

Intel Math Connections: A Three-Year Study of the Impact of a Math-Based Program on Elementary Teachers

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ABSTRACT

The paper considers the impact of a professional development program focused on improving math skills for elementary school teachers and their students in two mostly rural Southwestern Illinois counties. The Monroe/Randolph Regional Office of Education #45 was awarded two Illinois Math and Science Partnership grants to employ an Intel Math workshop and follow-up over three school years.

The Intel Math Connections Project included four projects that consisted of a 80 hour summer professional development module focused on middle and high school math concepts and a school year follow-up where teachers were divided into groups to form vertically aligned mathematical learning communities (MLCs). The learning communities were led by middle and high school math teachers and were focused on “stretching” math problems for application to all grades. A comparison group of teachers included four cohorts of matched control group elementary teachers. These teachers were not provided access to the project materials but received the same surveys and tests as the project teachers to form a quasi-experimental research study.

This study focused on the impact of the program on the project teachers in comparison to the control group teachers. Research questions include (1) teacher content understanding, and (2) teacher change in pedagogy.

Keywords: STEM, Conference Proceedings, Math, Professional Development

INTRODUCTION

STEM (Science, Technology, Engineering and Math) Education has become a federal priority. Speeches by President Obama, Secretary of Education Arne Duncan and others have called for a focused emphasis on these disciplines of learning (Duncan, 2009) (White House, 2012). These speeches have moved beyond the rhetoric and have been put into policy and developed action through programs such as the National Science Foundation’s Noyce scholarships to develop STEM teachers, and the Department of Education’s Mathematics and Science Partnerships, and Race to the Top. Priorities include increasing STEM literacy and students’ critical thinking skills, improving the quality of math and science teaching, and a greater awareness of careers associated with STEM. Specifically, the Common Core Standards, Next Generation Science Standards (proposed) and the federal Race to the Top initiative have emphasized the need to focus on these areas.

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The Intel Math Connections Project (IMCP) was developed to increase the academic achievement of students in mathematics in Monroe and Randolph Counties by enhancing the content knowledge and teaching skills of elementary and middle school mathematics teachers. Specifically, the project incorporated the Intel Math program that was developed for Intel by Dr. Kenneth Gross (University of Vermont), using measures from WestEd, and the support from the Institute for Mathematics and Education at the University of Arizona. The Intel Math program targeted teachers at high need school districts in the counties. It included four cohorts of elementary teachers, but also included special education, middle, and high school math teachers.

The primary objectives of the project were:

1. To increase content and concept knowledge of teachers in mathematics and the teachers' appreciation and understanding of the connections between the disciplines of mathematics including number sense, algebra and geometry.
2. To model appropriate pedagogy, problem-solving strategies, assessment techniques and instructional practices that can be replicated in the classroom.
3. To provide Illinois middle school and high school teachers the opportunity to work as a mathematical professional learning community to build collaboration as they continue to incorporate and investigate student teaching and learning in mathematics.
4. To introduce Illinois elementary school and middle school teachers to an array of resources available locally, nationally and electronically to help them incorporate inquiry, critical thinking, career awareness and application of mathematics into their classroom.
5. To increase teachers' pedagogical expertise to effectively incorporate critical thinking, problem solving and technology use into the classroom and to use action research to make educational decisions.
6. To build leadership capacity within departments, across districts and among teachers and professionals in the area and the state.

The project recruited project teachers who volunteered to be involved with the IMCP and who completed surveys and tests for the program evaluation research. Matched comparison control elementary teachers were recruited and paid to complete the same surveys and tests to provide for a quasi-experimental research project. The control group teachers were not provided access to IMCP resources and professional development.

LITERATURE REVIEW AND BACKGROUND

Regional Background and Needs

ROE #45 serves two predominantly rural counties in southwestern Illinois. In many ways the two counties are very similar, yet in other ways they are polar opposites.

