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Professional Learning Activities in Context: A Statewide Survey of Middle School Mathematics Teachers

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Abstract: Based on a statewide survey of professional learning activities among 577 middle school mathematics teachers in Missouri, this study examined two questions: 1) What professional learning activities do middle school math teachers participate in and how much time do they spend in these activities?, and 2) How are teacher qualifications and contextual characteristics associated with the amount of their professional learning activities? The study examined seven types of formal and informal professional learning activities: 1) professional development programs, 2) teacher collaboration, 3) university courses, 4) professional conferences, 5) mentoring/coaching, 6) informal communications, and 7) individual learning activities. The study found that middle school mathematics teachers spend the greatest amount of time involved in teacher collaboration, professional development programs, and individual learning activities. In addition, mathematics teachers in high-poverty and ethnically diverse districts tend to spend more time in formal learning activities such as professional development programs, teacher collaboration, and mentoring/coaching than do mathematics teachers in wealthier and less diverse districts. To promote a greater level of teachers' participation in shared learning activities, it is important for district and school administrators to offer professional learning activities that meet mathematics teachers' learning needs for understanding students' mathematical knowledge and thinking.

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Keywords: teacher learning; professional development; mathematics teachers; survey.

Actividades de aprendizaje profesional en contexto: Una encuesta a nivel estatal con maestros de escuelas secundarias de matemáticas

Resumen: Basado en una encuesta sobre actividades de aprendizaje con 577 profesores de matemáticas de escuelas secundaria en el estado de Missouri, este estudio examinó dos preguntas: 1) ¿Cuáles son las actividades profesionales de aprendizaje que los profesore/as de matemáticas de escuelas secundarias participan y por cuánto tiempo participan estas actividades? y 2) ¿Cómo se asocian las calificaciones de los profesore/as y las características contextuales con la cantidad de actividades de aprendizaje profesional? El estudio examinó siete tipos de actividades formales e informales de aprendizaje profesional : 1) programas de desarrollo profesional, 2) colaboración entre profesores, 3) cursos universitarios, 4) conferencias profesionales, 5) mentores / entrenadores, 6) comunicaciones informales, y 7) actividades de aprendizaje individuales. El estudio encontró que los profesores de matemáticas en escuelas secundaria pasan una gran cantidad de tiempo en colaboración entre profesores/as, los programas de desarrollo profesional y actividades de aprendizaje individuales. Además, los profesores de matemáticas que trabajan en los barrios con mayores índices de pobreza y diversidad étnica, tienden a pasar más tiempo en actividades formales de aprendizaje, tales como el cursos de profesionalización docente, colaboración entre docentes y asesoramiento / entrenamiento a los docentes comparados con docentes de matemáticas de los distritos más ricos y con menos diversidad étnica. Para promover un mayor nivel de participación del profesorado en actividades de aprendizaje compartido, es importante que los administradores de distritos escolares y escuelas ofrezcan actividades de aprendizaje profesional que respondan a las necesidades de aprendizaje de los docentes para comprender el conocimiento y entendimiento matemático de sus estudiantes.

Palabras-clave: aprendizaje docente desarrollo profesional; profesores/as de matemáticas; investigación.

Atividades de aprendizagem profissionais em contexto: Um levantamento estadual dos professores de ensino médio de matemática

Resumo: Baseado em uma pesquisa de atividades de aprendizagem profissional entre 577 professores de matemática do ensino médio no estado de Missouri, este estudo analisou duas questões: 1) Quais são as atividades de aprendizagem profissional que os professores de matemática no ensino médio participam e quanto tempo eles usam nessas atividades? e 2) Como são as qualificações dos professores e características contextuais associados com a quantidade de suas atividades de aprendizagem profissional? O estudo examinou sete tipos de atividades formais e informais de aprendizagem profissionais: 1) programas de desenvolvimento profissional, 2) colaboração entre professores, 3) cursos universitários, 4) conferências profissionais, 5) tutorias/coaching, 6) comunicações informais, e 7) atividades de aprendizagem individual. O estudo descobriu que professores de matemática do ensino médio passam a maior parte do tempo envolvidos em colaboração entre professores, programas de desenvolvimento profissional e atividades individuais de aprendizagem. Além disso, professores de matemática que trabalham em distritos escolares com altos índices de pobreza e etnicamente diversos tendem a gastar mais tempo em atividades de aprendizagem formal, tais como programas de desenvolvimento profissional, colaboração de professores e tutoria/coaching do que os professores de matemática nos distritos mais ricos e menos diversos etnicamente. Para promover um maior nível de participação dos

professores em atividades de aprendizagem compartilhada, é importante que os administradores dos distritos escolares e das escolas ofereçam atividades de aprendizagem profissional que atendam as necessidades de aprendizagem dos professores de matemática para a compreensão do conhecimento e pensamento matemáticos dos alunos.
Palavras-chave: aprendizagem de professores, desenvolvimento profissional; professores de matemática; pesquisa.

Introduction

Teachers' continuous professional learning activities are crucial for success of educational reforms aimed at improving instructional practice and student learning (Cohen & Hill, 2001; Darling-Hammond & Sykes, 1999; Desimone, 2009; Little, 1993, Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). The importance of professional learning activities is also communicated in the No Child Left Behind Act (NCLB) of 2001. Title II, Part A of NCLB provides $3 billion annually to states to improve teacher qualifications through various strategies including enhancing teachers' professional learning opportunities (Birman et al., 2009). In addition, the NCLB requires that schools in improvement status spend at least 10% of their Title I funds for professional learning activities. According to the Quality Counts report, as of the 2009-2010 academic year, 40 states have developed formal professional development standards and 24 of these finance professional development for all districts (Editorial Projects in Education, 2011).

Despite the importance of teachers' professional learning activities, our knowledge about how teachers spend their time in professional learning activities is limited (Little, 1993; Wilson & Berne, 1999). Although extensive amount of empirical studies have been conducted on formal professional development programs (Desimone, 2009; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Wayne, Yoon, Zhu, Cronen, & Garet, 2008), professional learning communities (Grossman, Wineburg, & Woolworth, 2000; Little, 2002, 2003; McLaughlin & Talbert, 2001; 2006), and new teacher mentoring (Carver & Feiman-Nemser, 2009; Schwille, 2008; Smith & Ingersoll, 2004), we do not yet know the various types and amounts of both formal and informal professional learning activities teachers engage in. Examining the time teachers spend in various types of professional learning activities is the first important step toward understanding holistically the nature of teachers' learning activities and considering how policymakers and district and school administrators can support teachers to engage in effective professional learning activities.

