

Abstract Name: Links Between Teacher Professional Development, Mathematical Knowledge for Teaching, and Student Achievement

MSP Project: Milwaukee Mathematics Partnership

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Summary

The Milwaukee Mathematics Partnership (MMP) theory of action claims that teacher professional development leads to improved teacher mathematical knowledge for teaching (MKT) which leads to improved student achievement. Through our work, we have found that participation in MMP-sponsored mathematics focused courses predicts higher MKT scores. Similarly, we have evidence that teacher MKT positively predicts variability in student mathematics achievement. What is missing is the link between teacher participation in content focused courses and student achievement. This analysis combines data from three sources—teacher MMP course enrollment, teacher MKT scores, and student math achievement—and presents the evidence developed to date.

Section 1: Questions for dialogue at the MSP LNC

The primary issue for the LNC session will be what constitutes reasonable evidence that the theory of action proposed by an MSP project is actually working. It is often possible, as in the case of the MMP, to establish linkages between various components of the theory but not for the theory of action as a whole. Thus, we are interested in understanding, given our case, how other projects have examined these linkages and the extent to which they have developed reasonable evidence to support their claims.

Section 2: Conceptual framework

One of the fundamental objectives of the MMP has been to improve teacher quality and by doing so, contribute to improvements in student achievement. In the context of this project, student success is defined as performance on the Wisconsin Knowledge and Concepts Examination (WKCE). This exam assesses all state standards which includes mathematical processes, number and operations, geometry, measurement, statistics and probability, and algebraic relationships. Students complete both selected and constructed response items. For each student taking the WKCE, a scale score is provided along with an assessment of their proficiency level on a four-point scale (1=minimal, 2=basic, 3=proficient, 4=advanced). For this work, student scale scores were used as the dependent variable to examine relationships to student mathematics performance.

Measurement of teacher competence has been conducted using measures of mathematical knowledge for teaching (MKT) developed by the LMT project at the University of Michigan. MKT has been used as the primary measure of teacher competence because it has been shown to be related to student achievement (Hill, Rowan, & Ball, 2005; Hill & Ball, 2004). MKT is the knowledge that teachers need to carry out the work of teaching mathematics. It includes knowing mathematics content, mathematical connections, which concepts are easy or difficult for students to learning, ways of representing concepts, and ways students might be thinking or understanding.

A key strategy for improving teacher competence has been to offer university mathematics and mathematics education courses specifically for classroom teachers in the Milwaukee Public Schools. These courses have been offered since the beginning of the MMP and nearly 1300 different teachers have completed at least one MMP course. Content of courses has included, but not been limited to, number and computation development, mathematical communication, fractions, geometry, statistics, and algebraic reasoning. All courses embed aspects of MKT such as studying mathematics content

connections and representations, and examining student learning trajectories and misconceptions. Course goals include deepening teachers' understanding of the mathematics content they teach students and to improving teachers' pedagogical content knowledge.

Given the in-depth learning related to MKT that occurs in the MMP courses, we predict that participation in the courses would contribute to teacher MKT. Based on the work of Deborah Ball, Heather Hill, and colleagues, we further predict that higher MKT will be related to student mathematics achievement. Based on this theory of action, we hypothesize that:

1. A positive relationship exists between the number of MMP courses completed by a classroom teacher and his or her MKT assessment score.
2. Classroom teachers who have completed at least one MMP course score higher on the MKT assessment than teachers who have not completed at least one course.
3. Teacher MKT is positively related to variation in student achievement after controlling for student demographic differences.
4. Course completion is positively related to variation in student achievement after controlling for student demographic differences.

We realize that factors beyond MMP course participation may contribute to MKT, such as educational background, years of teaching experience, grade level of teaching experience, and other professional learning experiences. In future analyses, we intend to examine relationships of additional teacher level variables to MKT and student achievement.

Section 3: Explanatory framework

Methods

Examination of these hypotheses entailed the use of three data sets. First, course enrollment records were compiled for all teachers who attended at least one MMP course. These records were aggregated to indicate the number of enrollments per teacher. Overall, 1290 teachers enrolled in at least one MMP course.

Second, MKT scores were obtained for all classroom teachers who took the MKT as part of the MMP evaluation. A total of 665 teachers completed the MKT assessment. Of these teachers, 236 enrolled in at least one MMP course. Analysis of variance and regression analysis were used to examine differences in MKT scores based on course enrollment.

Third, student data from the Fall 2009 Wisconsin Knowledge and Concepts Examination (WKCE) were obtained from the Milwaukee Public Schools. The next step was to link teacher MKT scores to the WKCE scores of their students. We restricted this sample to classroom teachers who completed the MKT assessment in Spring 2009 because they were the primary influence on their students' mathematics performance in Fall 2009. A total of 73 teachers who completed the MKT in Spring 2009 could be linked to their student scores on the Fall 2009 WKCE. Hierarchical Linear Modeling (HLM) was used to analyze the relationship between MMP course enrollment, teacher MKT, and student achievement in mathematics.

Results

Results of data analysis confirm claims 1, 2, and 3. Claim 4 was not confirmed, course enrollment was not positively related to student achievement.

Claim 1. A positive relationship exists between the number of MMP courses completed by a classroom teacher and his or her MKT assessment score.