The northernmost county of the two encompasses 388 square miles, mostly rural. There is no major industry within the county. Monroe County has three main communities (around which its three public school districts are centered): All three communities, as well as the school districts they serve, are growing rapidly. Of the over 32,000 residents of Monroe County surveyed in 2007, 89.7% had attained a high school diploma or better while 24.2% had received a Bachelor's degree. Monroe County is predominantly a "bedroom community," where many of its residents travel to St. Louis to work.

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The southernmost county, Randolph County, encompasses 578 square miles, almost entirely rural. There are six primary communities (around which six public school districts are centered). Of the 32,000 plus residents of Randolph County surveyed in 2007, 79.8% had received a high school diploma or better. In addition, 12.3% of the residents had achieved a Bachelor's degree. Many of the residents of the county have been employed in local industries, such as a major commercial bakery, coal mines, local hospitals or agriculture-related activities.

Prior to starting the project a review of the summary data from schools in the two counties' 2009 standardized state assessments was performed. A relatively high percentage (85 percent) of 8th-grade students met or exceeded state standards on math (Illinois State Board of Education, 2010). However, that percentage dropped to 53 percent on the 11th grade high school assessments (Illinois State Board of Education, 2010). It was concluded that a stronger emphasis on problem-solving skills and conceptual knowledge in elementary and middle school was needed to lessen the obvious K-8 and high school math score gaps. Further it was concluded that students need better preparation in earlier grades to be successful in middle and high school.

Many studies confirm conventional wisdom that U.S. teachers lack content knowledge and the ability to reason about mathematics, especially relative to international peers. Ma's landmark work (1999) demonstrated that Chinese teachers were able to reason and experiment about mathematics, to present multiple solution methods, and to use manipulatives to effectively explore the conceptual heart of a mathematical idea much better than their U.S. peers. Nonetheless, there is little research on the effect of professional development (and even preservice teacher preparation) on student achievement. The 2008 Final Report of the National Mathematics Advisory Panel (U.S. Department of Education, 2008) concludes that many studies of professional development programs are "descriptive" in nature and "did not include a comparison group, but used a pre-test/post-test design." They found that there were "some positive effects of professional development on students' achievement gains" but that more evidence was needed. However, Beilock et. al. (2010) showed that female teachers' math anxiety did transfer to their female students, resulting in "significantly worse math achievement" than girls that did not have such an experience with a teacher.

The IMCP was developed to increase the academic achievement of students in mathematics in Monroe and Randolph Counties by enhancing the content knowledge and teaching skills of elementary mathematics teachers.

Intel Math

The University of Arizona sponsored Intel Math program is research-based and supported by evaluation [Institute for Mathematics Education (IME), 2010]. A summary of the overall findings, taken from the document "Final Report: Evaluation of Intel Math Initiative—Professional Development Course and Teacher Learning" (see Attachments for excerpts from full document) (IME, 2010), reported the following:

1. Results of the content assessment "indicate an increase in the percent of teachers who can solve mathematics problems correctly on the post survey in all content areas assessed."
2. Survey results "indicate growth in teachers' conceptual understanding and computational skills."
3. "Teachers described varying ways of applying their knowledge of the course to their classrooms, and they reported multiple benefits to students."

4. Course instructors (a mathematician and a mathematics educator) “developed relationships with participating teachers and created collaborative learning communities.”

A core tenet of the Intel Math professional development program is to explore the connections between arithmetic, geometry, and algebra in a problem-solving framework; the abstraction of the materials increase over the course of the program. Floersheim and Johnston (2010) suggest that it is exactly the inability of students to move toward abstraction that causes students to drop in STEM interest and ability from elementary to middle school. One aim of the IMCP was to help teachers see both concrete and abstract formulations of the same concepts.