This study defined teachers' "professional learning activities" as intentional activities to gain new knowledge about teaching and student learning. Although these activities can potentially promote "professional learning," that is, cognitive changes in teachers' knowledge and beliefs, it is important to note that such learning is not guaranteed solely by their participations in these activities (Richardson & Placier, 2001; Smylie, 1995). In addition, professional learning can also occur outside of intentional activities, even beyond learners' awareness (Eraut, 2004; Marsick & Watkins, 1990; Watkins & Marsick, 1992; Smylie, 1995). However, this study focused on intentional learning activities because these activities can be measured by teacher reports through a survey, and policymakers can influence teachers' intentional learning activities more effectively than teachers' unconscious learning experiences.

Previous conceptual studies and case studies of teachers' professional learning activities have documented that teachers engage in various types of learning beyond formal activities such as professional development programs and mentoring (Borko, 2004; Little, 1993; Scribner, 1999, 2003; Smylie, 1995; Wilson & Berne, 1999). Teachers have informal communications with their colleagues

and engage in individual learning activities (e.g. reading professional journals, analyzing students' work). A systematic examination of the various types and amounts of these learning activities requires a large-scale data collection through a teacher survey. To fill this knowledge gap, a statewide survey of 577 middle school mathematics teachers in Missouri was conducted in 2009 to examine how much time middle school mathematics teachers spend for seven types of professional learning activities: 1) professional development programs, 2) teacher collaboration, 3) university courses, 4) professional conferences, 5) mentoring/coaching, 6) informal communications, and 7) individual learning activities.

Missouri was selected because its levels of student achievement and educational opportunities are similar to the national average. Quality Counts 2011 ranks states using a K-12 achievement index which includes: 1) achievement levels in 2009 and achievement gains from 2003 to 2009 in fourth and eighth graders' mathematics and reading scores on the National Assessment of Educational Progress (NAEP), 2) achievement gap between high-socioeconomic status (SES) and low-SES students, 3) high school graduation rates, and 4) advanced placement (AP) test scores (Editorial Projects in Education, 2011). The index ranged from 55.3 in Mississippi to 85.0 in Massachusetts. Missouri's index was 69.2, similar to the national average of 68.7. In addition, another index in Quality Counts 2011, Change-for-Success index measured by family income, parent education level, school enrollment rates, and adult outcomes (educational attainment, annual income, full-time employment) showed that Missouri's index was 79.4, similar to the national average of 78.2 (Editorial Projects in Education, 2011). This index ranged from 65.6 (Nevada) to 94.0 (Massachusetts).

Teacher learning is enhanced when teachers are involved in activities that: 1) are sustained and continuous, 2) are coherent with teachers' learning goals as well as with school missions and reform goals, 3) focus on teaching practices and student learning in the context of actual classrooms, and 4) provide opportunities for teacher collaboration (Borasi & Fonzi, 2002; Clarke, 1994; Desimone, 2009; Elmore, 2002; Hawley & Valli, 1999; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Wen, et al., 2009; Wilson & Berne, 1999). Before we can understand if teachers are engaging in professional learning activities with these characteristics, it is important to first examine how teachers allocate their time for various types of professional learning activities. If we focus on only one type of learning activity such as professional development programs or mentoring, we would not be able to understand how teachers' professional learning is influenced by a variety of formal and informal professional learning activities teachers participate in or how these activities might interact with one another to enhance teachers' professional learning. Thus, this study takes the first step to understand how teachers allocate their time for seven types of professional learning activities as a foundation for future studies on the quality and content of these activities.

This study addressed the following research questions:

1. What professional learning activities do middle school math teachers participate in and how much time do they spend in these activities?
2. How are teacher qualifications and contextual characteristics associated with the amount of their professional learning activities?

The findings from this study will advance our knowledge of teachers' professional learning activities that span from formal to informal, from planned to serendipitous, and from within immediate work contexts to broader professional contexts. Information on the types and amounts of various professional learning activities will be useful for policymakers and administrators in their efforts to support instructional improvement. In addition, an examination of the teacher qualifications and contextual characteristics (district characteristics) associated with the amount of professional learning activities teachers engage in will inform school, district, and state efforts to

promote professional learning activities. These findings will not only expand our knowledge of teachers' professional learning activities and their correlates, but also provide insights for policymakers about the supports needed to enhance professional learning opportunities.

The focus on middle school mathematics teachers is important because mathematics teachers in grades three through eight are working under tremendous pressure to improve student scores on state assessments as a result of the accountability reforms required by NCLB. In addition, the achievement gap in mathematics between White and African American students is wider at the middle school level than at elementary school level; according to the 2007 NAEP results, the achievement score gap at the eighth grade level was 31 points (290 for White vs. 259 for African American) compared with 26 points (248 for White vs. 222 for African American) at the fourth grade level (Vanneman, Hamilton, Baldwin Anderson, & Rahman, 2009). Likewise, the 2007 Trends in International Mathematics and Science Study (TIMSS) showed that, while U.S. fourth graders' mathematics achievement is above the international average (528 vs. 500), eighth graders' mathematics achievement is similar to the international average (508 vs. 500) and lags behind that of other industrialized nations (Gonzales et al., 2008). Thus, understanding professional learning activities of middle school mathematics teachers is important for identifying factors that may contribute to larger achievement gaps and lower achievement at the middle school level.

Background

Theoretical Framework: Situated Perspective

This study takes a situated perspective on teacher learning (Putnam & Borko, 2000). The situated perspective on teacher learning posits that:

> The physical and social contexts in which an activity takes place are an integral part of the activity, and that the activity is an integral part of the learning that takes place within it. How a person learns a particular set of knowledge and skills, and the situation in which a person learns, become a fundamental part of what is learned (p.4).

Based on this perspective, to understand the learning of mathematics teachers, it is essential to holistically understand the contexts where mathematics teachers engage in professional learning activities (Shulman & Shulman, 2004). Despite the theoretical importance of investigating various learning activities and their contexts, no large-scale systematic investigation of teachers' professional learning activities has been conducted thus far.

The lack of such investigation may be due to the difficulty of measuring a complex nature of professional learning activities teachers engage in. Wilson and Berne (1999) pointed out the scattered and serendipitous nature of teachers' professional learning activities. Ball and Cohen (1999) observed that there is no coherent infrastructure for professional learning activities across the state, district, and school levels. These studies observed that the "apprenticeship of observation" in Lortie's (1975) sociological work still holds true as a major characteristic of teachers' professional learning activities.

