The project could have built in more activities that were conducive to sustainability, such as providing support for writing district-level grants and designing long-term professional development leadership plans.

If both of these elements—data collection and sustainability—had been part of the project from the beginning, they could have been discussed by the leadership at each of the monthly meetings. More and better data would have been collected and documentation of all project activities could have been more thorough, consistent, and useful. Activities could have been focused on helping districts provide their own plans for sustainability and data collection.

Helping Teachers to Deepen Their Content Knowledge Takes Time

Lastly, a strength of this project was its long-term commitment to working with elementary teachers. The original five-year timeline allowed time for teachers to learn how to implement the

curriculum; time to build relationships among teachers, teacher leaders, district coordinators, and IMI team leadership members; time for teachers to reflect upon what was happening in their own classrooms, and time to learn about what was happening across and within different grade levels. Mathematical ideas were revisited after teachers had experience teaching them, and then again when they were mentoring other teachers or leading professional development.

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