Loucks-Horsley and Matsumoto (2010) propose that a successful professional development program should employ the following strategies: immersion (doing mathematics), curriculum and examining practice, collaborative work, and considering various structures through which professional development can occur. Further, teacher professional that occurs over a 12 month period, that is intensive, and has a substantial number of hours (> 50) has been shown to directly affect student achievement (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). The IMCP deliberately focused on exactly these qualities. Teachers were immersed in an intensive summer experience of doing mathematics through problem solving (as opposed to a lecture model). Teachers did some review of student work in the summer program, but the MLCs extend this and offer an opportunity to collaborate with other teachers in vertically aligned groups. Finally, the structure of the MLCs and the composition of the summer program were designed to, in the words of Loucks-Horsley and Matsumoto, “develop professional developers” --- the peer leaders and participants become leaders in their own schools and districts and establish a community where experimentation and review of student work and pedagogy is safe and welcome.

Math and Science Partnerships

The U.S. Department of Education Mathematics and Science Partnerships (MSP) funded the IMCP through the Illinois Mathematics Science Partnership program. The conceptual model for the program is that student achievement in mathematics and science occur as a result of improved classroom instruction, which occur through the provision of professional development programs by LEAs and local institutions of higher education [U.S. Department of Education (ED), 2013a]. The MSP program provides block grants to states based on student populations and poverty rates (ED, 2013b). The state based programs are required to administer a competitive grant program that promotes the goals of the ED MSP program and the developed state-based goals.

The IMCP developed the first successful grant proposal in spring 2010 for two cohorts of teachers who started in summer 2010 and summer 2011. A second replication grant was funded in spring 2011 for two additional cohorts that started in summer 2011 and summer 2012. Each funded project lasted approximately 2.5 years or over three fiscal years. For example the first funded project ran from April 2010 through September 2012. After budget negotiations and adjustments for budget cuts, a project would typically receive about \$200,000 per fiscal year for the provision of the program activities, support, and evaluation.

PROGRAM DESCRIPTION

The IMCP targeted four cohorts of 25 elementary, middle school, and special education teachers during the 2010-2011, 2011-2012, and the 2012-2013 school years. Each cohort was involved in two phases. The first phase was the Intel Math summer professional development project that

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lasted for two weeks or 80 hours. The second phase occurred during the following school year and involved follow-up from the summer and involvement in vertically aligned district oriented MLCs.

While the project focused on recruiting elementary and special education teachers it also recruited 5 additional middle and high school math educators who participated fully in the professional development activities with the perspective of becoming lead facilitators for the mathematical learning communities that occurred during the school year.

The summer sessions were instructed by one of two teams of three mathematics professionals that included a university math professor (from the math department), a math educator (from the education department) and a practicing senior mathematics educator from a local high school. The instructors took part in four days of training provided by the University of Arizona Institute of Mathematics and Education, which is the National Training Agency of the Intel Math program. During the training the instructors learned the essentials of successfully implementing the Intel Math program. The “train the trainers” workshop included an examination of unit-by-unit activities, instruction in differentiation of material and homework, guidelines for facilitating discussion and pedagogy.

The Intel Math program implementation model consisted of eighty hours of Intel Math curriculum utilizing eight units of additive math understanding. The program included the following units:

Unit 1: Addition
Unit 2: Subtraction
Unit 3: Multiplication
Unit 4: Division

Unit 5: Operations with Fractions
Unit 6: Rational Numbers
Unit 7: Linear Relations
Unit 8: Functions

The units were organized into four to seven sessions. Each session considered novel and applied approaches to both understanding the concepts (from a teachers perspective) and applies these ways of learning in ways that were consistent with good classroom instruction and assessment. Many of the sessions included the use of manipulatives, required teachers to work in small groups, and asked teacher groups to present findings to the entire class of teachers.

The University of Arizona, Institute for Mathematics Education (IME) recommends that the implementation model consist of 13 days, with five or more consecutive days during the summer and the remaining days dispersed throughout the fall semester (IME, 2010). The first three cohorts covered most of the information during the summer and had two or three follow-up sessions for the remaining content. The last cohort covered all of the content during the summer and used follow-up days for study on the implementation of the Math Common Core standards and with the MLCs.