There is a need for a systematic investigation of the complex nature of teachers' professional learning activities. Thus far, existing national databases such as the Schools and Staffing Survey (SASS) and the teacher background survey in the National Assessment of Educational Progress (NAEP) included only structured learning activities such as professional development programs, university courses, and mentoring. Other national data collected by researchers also focused only on professional development programs (Desimone, et al., 2002; Garet, et al., 2001). However, there are several case studies that uncovered the nature of teachers' professional learning (Scribner, 1999,

2003). This survey was developed based on these carefully conducted case studies, which are reviewed below.

Case Studies on Professional Learning Activities

In a multiple-site, embedded case study, Scribner (1999) interviewed 45 teachers identified as excellent teachers by their colleagues in three ethnically-diverse high schools to explore teachers' experiences with professional learning activities. Scribner found that teachers engaged in numerous activities that included: collaboration, individual inquiries, experiential learning, conferences or workshops, school-based in-service activities, and graduate courses. However, what they perceived they can learn through these activities varied by the type of learning activities. For example, teachers perceived that collaboration was useful for learning pedagogical skills and classroom management, whereas they found both individual inquiries and other formal learning opportunities (workshops, conferences, and graduate courses) useful for learning subject content knowledge. For learning about students' lives and diverse cultures, they relied on their own classroom experience and knowledge gained through trial and error.

Another study by Scribner (2003) based on multiple case studies of 20 teachers in three rural high schools examined the work contexts that shape teachers' professional learning. The author identified students and subject matter as the core context in which professional learning occurs. Teachers learned most from students' reactions to their instructional approaches and building relationships with students when managing their classrooms. In addition, teachers' learning occurred through individual activities to enhance subject content knowledge. He described these learning activities to be experiential, usually non-reflective, and lonely (Scribner, 2003).

Drawing from these two studies, I identified seven types of learning activities middle school mathematics teachers engage in: 1) professional development programs, 2) teacher collaboration, 3) university courses, 4) professional conferences, 5) mentoring/coaching, 6) informal communications, and 7) individual learning activities. Based on the previous studies that identified the importance of subject content focus in professional learning activities (Banilower, Heck, & Weiss, 2005; Cohen & Hill, 2001; Desimone, et al., 2002; Garet, et al., 2001), this study measured learning activities for *mathematics teaching and learning*. Therefore, this study does not focus on other subject areas or non-subject-specific content such as classroom management and equity.

Amount of Professional Learning Activities

Previous national statistics reported the amount of formal professional development activities among secondary school mathematics teachers. Based on a nationally representative sample of 1,700 math teachers, Birman et al. (2009) found that, on average, mathematics teachers spent a total of 28.4 hours on mathematics professional development during the 2005-2006 academic year (p. 93). Out of 28.4 hours, they spent 17.3 hours for instructional strategies for teaching mathematics, and 11.1 hours for in-depth study of mathematics topics. In addition, the percentage of teachers who participated in these types of professional development for more than 24 hours increased from 16% to 22% (instructional strategies) and from 10% to 15% (mathematics topics) between the 2003-2004 academic year and the 2005-2006 academic year (pp. 95-96). These statistics show that mathematics teachers are spending more time in professional development in recent years, yet the average total amount of mathematics-focused professional development is only 28.4 hours or 3.5 days per year.

Birman et al. (2009) further identified the percentage of teachers who participated in various learning activities. Based on a nationally representative sample of elementary teachers and secondary mathematics and reading teachers, the researchers found that, during the 2005-2006 academic year,

91% of the teachers consulted with other teachers about individual students and 84% exchanged feedback with other teachers based on student work at least once or twice a month (p.108). In addition, 74% planned lessons or courses with other teachers. Less common learning activities were: 1) exchanging feedback based on class observations (48%) and 2) participation in a learning community (47%). In addition, Smith and Ingersoll's (2004) analysis of the 1999-2000 Staff and Schooling Survey (SASS) found that only 70.4% of new teachers in public, non-charter schools had a mentor assigned.

Although these statistics reported the *percentage* of teachers who participated in various types of learning activities, *the amount of time* devoted for each type of these learning activities is not yet known. There is a major difference between spending one hour and 100 hours for professional learning activities. This study documents the amount of seven types of mathematics-focused learning activities middle school mathematics teachers participated in.

Factors Associated with Professional Learning Activities

Teacher characteristics.

Understanding the individual and contextual correlates of the amount of teachers' professional learning activities will inform policymakers and administrators in their efforts to promote and support such activities. Previous empirical studies examined two teacher characteristics: 1) mathematics or mathematics education major (Desimone, Smith, & Ueno, 2006) and 2) teaching experience (Birman, et al., 2009; Smith & Desimone, 2003) as predictors of teachers' participation in professional development programs and university courses. Based on a secondary analysis of teacher survey data from the 2000 NAEP dataset, Desimone et al. (2006) found that mathematics teachers who majored or minored in mathematics or mathematics education were more likely than teachers without a mathematics-related major or minor to participate in sustained content-focused professional development activities or take university courses for 16 hours or more.

Smith and Desimone (2003) examined the relationship between teaching experience and participation in professional development using teacher survey data from the 1999-2000 Staff and Schooling Survey (SASS). The authors found that the percentage of teachers who participated in 9 or more hours of professional development that specifically focused on the content and teaching methods in their assigned fields were higher among mid-career teachers (8 to 25 years of teaching) than less experienced teachers (1-7 years) and more experienced teachers (more than 25 years of teaching). Similarly, Birman et al. (2009) compared the total amount of professional development between beginning teachers with less than 3 years of experience and other teachers and found that beginning teachers spend 117 hours compared to 98 hours among all other teachers in the 2005-2006 academic year (p. 106). The findings from these studies are not consistent and more studies are needed to examine the relationship between teaching experience and participation in professional learning activities.

In sum, these studies suggest that the amount of professional learning activities teachers engage in could differ by teacher qualifications such as subject major or minor and teaching experience. If these factors are associated with the amount of professional learning activities teachers engage in, other teacher qualifications such as mathematics certification and education level (e.g. Bachelor's degree, Master's degree) may be also associated with the amount of professional learning teachers engage in. Previous studies showed that basic teacher qualifications measured by full certification, mathematics or mathematics education major, and teaching experience are associated with higher student achievement (Akiba, LeTendre, & Scribner, 2007; Darling-Hammond & Youngs, 2002; Rice, 2003; Wayne & Youngs, 2003; Wilson, Floden, & Ferrini-Mundy, 2002). It is

possible that these teachers with better qualifications are also more likely to engage in professional learning activities, which could lead to improved instruction and student achievement. Thus, in this study, I examined how four types of teacher qualifications (mathematics-related major, teaching experience, mathematics certification, education level) are associated with the amount of teachers' participation in seven types of professional learning activities.