Descriptive statistics for the sample of 665 teachers who completed a MKT assessment are shown in Table 1. Regression analysis showed that course attendance significantly predicted MKT scores,

$F(1,663)=10.06$, $p=0.002$. R^2 for the model was 0.015. The relatively weak strength of this relationship suggested that course attendance may not be a predictor of student achievement when included in the HLM analysis. The weakness of this relationship may also have been due to the skewed distribution of course attendance. The majority of teachers with an MKT score attended one or zero MMP courses and a relatively small number of teachers attended multiple courses. Other teacher characteristics may also contribute to these results, such as experience and education.

Table 1. Descriptive Statistics for the Sample of Teachers With MKT Scores

	N	Minimum	Maximum	Mean	Std. Deviation
MKT Ability	665	-3.27	2.33	-0.2279	0.76577
Courses Attended	665	0	10	0.79	1.401

Claim 2. Classroom teachers who have completed at least one MMP course score higher on the MKT assessment than teachers who have not completed at least one course.

Table 2 displays descriptive statistics on MKT for the teachers who completed at least one MMP course and for teachers who completed zero courses. Analysis of variance showed that classroom teachers completing at least one course had significantly higher MKT scores than those that did not enroll in any courses ($t=2.43$, $df=663$, $p=0.016$).

Table 2. Descriptive Statistics by Course Attendance Group

	Course	N	Mean	Std. Deviation	Std. Error Mean
MKT Ability	At least 1 course	236	-0.1311	0.75110	0.04889
	0 courses	429	-0.2811	0.76941	0.03715

Claim 3. Teacher MKT is positively related to variation in student achievement after controlling for student demographic differences.

Claim 4. Course completion is positively related to variation in student achievement after controlling for student demographic differences.

Claims 3 and 4 are addressed jointly as they are covered in the same HLM analysis. Overall, 3063 student test scores were matched to the 73 teachers in our sample. Two models were fit to the data. First, an unconditional model was fit that included student demographics as predictors of student achievement. Table 3 depicts the results from fitting the unconditional model to the sample of students using the Fall 2009 WKCE score as the dependent variable.

The results indicate that 42 percent ($1254 / (1254 + 1716)$) of the variability in student WKCE scores can be attributed to teacher level variables. Thus, it is important to then introduce teacher level factors that might help partition this variation to enable a deeper understanding of which teacher level variables help predict student outcomes.

Table 3. Results from fitting the Unconditional Model to WKCE Scale Scores

<i>Estimated Fixed Effects</i>	Coefficient	SE	t-ratio	df	p
Mean WKCE Scale Score	380.11	7.68	49.5	72	0.00
Gender	-3.09	1.53	-2.02	3057	0.04
Ethnicity	14.11	3.37	4.18	3057	0.00
Special Education Status	35.74	2.17	16.43	3057	0.00
ELL Level	5.61	0.93	5.99	3057	0.00
Free-Reduced Lunch Status	17.55	2.23	7.86	3057	0.00
<i>Estimated Random Effects</i>	SD	Var	df	χ^2	p
Mean teacher scale score	35.42	1254	72	2333	0.00
Student WKCE scale score	41.42	1716			

Table 4 displays the results of fitting the conditional model where teacher MKT and course enrollment are included as predictor variables. While other teacher factors may be introduced to this analysis in the future, we expect that these other factors may have predictive value. These results show that 7 percent ((1254-1165)/1254) of the variability in student achievement due to between teacher differences is attributed to teacher MKT scores. Course enrollment was a non-significant predictor, indicating that this variable did not help explain variability in student achievement beyond that explained by teacher differences in MKT scores.

Table 4. Results from fitting the Conditional Model to WKCE Scale Scores

<i>Estimated Fixed Effects</i>	Coefficient	SE	t-ratio	df	p
Mean WKCE Scale Score	383.60	8.26	46.42	70	0.00
Teacher MKT Score	14.10	5.44	2.59	70	0.01
Teacher Course Enrollment	-1.49	3.08	-0.49	70	0.63
Gender	-3.09	1.53	-2.02	3055	0.04
Ethnicity	14.15	3.37	4.19	3055	0.00
Special Education Status	35.82	2.17	16.47	3055	0.00
ELL Level	5.52	0.93	5.90	3055	0.00
Free-Reduced Lunch Status	17.46	2.23	7.81	3055	0.00
<i>Estimated Random Effects</i>	SD	Var	df	x²	p
Mean teacher scale score	34.14	1165	70	2000	0.00
Student WKCE scale score	41.42	1716			

Conclusions

These analyses provide evidence that the theory of action proposed by the Milwaukee Mathematics Partnership does, in part, hold true. Our theory of action claims that teacher professional development leads to improved teacher mathematical knowledge for teaching (MKT) which leads to improved student achievement in mathematics. We found that differences in MKT can be linked to whether or not classroom teachers have participated in MMP professional development courses. Similarly, we found that MKT predicts variability in student achievement on the state mathematics examination. We do not see evidence, though, that course enrollment by classroom teachers predicts student mathematics achievement. We know that classroom teachers participate in school-embedded professional learning and district-wide workshops that are focused on mathematics teaching and learning beyond enrollment in MMP courses. We will continue to refine our measures of teacher professional learning in order to further examine the link between mathematics professional development and student achievement.

References

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