The MLCs were smaller groups of five to seven teachers led by the middle or high school math teachers, who had more math content background. As professional learning communities the groups reviewed modules that were created by the University of Massachusetts Medical College (UMASS) Mathematical Learning Communities model. This model was designed to complement the Intel Math curriculum (IME, 2010) and is recommended by the IME. The UMASS Regional Science Resource Center partnered with the Massachusetts Department of Elementary and Secondary Education to develop Mathematics Learning Community (MLC)

curriculum materials. The materials outline protocols, procedures, structure and organizational suggestions to facilitate meaningful mathematical conversations among teachers.

The teacher facilitator was responsible for scheduling and meeting with their teams at least five times throughout the school year (in addition to other whole group grant activities). When possible the MLCs were organized by school district to provide for vertical discussion among teachers that work within the same community and are responsible for the academic preparation of the same children, at different points in time. The modules often considered problems that were “stretched” among the grades. In other words, MLC participants from different grades identified a similar problem and redefined it to make it appropriate for their students’ developmental level. The modules also focused on multiple ways of assessing student work and multiple ways that students understand and solve problems.

In addition to the teachers who were involved with the IMCP, control group teachers were recruited to provide a comparison for the purposes of determining the impact of the program on the project teachers. The matched comparison teachers were drawn from the same geographical region and taught in rural schools. The teachers were paid \$25 for their first pre-testing session and were paid \$75 for the post-testing session.

METHODOLOGY

The broad IMCP project hypothesis followed the ED conceptual model that improved mathematics content expertise and improved pedagogical skills will lead to higher teacher quality and greater student achievement (ED, 2013a). The following were the specific research questions considered for this research project.

1. Did elementary teachers who participated in the STEM project increase their content and conceptual knowledge of mathematics? (Knowledge Gain)
2. Were elementary teachers able to integrate scientifically based instructional strategies into their classrooms? (Pedagogy Change)

Hypotheses

The following are the null and alternative hypotheses for the two research questions. Each research question had two hypotheses concerning the change in project teacher results and the differences between project and control post test results.

1. Knowledge gain – Change in project teacher content scores

$H1a_0$. The mean of project teacher content pre-test results (μ_{preimc}) will be equal to the project teacher content post-test results ($\mu_{postimc}$) when accounting for changes in control group scores

$H1_0: \mu_{preimc} = \mu_{postimc}$

$H1_1$. The mean of project teacher content pre-test results (μ_{preimc}) will be less than the project teacher content post-test results ($\mu_{postimc}$) when accounting for changes in control group scores

$H1a_1: \mu_{preimc} < \mu_{postimc}$

2. Pedagogy Change – Change in project teacher survey ratings on communicating mathematical understanding.

$H2a_0$. The mean of project teacher presurvey ratings (μ_{precmu}) will be equal to the project teacher postsurvey ratings ($\mu_{postcmu}$) on communicating mathematical understanding when accounting for changes in control group ratings

$H2a_0: \mu_{\text{precmu}} = \mu_{\text{postcmu}}$

$H2a_1$. The mean of project teacher presurvey ratings (μ_{precmu}) will be less than the project teacher postsurvey ratings (μ_{postcmu}) on communicating mathematical understanding when accounting for changes in control group ratings

$H2a_1: \mu_{\text{precmu}} < \mu_{\text{postcmu}}$

Statistical Approach

Each hypothesis was investigated using an analysis of variation (ANOVA) repeated measures cross over design (Vonesh & Chinchilli, 1997). This method allowed the researcher to take measurements on the same subjects over time under different conditions. The two conditions are the pre-test (before the treatment) and the post-test (after the treatment has been administered to the project group). The cross over design provides for two groups of subjects, which in this case is either the project or control group. The design controls for error while testing for group effects at the same time as testing for change effects due to the treatment.

Group Selection and Recruitment

Project teachers were recruited by the IMCP staff with the assistance of school district administrators such as superintendents, principals, and department heads. Each of the four cohorts had a lead school district partner whose teachers were selected as a priority over other regional teachers. Teachers from other districts were required to secure permission to participate from their principals and superintendents. This permission document also outlined their involvement with the summer and school year activities.