School and district characteristics.

School and district characteristics are important contexts for teachers' participation in professional learning activities. Previous studies identified the important roles played by organizational and cultural contexts in shaping teachers' professional learning activities (Johnson, 2004; Peressini, et al., 2004; Scribner, 1999, 2003). In addition, the NCLB requirement that Title I schools that are in improvement status must spend at least 10% of their Title I funds for professional development could influence the amount of time mathematics teachers spend in professional learning activities. Previous empirical studies examined the association between the amount of teachers' participation in professional learning activities and the following school characteristics: 1) poverty level, 2) achievement level, 3) school location, and 4) percentage of ethnic minority students.

The findings on the relationship between poverty level and the amount of teachers' participation in professional learning activities are inconsistent. Whereas Desimone et al. (2006) found no statistically significant relationship between these two factors using the 2000 NAEP data, Smith and Desimone (2003) reported that a greater percentage of teachers in high-poverty schools participate in content-focused professional development than teachers in low-poverty schools using the 1999-2000 SASS data. More recent data by Birman et al. (2009) showed that teachers in high-poverty schools (75% or more students receiving free or reduced lunch) and low-poverty schools (less than 35%) are more likely to participate in professional development activities than those in the schools with the medium level of poverty (35% to 75%).

Research on the association between school achievement level and teachers' professional learning activities is also mixed. Although Birman et al. (2009) showed that teachers in the schools in improvement status are more likely to participate in professional development, Desimone et al. (2006) did not find student achievement level to be significantly associated with the amount of content-focused professional development or university courses that teachers participated in. The findings on school location are also inconsistent; Birman et al. (2009) found that the teachers in urban schools spent more hours in professional development activities than those in suburban or rural schools, while Desimone et al. (2006) found that school location was not associated with the amount of professional development.

Finally, two studies have found that the percentage of ethnic minority students within a school was an important predictor of the amount of professional development activities teachers engage in. Garet et al. (2001) found, using a continuous variable on the percentage of ethnic minority students, that teachers in the schools with a larger percentage of ethnic minority students were more likely to spend time for professional development. Birman et al. (2009) found that the schools with medium level of ethnic minority concentration (25% to 75%) were more likely to participate in professional development activities than teachers in schools with a higher percentage (75% or higher) or a lower percentage (less than 25%) of ethnic minority students.

These inconsistent findings may stem from the differences among these studies in: 1) the time of data collection (before NCLB and after NCLB), 2) sampling methods across different national datasets, and 3) whether or not statistical tests of the mean or percentage differences were conducted. Regardless, the findings suggest the importance of examining the relationship between

these school and district characteristics and teachers' participation in professional learning activities to clarify these inconsistencies. In addition, school or district size is another characteristic that could influence the amount of mathematics teachers' participation in professional learning activities. Scribner (2003) showed that teachers in rural schools have few opportunities to collaborate because of the small faculty size. Thus, school or district size will be examined in this study in addition to poverty level, achievement, and percentage of ethnic minority students. Because school location is highly correlated with school size, it was excluded from the analysis. Whereas these previous studies examined school characteristics using binary statistics or simple comparisons, this study examined these characteristics in multivariate models to test which characteristics are most important correlates of the amount of teachers' participation in seven types of professional learning activities.

Methods

Context

The Teachers' Opportunity to Learn (TOTL) survey was developed for the purpose of understanding: 1) middle school mathematics teachers' participation in various professional learning activities and 2) work contexts that influence teachers' participation in professional learning activities. The TOTL survey was conducted over three years in 2009, 2010, and 2011 in the state of Missouri. The TOTL survey is a major part of the five-year mixed-methods project that examines: 1) the nature of middle school mathematics teachers' professional learning activities for instructional improvement, 2) the influence of work contexts on the quality of professional learning activities mathematics teachers engage in, and 3) the relationship between mathematics teachers' professional learning activities and changes in student mathematics achievement over four years (2008-2011).

In Missouri, the Excellence in Education Act of 1985 requires each district to form a Professional Development Committee (PDC) (MDESE, n.d.). The PDC members are selected by teachers and responsible for: 1) identifying teachers' instructional concerns and remedies, 2) serving as confidential consultants upon a teacher's request, 3) assessing teachers' learning needs and develop in-service opportunities for them, and 4) presenting teacher suggestions, ideas, and recommendations regarding classroom instruction to the proper authorities (MDESE, n.d.).

The Outstanding School Act of 1993 further specified that beginning with the 1994 fiscal year, all districts in Missouri receiving state funding need to spend one percent of their operational funds for teachers' professional development, and 75 percent of these monies need to be spent for the purposes determined by the PDC. The state also requires districts to provide two years of mentoring to new teachers, following the Mentoring Program Standards (MDESE, 2008, n.d.).

In addition to the professional development programs provided by districts based on the PDC's recommendations, various professional development opportunities are provided by nine regional professional development centers (RPDCs) under the Missouri Department of Elementary and Secondary Education (MDESE), universities and colleges across the state, private professional providers, and regional educational labs (e.g. McREL). Districts or schools may choose to require or encourage teachers' participation in these professional development opportunities. The TOTL survey revealed that there is a considerable variation in teachers' participation in professional learning activities and the amount of their participation differs by teacher and district characteristics.

Data Collection

To administer the TOTL survey, the research team first obtained a license for using restricted-use core data from the MDESE. The core data include teachers' names, subject areas of teaching, home address, and school address. The core data also include a large number of variables

on school and district characteristics including the percentage of students receiving free or reduced-price lunch, the percentage of ethnic minority students, school location, and student enrollment.

From the core data, the project team selected only mathematics teachers who were teaching in middle schools with a grade six to eight configuration as of December 2008. We chose mathematics teachers in these grades 6-8 middle schools, not in other middle-grade schools with different grade configuration (e.g. grades 5-6, 6-7, 7-8, or 5-8) for the purpose of isolating the effect of student mobility from one school to another on student achievement. This project will eventually examine the impact of teachers' professional learning activities on student achievement growth in mathematics from 2008 to 2011 using state standardized assessment data. Thus, the project's focus on teachers in grades 6-8 middle schools allows us to control for school transition effects. Middle schools with a grade six to eight configuration constitute 80% of all middle-grade schools in Missouri.