Control teachers were recruited by the evaluator in coordination with the IMCP project staff, project teachers, and district administrators. While middle and high school teachers were selected for the project for assistance with the MLCs, only elementary and special education teachers were selected for the control group as a matched comparison group. It was reasoned that middle and high school teachers had strong content understanding and were not expected to show content gains. (While this study does not consider their results, this assumption was correct; middle and high school project teachers did not demonstrate any content gains because most of them had very high scores on the pre-tests.) Protocols for control teacher recruitment, selection, and payment were developed with the first cohort; the first cohort was very small because these protocols were not yet developed.

The following table represents the numbers of elementary teacher participants by group (project or control) for the two projects over the three academic years. Please note that the code represents the project, cohort, and academic year. For example “P1-2 2012” is the first funded project (P1), second cohort (-2), in the 2011-2012 academic year (2012).

Table 1: Group Participants

GROUP	P1-1 2011	P1-2 2012	P2-1 2012	P2-2 2013	TOTAL
Project	14	19	14	19	66
Control	5	20	23	24	72
TOTAL	19	39	37	43	138

Instrumentation

For the Knowledge Gain research question the research project used the Intel Math Content Inventory (IMC) (IME, 2010). The IMC was designed specifically to accompany the Intel Math professional development program. The 20 item inventory includes questions that refer to specific program units. It was validated by the IME as part of the program development with Intel, WestEd, and Dr. Kenneth Gross. The test is scored as a percentage of items correct on a scale of 0 to 100. The test required teachers to complete math problems and show their work. Teachers could receive partial credit through their written work when they got an answer wrong, but demonstrated a partial understanding for the concept.

To measure Pedagogy Change, the project adapted the Surveys of Enacted Curriculum – Math (Blank, Porter, & Smithson, 2001) for use with elementary teachers. The original survey was developed jointly by Council of Chief State School Officers (CCSSO) and the Wisconsin Center for Education Research with funding from the National Science Foundation (Blank, Porter, & Smithson, 2001). The original survey contained 150 questions, which project organizers deemed to be too long and too exhaustive for the purposes of this project. The resulting survey was designed based on findings from the CCSSO report, New Tools for Analyzing Teaching, Curriculum and Standards in Mathematics & Science: Results from Survey of Enacted Curriculum Project Final Report (Blank, Porter, & Smithson, 2001). The researchers validated the use of the items and reported the strongest items in the Appendix C (Blank, Porter, & Smithson, 2001). The strength of the items and the suggestions by the researchers were used when identifying the items to be used in the abbreviated survey.

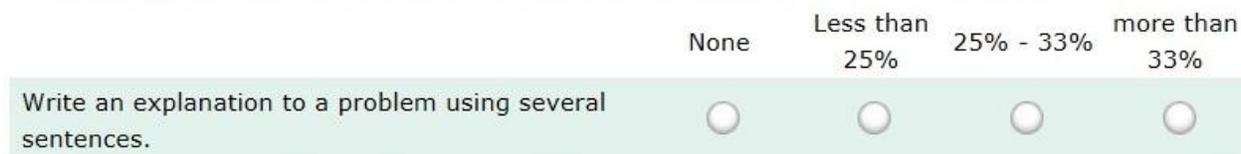
The project adapted survey, The Math Curriculum Survey, included eight sections with 47 survey questions. This research paper only considers the seven questions from the Communicating Mathematical Understanding section. Teachers were asked to indicate the percent of time students were engaged in the following activities.

- Write an explanation to a problem using several sentences.
- Talk about ways to solve mathematics problems
- Work on a writing project where group members help to improve each others' (or the groups') work
- Present information to students concerning a mathematical idea or project
- Display and analyze data
- Individual or group demonstration, or presentation

Teachers used a scale from 1 to 4 where 1 = “None”, 2 = “Less than 25%”, 3 = 25% - 33%, and 4 = more than 33%. The following is a snapshot of the first question that teachers saw when they completed the survey online.

Figure 1: Survey Snapshot

What percentage of mathematics instructional time in your class do students:



Administration

Project teachers completed the instruments three times during their involvement with the project. The pre-test occurred either in the May before the summer workshops or on the first day of the summer workshops, which occurred in either June or July. A first post-test was administered on the last day of the summer workshops. (This post-test was not considered for this research project.) A second post-test was administered to the project teachers at the end of the fall semester after the summer workshops and during the implementation of the MLCs. For all administrations, the project teachers completed additional instruments beyond the two selected for this research study; these included project developed satisfaction surveys, an Intel Math survey, and the Learning Mathematics for Teaching (LMT) instrument. Project teachers, on average, took 45 minutes to complete the test and surveys.

Control group teachers completed a pre-test in August or September of the school year following the summer workshop project. While it would have been preferable to pre-test the control group teachers at the same time as the project teachers, this was not possible due to the fact that teachers are often unreachable during the summer and recruitment for the project was a higher priority than the control group recruitment. Post-tests were administered at the end of the fall semester at around the same time as the project teachers completed their post-tests. Control group teachers took, on average, 30 minutes to complete the test and surveys.

All project teachers and control teachers completed an informed consent document that outlined their rights as a participant and how the data would be used. All data were kept confidential and only reported in aggregate to protect the research participants. Project teachers were informed that the evaluation data was necessary for the grant, but were given the option to opt-out of the research study. Control group members were required to participate in the evaluation and research study as a condition for their payment. If control group members opted out, they did not complete the instruments and were not paid.

FINDINGS

1. Knowledge Gain

There was a significant main effect for all teachers, $F(1, 133) = 121.63, p < 0.001$, and a significant interaction between groups, $F(1, 133) = 31.23, p < 0.001$. The project teachers and control teachers demonstrated significant gains on the IMC content test. When analyzed using a repeated measures cross over design, the analysis demonstrated that project teachers had significant increases when accounting for the changes in the control group. This provides evidence to reject the null hypothesis and accept the alternative hypothesis that project teachers had significant increases in math content scores after accounting for control group test scores.

Table 2: IMC Descriptive statistics

	PROJECT		CONTROL	
	Pre Test	Post Test	Pre-Test	Post Test
Average	51%	69%	38%	44%
StDev	0.224	.219	.202	.224
Number	66	66	69	69
Low Score	5%	15%	0%	5%
High Score	90%	100%	90%	93%

Table 3: Knowledge Gain Split-Plot ANOVA

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>Sig</i>
pre_post_imc	1.003	1	1.003	121.63	<0.001
pre_post_imc*group	.258	1	.258	31.23	<0.001
Error	1.097	133	.008		

While the control teachers exhibited a significant increase in content test scores, the interaction among the two groups and the greater gains by the project teachers supports the alternative hypothesis designation. Further this difference in gains demonstrates the impact of the program on project teacher content understanding.

2. Pedagogy Change – Communicating Mathematical Understanding

There was a significant main effect for all teachers, $F(1, 128) = 10.669$, $p=0.001$, and a significant interaction between groups, $F(1, 128) = 6.093$, $p =0.045$. This means that the project teachers demonstrated significant changes in the way that they instruct their math classes. When analyzed using a repeated measures cross over design, the analysis demonstrated that project teachers had significant increases when accounting for the changes in the control group. This provides evidence to reject the null hypothesis and accept the alternative hypothesis that project teachers had significant increases in implementing classroom strategies to communicate mathematical understanding, which was not observed in the control group. It is noted that the control group demonstrated a decrease in average test score on the instrument. The difference was not significant and was considered due to random error.

Table 4: Communicating Mathematical Understanding Descriptive statistics

	PROJECT		CONTROL	
	Pre Test	Post Test	Pre-Test	Post Test
Average	2.39	2.69	2.69	2.58
StDev	.597	.593	.593	.571
Number	66	66	64	64

Note: This composite score included 7 items that used a scale from 1 to 4 where 1 = “None”, 2 = “Less than 25%”, 3 = 25% - 33%, and 4 = more than 33%.