The population of 886 mathematics teachers in grades 6-8 middle schools in Missouri was selected as the survey participants for the first year administration of the TOTL survey in 2009. The survey data were collected from January to May through five waves of mailing: 1) the first survey mailing in early January, 2) a post-card reminder 3 weeks later, 3) the second survey mailing in February, 4) a post-card reminder 3 weeks later, and 5) the final survey mailing in late April. Each survey participant was given a $30 gift card in a major retail store as a financial incentive. After five waves of mailing, 577 mathematics teachers provided usable surveys (65% response rate). This study analyzed the data collected from these 577 mathematics teachers working in 179 middle schools located in 117 districts across Missouri.

Comparison among Survey Participants, Teacher Population in Missouri, and National Sample

Table 1 presents the comparisons of the characteristics of mathematics teachers, schools, and districts among three groups: 1) survey participants (sample) in Missouri, 2) the population of teachers in Missouri, and 3) a national sample of teachers. The first row presents the teacher characteristics, the second the characteristics of the middle schools where these teachers work, and the third the characteristics of their school districts. The national statistics on middle school mathematics teachers were computed using the 2007-2008 Schools and Staffing Survey (SASS) data. The statistics on grades 6-8 middle schools and the districts with at least one grades 6-8 middle school were obtained from the 2008-2009 Common Core Data (CCD). The results of t-tests or chi-square tests comparing two groups are presented in the right column.

In comparing the characteristics of survey participants and the characteristics of their schools and districts with those of the population of teachers in Missouri, we can see the sample and population characteristics are similar across the board and the differences were not statistically significant. One exception was school size. The survey participants tended to come from relatively larger schools with an average of 510 students, compared to the state average of 435, and the difference was statistically significant. Despite this difference, we can reasonably state that the findings from this survey can be generalizable to the population of mathematics teachers in grades 6-8 middle schools across the state.

Table 1
Comparison among survey participants, teacher population in Missouri, and national Sample

	Survey Participants (Sample)	Teacher Population in Missouri	National Sample	T/X^2-value[1]
Math Teachers in Middle Schools[2]	N=577	N=886	N=370	
% Math Certification	83.2	81.0	59.5	MO sample vs. MO population: χ^2=1.09 MO sample vs. National: χ^2=65.84**
% Master Degree or above	34.8	34.4	52.4	MO sample vs. MO population: χ^2=.03 MO sample vs. National: χ^2=28.71**
% Female	79.7	76.2	70.0	MO sample vs. MO population: χ^2=2.51 MO sample vs. National: χ^2=11.66**
Middle Schools[3]	N=179	N=188	N=179	
Mean % FRL	41.1	41.1	47.8	MO sample vs. MO population: t= - .02 MO sample vs. National: t= - 2.67**
Mean % Ethnic Minority	23.2	21.8	45.0	MO sample vs. MO population: t=.50 MO sample vs. National: t= - 6.88**
Mean School Size	509.8	435.3	656.8	MO sample vs. MO population: t=2.50* MO sample vs. National: t= - 4.19**
Location				
% Urban	17.3	17.0	34.6	MO sample vs. MO population: χ^2=.02
% Suburban	52.0	51.6	39.1	MO sample vs. National: χ^2=14.21**
% Rural	30.7	31.4	26.3	
Districts[4]	N=117	N=126	N=117	
Mean % FRL	45.2	45.7	39.2	MO sample vs. MO population: t= -.27 MO sample vs. National: t=2.30*
Mean % Ethnic Minority	15.3	16.0	30.9	MO sample vs. MO population: t= -.26 MO sample vs. National: t= - 4.68**
Mean District Size	3725.8	3626.3	7495.9	MO sample vs. MO population: t=.15 MO sample vs. National: t= - 2.81**
Location				
% Urban	6.8	7.1	15.4	MO sample vs. MO population: χ^2=.01
% Suburban	49.6	49.2	41.9	MO sample vs. National: χ^2=4.61
% Rural	43.6	43.7	42.7	

*p< .05, **p < .01

[1] In comparing Missouri sample with the national sample, the same numbers of schools and districts as those of Missouri sample were randomly selected for the t-tests and chi-square tests in order to more accurately examine the statistical significance levels.

[2] NCES, Schools and Staffing Survey (SASS) 2007-2008, unweighted data.

[3] NCES, Common Core Data, 2008-2009. The statistics are on the grades 6-8 middle schools.

[4] NCES, Common Core Data, 2008-2009. The statistics are on the districts with at least one grades 6-8 middle school.

However, when the survey participants are compared with the national sample, we can see statistically significant differences between these two groups. A greater percentage of the middle school mathematics teachers in Missouri have mathematics certification than the national sample (83.2% vs. 59.5%), yet a smaller percentage of teachers in Missouri have a master degree or a higher degree than the national sample (34.8% vs. 52.4%). A greater percentage of middle school mathematics teachers are female compared to their national counterparts (79.7% vs. 70.0%). For school characteristics, middle schools in Missouri have smaller percentages of: 1) students receiving free or reduced price lunch (41.1% vs. 47.8%) and 2) ethnic minority students (23.2% vs. 45.0%). These schools are also smaller than the national average (509.8 vs. 656.8) and are more likely to be located in suburban areas than urban areas.

These characteristics of the survey participants and their schools are reflected in district characteristics as well. The districts of the sampled middle school mathematics teachers have fewer ethnic minority students (15.3% vs. 30.9%) and are smaller in size (3,726 vs. 7,496). However, the poverty level of these districts was higher than that of the average district in the country (45.2 vs. 39.2) probably due to the small district sizes in Missouri. It is important to consider these differences in interpreting the findings from this study conducted in Missouri.

Measures

Professional learning activities.

The initial draft of the survey on professional learning activities was developed in 2007 based on a thorough review of literature on teacher learning. I identified seven types of teacher learning activities: 1) professional development programs, 2) teacher collaboration, 3) university courses, 4) professional conferences, 5) mentoring/coaching, 6) informal communications, and 7) individual learning activities. For each type of learning activities, a set of survey items were developed to examine: 1) the amount (hours spent during the previous 12 month or a typical month), 2) activity content and focus, and 3) alignment with students' learning needs, teachers' learning needs, school or district missions, state or district mathematics standards, and mathematics reform goals.

The survey was pilot-tested in the spring of 2007 with 141 middle school mathematics teachers. Based on the analysis of the response patterns, feedback from the participants, and teacher interviews, the survey was revised and finalized in the spring of 2008. Appendix A presents: 1) the definitions of seven types of professional learning activities provided on the survey cover page, 2) survey items asking the amount of time teachers spent in professional learning activities, and 3) original and final coding schemes. The definitions were provided on the cover page of the survey to clarify the meanings of seven types of professional learning activities before the teachers started the survey. I conducted teacher interviews to receive their feedback on the initial definitions and survey items, and they were then refined to better reflect teachers' understandings of professional learning activities. The additional teacher interviews confirmed that the finalized definitions accurately represent mathematics teachers' understanding of professional learning activities.

The answer categories for the amount of professional learning activities were developed based on the teachers' responses during the pilot test. Based on the literature and teacher interviews, I decided to ask the teachers to report the amount of time they spent during the previous *12 months* on professional development programs, teacher collaboration, university courses, and professional conferences. For more frequent activities; mentoring/coaching, individual communications, and individual learning activities, they were asked to report the amount of time they spent during *a typical month*. The analysis of pilot survey data from 141 middle school

mathematics teachers also confirmed the time span for teachers to report the amount (12 months vs. typical school month) and the answer categories provided to them were appropriate for all seven types of professional learning activities.

The original response coding is a range of hours such as 1=1-2 hours, 2=3-5 hours, 3=6-10 hours and so on as shown in Appendix A. These responses were re-coded as 1.5=1-2 hours, 4=3-5 hours, 8=6-10 hours and so on so that the final coding roughly represents the actual hours teachers spent for each learning activity. In instances when teachers responded "no" to an initial question asking whether or not the teacher participated in the activity, the variable on the amount was coded as 0. The same re-coding method was used for all seven activities.

Teacher qualifications.

The TOTL survey also asked the mathematics teachers to report the following information related to their qualifications: 1) mathematics major, 2) mathematics education major, and 3) their teaching experience. In addition to these variables, information on mathematics certification and the highest degree attained was obtained from the restricted-use core data from the MDESE. Mathematics major and mathematics education major were coded as 1=majored in mathematics or mathematics education in an undergraduate or a graduate program and 0=no major in an undergraduate or a graduate program. For teaching experience, teachers reported their total number of years of teaching. The data were recoded into three categories: 1) beginning teachers (0-5 years of experience), 2) mid-career teachers (6-15 years) and 3) experienced teachers (16 years or more). Mathematics certification was coded as 1=certified in mathematics, 0=no certification or certified in another subject. The highest degree a teacher obtained was originally coded as 1=bachelor's degree, 2=master's degree, 3=specialist degree, 4=Ph.D. or other professional degree. As there were only four cases with the coding of 3 or 4, this variable was re-coded into 0=bachelor's degree and 1=master's degree or above and labeled as "Master's degree or above."

District characteristics.

I originally created both school and district variables for four characteristics: 1) poverty level (percentage of students receiving free or reduced price lunch), 2) diversity level (percentage of ethnic minority students), 3) size (number of enrolled students), and 4) mathematics achievement (percentage of students meeting the proficient level based on the state standardized assessment in mathematics). After analyzing the variance components for the amounts of time teachers spent in seven types of professional learning activities at three levels: teachers, schools, and districts based on fully unconditional models in three-level Hierarchical Linear Modeling (HLM), I found that most variations in the amount of activities (number of hours) were explained at the teacher and district levels. The percentage of variance explained at the teacher level ranged from 77.5% for professional conferences to 97.2% for individual learning activities. The percentage at district level ranged from 2.7% for individual learning activities to 22.5% for attending professional conferences. The other relatively large percentages of variations explained at the district level were found for teacher collaboration (20.7%), mentoring/coaching (19.8%), and professional development program (18.5%). In contrast, less than 1.3% of the total variations in the amounts of professional learning activities were explained at the school level. Therefore, the study analyzed the four district characteristics listed above as the independent variables to answer the second question, "How are teacher qualifications and contextual characteristics associated with the amount of their professional learning activities?"

Data Analysis

To answer the first question, "What professional learning activities do middle school mathematics teachers participate in and how much time do they spend in these activities?", I computed the percentages of teachers who participated in and the mean hours teachers engaged in seven types of professional learning activities during the previous 12 months or a typical month. I also reported the mean hours separately for beginning teachers (0-5 years of experience), mid-career teachers (6-15 years), and experienced teachers (more than 16 years), and conducted ANOVA and post-hoc tukey analyses to examine if there was a statistically significance difference among these three groups. As I found that teachers spent a significant amount of time for individual learning activities, the amount of time teachers spent in five specific types of individual activities were further reported.

To answer the second question, "How are teacher qualifications and contextual characteristics associated with the amount of their professional learning activities?" I conducted 2-level HLM analyses with teacher data at level 1 and district data at level 2. I used intercept-as-outcome models as I was interested in the direct effects of teacher qualifications and district characteristics on the amounts of professional learning activities teachers engaged in. Five teacher qualifications: 1) teaching experience (two dummy variables of beginning and experienced teachers with mid-career teachers as the reference group), 2) mathematics certification, 3) masters' degree or above, 4) mathematics major, and 5) mathematics education major, and four district characteristics: 1) poverty level (percentage of students receiving free or reduced price lunch), 2) percentage of ethnic minority students, 3) district size (number of enrolled students), and 4) district mathematics achievement (percentage of students meeting the proficient level on the state standardized assessment) were examined as the independent variables. Seven HLM models were analyzed for the amounts of seven types of professional learning activities. The variance components at level 1 (teacher) and level 2 (district) were also computed for: 1) fully unconditional models before entering independent variables into the model, and 2) conditional models with all independent variables.

Results

Amount of Professional Learning Activities

Table 2 presents the percentages of middle school mathematics teachers who participated in seven types of professional learning activities and the average hours teachers spent in these activities. The percentages and average hours during the previous *12 months* were reported for professional development programs, teacher collaboration, university courses, and professional conferences, and the percentages and average hours during *a typical school month* were reported for mentoring/coaching, informal communication, and individual activities. The table also breaks down the average hours by teaching experience: 1) beginning teachers with 0-5 years of teaching experience, 2) mid-career teachers with 6-15 years of experience, and 3) experienced teachers with more than 15 years of teaching experience. F-tests and post-hoc tukey tests were conducted to examine if the average hours significantly differed among the three groups, and F-values and significance level are presented in the table.

When we look at the percentages of teachers who participated in seven types of professional learning activities, we can see that teachers' participation in professional development programs, teacher collaboration, informal communication and individual learning activities was common because over 70% of teachers participated in these activities. The most common type of activities that almost all teachers (99.8%) engaged in were individual learning activities. Participation in professional development programs was also common; 78.0% of teachers participated in one or

more professional development programs. In addition, 71.8% of teachers participated in teacher collaboration and 72.4% of them communicated informally with their colleagues to learn about mathematics teaching and learning. These percentages show that a majority of teachers participated in both formal and informal learning activities.