Table 5: Communicating Mathematical Understanding Split-Plot ANOVA

	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>Sig</i>
pre_post_cmu	1.892	1	1.892	10.669	0.001
pre_post_cmu*group	1.080	1	1.080	6.093	.045
Error	22.695	128	.177		

DISCUSSION

The IMCP use of the Intel Math and MLC methods created positive impacts on project teachers with the use of a matched comparison control group to account for environmental changes. Specifically, elementary teachers involved with the program demonstrated improved understanding for mathematical concepts that their students will be required to learn in middle and high school. Further, the project teachers increased their use of research-based instructional practices in their classrooms.

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Environmental changes are felt by most (if not all) elementary teachers. These changes have included the implementation of Common Core State Standards Initiative, and other pressures to increase math scores. As a result teachers have been involved with math professional development. These environmental changes may be characterized as full of change and confusion caused by new and/or revised teacher expectations. The quasi-experimental approach with a control group helped account for this environment where almost all math teachers were experiencing some professional development.

It is important that elementary teachers have a better understanding for these math concepts because elementary teachers need to be aware of what concepts their students will be learning in middle and high school. Through an understanding of these concepts, teachers can alter the content to tailor it towards the instruction students will experience in the future.

The Intel Math workshop allowed teachers time to work together on concepts that they had often forgotten or no longer apply. Beyond the concepts, the instructors provided excellent examples for good classroom instruction through the use of manipulatives, working in small groups, and asking teams to report out to the whole class. While not a focus of this research study, teachers often commented on how it was difficult to assume a student role and that this helped remind them what it must be like for their students in their classes.

The MLCs provided an opportunity for teachers to work with their “vertical” district peers. This included those teachers who teach math to students in different grades from kindergarten to 12th grade. The conversations among these teachers were rich and helped to guide an understanding among common topics that could be applied (i.e., “stretched”) to differing class levels. Through further connection to other teachers in the district, the elementary school teachers were able to connect concepts at their level to the future concepts students will learn in middle and high school.

One unexplained finding was the differences in pre-test scores among the project and control teachers. It was not a focus in the findings section but the control teachers had very low pre-test scores ($\mu_{controlpre} = 38\%$). While they showed improvements, the control post-test scores ($\mu_{controlpost} = 44\%$) was still not as high as the project pre-test scores ($\mu_{projectpre} = 50\%$). While there is no evidence to support this, the control group teachers may not have been as motivated to do well on the tests since they were not involved with the project activities.

Many of the control group teachers had the opportunity to participate in the project but chose not to participate. A latent motivation variable may account for these differences as well. In other words, the project teachers who chose to be involved may be more motivated for self-improvement, which underlies some of their performance on the content tests and the ways that they change their classroom instruction.

A study limitation concerned the administration of the pre-tests to the control teachers. Given time constraints, control teachers did not complete the pre-test at the same time as the project teachers. Project pre-tests occurred in May or on the first day of the workshops during the summer. The control pre-tests were mostly completed in August and September after the workshop had been conducted and when teachers had returned to school.

Further Research

This study only considered a couple parts of the evaluation data that were collected. Another study should concern the impact of this program on the students using standardized test data. The evaluation also developed an MLC Pedagogy Survey specifically concerning activities discussed

the MLC modules. The instrument needs to be validated and these pre-test and post-test findings need to be analyzed and reported to support this study. Further, a qualitative research study could be completed concerning an analysis on teacher comments on surveys, and the journals that they kept while participating in the MLCs.

Implications for Practice

This quasi-experimental study provides support for the impact of the Intel Math curriculum and the MLCs for elementary school teachers. Further implementation of these workshops have the capacity to change mathematical instruction in elementary classrooms. These implementations have the capacity to better prepare students for middle and high school math, which may result in students who are college and career ready. At a minimum, an elementary school teacher who feels comfortable with secondary school math concepts should be able to ease some of the anxiety that students feel for these concepts. If students are comfortable with math in elementary school, they will be more likely to be open to learning math in middle and high school.

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