Table 2
The percentage and amount of teachers' participation in professional learning activities

	% Participated	All Teachers	Beginning Teacher (0-5 yrs)	Mid-Career Teacher (6-15 yrs)	Experienced Teacher (>15 yrs)	F-value
Percentage/Hours per Year						
Professional Development Programs	78.0%	26.8 (28.6)[a]	28.5 (28.8)	26.2 (29.1)	25.9 (27.7)	0.44
Teacher Collaboration	71.8%	30.5 (37.4)	33.7 (38.9)	27.7 (36.6)	31.3 (37.1)	1.33
University Courses[b]	13.2%	6.2 (22.2)	11.6 (32.9)	5.1 (16.9)	2.5 (14.2)	7.50**
Professional Conferences	27.4%	4.3 (10.2)	5.1 (11.7)	4.1 (10.7)	3.8 (7.8)	0.76
Percentage/Hours per Month						
Mentoring/ Coaching[b]	20.3%	0.8 (2.3)	1.5 (3.1)	0.6 (1.9)	0.5 (1.6)	10.11**
Informal Communications	72.4%	3.9 (4.1)	4.2 (4.1)	3.9 (4.2)	3.6 (4.0)	0.69
Individual Learning Activities	99.8%	36.1 (24.9)	37.1 (27.4)	34.4 (23.3)	37.6 (24.7)	1.00
N		577	162	244	171	

*p< .05, **p < .01
Note: [a] Standard deviation
[b] Post-hoc tukey analyses showed that the amounts of time beginning teachers spent receiving mentoring or coaching and taking university courses were significantly larger than mid-career or experienced teachers. There were no statistical differences in the amounts of time that mid-career and expereinced teachers engaged in these activities.

The other three types of learning activities are less common among middle school mathematics teachers. Only 27.4% of mathematics teachers attended a professional conference as a

presenter or an audience member. As mentoring and coaching are normally only for beginning teachers, it is natural that a small percentage of teachers (20.3%) worked with a mentor or a coach. The least common activity was taking university courses; only 13.2% of teachers took a university course during the previous 12 months.

The next column presents the average hours teachers spent for seven types of professional learning activities. Among the formal professional learning activities, on average, teachers spent the most time for teacher collaboration (30.5 hours during the previous 12 months). Teachers also spent a relatively large amount of time (26.8 hours) participating in professional development programs. This amount is similar to the national statistics of 28.4 hours in the 2005-2006 academic year reported by Birman et al. (2009). Teachers spent significantly fewer hours taking university courses (6.2 hours), attending professional conferences (4.3 hours), or receiving mentoring or coaching (0.8 hours per month). Among informal learning activities (i.e., informal communications and individual learning activities), teachers spent a larger amount of time in individual learning activities with an average of 36.1 hours per month, or 2 hours each day. In contrast, they spent an average of only 3.9 hours per month for informal communications with their colleagues to learn about mathematics teaching or learning.

The comparisons of the average hours among beginning, mid-career, and experienced teachers showed that there was no statistically significant difference in most activities except in taking university courses and receiving mentoring or coaching. Beginning teachers spent an average of 11.6 hours taking university courses compared to 5.1 hours for mid-career teachers and 2.5 hours for experienced teachers. A further analysis of the average hours reported by teachers with five or less years of teaching experience showed that the third and fourth-year teachers are taking more university courses (12.8 hours and 13.1 hours) than the first and second year teachers. Teachers in Missouri are required to complete 30 hours of professional development to obtain a career certification and receive tenure in their fifth year, and many teachers choose to take university courses to fulfill this requirement especially because university courses can lead them to obtain an advanced degree and to advance on the salary schedule. In addition, beginning teachers spent 1.5 hours on average with their mentors or coaches compared to 0.6 hours (36 minutes) among mid-career teachers, and 0.5 hours (30 min) among experienced teachers. This result is understandable as normally only beginning teachers are assigned a mentor or a coach.

Because of the large amount of individual learning activities reported by teachers, I further examined the types of individual activities they engaged in. Table 3 presents the mean hours per month and the percentage distribution of hours for each type of individual learning activity along with the standard deviation. The most common individual learning activity was "studying and analyzing student work." Mathematics teachers spent 16.3 hours per month studying and analyzing students' homework and worksheets, and student responses to their questions in class, which represents 45.2% of their total time spent on individual learning activities.

The high number of hours teachers reported for this activity could be because these teachers are reporting the time spent for grading students' work without analyzing or studying it. In the teacher interviews conducted to test the content validity of this item, however, all teachers reported that they would not report the time they spent on simple grading because of the definition of the individual learning activities provided in the survey (see Table 3). However, I cannot deny the possibility that some respondents may have reported the hours they spent on simple grading such as scoring student tests or worksheets. Because of the difficulty of clearly differentiating grading from studying or analyzing student work, it is important to keep in mind the possible over-reporting of this type of individual learning activity when interpreting the data.

These middle school mathematics teachers also spent an average of 7.8 hours (or 21.6% of the total time in individual learning activities) for "studying and developing student assessment tools and materials." These two activities occupied 66.8% of the total hours for individual learning activities, which shows these mathematics teachers' focus on examining student learning and understanding. Less common individual learning activities were: 1) searching web-based resources for curriculum and instruction (5.3 hours or 14.7%), 2) reading teachers' manual for adopted textbook (4.2 hours or 11.6%), and 3) reading professional journals or books on mathematics teaching and learning (2.2 hours or 6.1%).

Table 3
Content of individual learning activities

Individual learning activities refer to activities you engage in by yourself outside of the above-listed activities such as reading professional journals and analyzing student work.		
Q. How many hours during *a typical month* do you usually spend on your own for …?	**Mean**[a] (Percentage)	**SD**
1. Studying and analyzing student work (e.g., homework, worksheet, student responses to your questions in class)	16.3 (45.2%)	10.9
2. Studying and developing student assessment tools and materials	7.8 (21.6%)	7.6
3. Searching web-based resources for curriculum and instruction	5.3 (14.7%)	6.8
4. Reading teachers' manual for adopted textbook	4.2 (11.6%)	5.7
5. Reading professional journals or books on mathematics teaching and learning (e.g., Mathematics Teaching in the Middle School, Mathematics Teacher)	2.2 (6.1%)	3.7
6. Other (specify)	0.2 (.5%)	1.8
Total	36.1 (100%)	

In summary, teacher collaboration and professional development programs are two most common formal learning activities and individual learning activities are the most common informal learning activities. The most common types of individual learning activities were: 1) studying and analyzing student work and 2) studying and developing student assessment tools and materials, which indicates teachers' focus on understanding student learning. However, the data also showed major variations among teachers in the amounts of time spent for seven types of professional learning activities as we can see from the large standard deviations in Tables 2 and 3. It is important to examine what teacher and district characteristics are associated with these variations.

Teacher Qualifications, District Characteristics, and Professional Learning Activities

Before examining the relationships between teacher and district characteristics and the amount of teachers' participation in professional learning activities, a correlation analysis among independent variables was conducted and reported in the Appendix B. Because all six teacher variables are dichotomous variables (coded as 1 or 0), Kendall's *tau b*s were reported in the correlation table. While most of the correlation coefficients are statistically significant, most of them have a small coefficient size of less than .50. One exception was the relationship between poverty level and math achievement (b=-.579**). High-poverty districts have a lower percentage of students achieving at or above the proficient level on the state assessment in mathematics than low-poverty districts. Because the size of this coefficient is not large enough to cause a problem with multicollinearity, both variables were included in the final models.

Table 4 presents the results of 2-level HLM models that examined the relationships between the amounts of time teachers spent in professional learning activities and teacher qualifications and district characteristics. The models for the seven types of professional learning activities are presented. The variance component for teachers (level 1) and districts (level 2) are presented for fully unconditional models without any independent variables and conditional models after entering all the independent variables. From the variance components for fully unconditional models, we can see that over 75% of the total variations in the amounts of seven types of professional learning activities come from teacher level. This means that most of the variations are due to differences between individual teachers (either individual characteristics or their working conditions that are individually unique), rather than differences between districts.

Among the six teacher qualification variables in Table 4, teaching experience, mathematics certification, and mathematics major were significantly associated with teachers' participation in at least one type of professional learning activities. Consistent with the ANOVA and post-hoc tukey analysis results reported in Table 2, beginning teachers tended to spend more time taking university courses and receiving mentoring or coaching than mid-career or experienced teachers. Experienced teachers also spent less time than mid-career teachers taking university courses. The teachers without a mathematics certification spent more time in individual learning activities than teachers certified in mathematics. They may have felt a greater need to study and analyze students' mathematical understandings and develop student assessment tools or materials because they did not receive mathematics-related preparation in their teacher education programs.

The teachers who majored in mathematics spent more time taking university courses than non-mathematics majors. This finding is unexpected as the teachers with mathematics major should be well prepared in mathematics content. A further analysis revealed that 68.6% of teachers who majored in mathematics also majored in mathematics education, and 95.1% of them held a mathematics certification. Thus, they should be also well prepared in mathematics pedagogy as well. It may be that these teachers spend more time taking university courses because they value university courses for further advancing their mathematics content knowledge and pedagogical skills. Due to the lack of statistically significant relationships between most of the qualification variables and the amount of time teachers spent in seven types of professional learning activities, only a small percentage of the variation at teacher level was explained by these teacher qualifications in all seven models. The percentages of the variations explained by teacher qualification variables were quite small: 3.4% for mentoring/coaching and 3.0% for university courses, and all the other percentages were less than 1%. This indicates that other teacher characteristics beyond the basic qualifications examined here explain the variation in the amount of time teachers spent in professional learning activities.

Four district characteristics were examined as independent variables at level 2: 1) poverty level, 2) percentage of ethnic minority students, 3) district size, and 4) mathematics achievement. Table 4 shows that poverty level and percentage of ethnic minority students were significantly associated with the amount of time teachers spent in at least two types of professional learning activities. Mathematics teachers in high-poverty districts spent more time participating in professional development programs and being mentored or coached than mathematics teachers in low-poverty districts. In addition, mathematics teachers in ethnically diverse districts spent more time participating in professional development programs, and engaging in teacher collaboration, and receiving mentoring or coaching than mathematics teachers in less diverse districts.

However, district size and district mathematics achievement were not significantly associated with the amount of teachers' participation in any type of professional learning activities. Although larger districts have more middle school teachers, teachers in larger districts may not necessarily have more interactions or collaboration opportunities with other teachers for professional learning purposes. The lack of a significant relationship between district mathematics achievement as measured by the percentage of students meeting the proficient level on the state assessment and the amount of *formal* professional learning activities teachers participated (i.e. professional development programs, teacher collaboration, university courses, professional conferences) is unexpected because the schools in improvement status are required to spend at least 10% of their Title I funds for professional development. Because of the negative correlation between poverty level and achievement level (-.579**), I also examined alternative models without the poverty level. However, the results still showed no statistically significant relationship between district mathematics achievement and the amounts of teachers' participation in any type of professional learning activities.

A measurement limitation may explain this lack of a significant relationship between district mathematics achievement and the amount of time teachers spent in professional learning activities. District mathematics achievement may not be an accurate indicator of the actual amount of Title I funds used for professional learning activities in each district. Not all districts with low student achievement have Title I schools, and the actual amount of Title I funds used for professional learning activities depends on the proportions of Title I schools within each district. Although we could expect that district mathematics achievement would be reasonably correlated with the number of Title I schools in improvement status, it is important to note that district mathematics achievement is only a proxy measure of the amount of Title I funds used for professional learning activities.

However, if we assume that district mathematics achievement is a reasonable indicator, if not a perfect indicator, of the total amount of Title I funds used for offering professional learning opportunities for teachers, this lack of a significant relationship may indicate that 10% of Title I funds schools are required to spend for professional development may not necessarily increase the amount of teachers' participation in professional learning activities. Many schools may be already spending more than 10% of their Title I funds for their professional development programs; therefore, the NCLB requirement may not make a major difference. Even without the NCLB requirement on the use of Title I funds, I expected that that the districts with low student achievement level would encourage or require teachers to participate in professional development programs because of the greater accountability pressure these districts experience.

Instead, the levels of poverty and ethnic diversity seem to be more important factors associated with the amount of professional learning activities teachers engage in. As the four district characteristics were examined simultaneously, low achievement is not the reason why the teachers in high-poverty and ethnically diverse districts are spending more time in professional learning

Table 4

Teacher qualications and district characteristics associated with amount of professional learning activities

	Professional Development Programs	Teacher Collaboration	University Courses	Professional Conferences	Mentoring/ Coaching	Informal Communications	Individual Learning Activities
Level 1: (N=577)							
Teacher Characteristics							
Beginning (0-5 yrs)	.86(3.06)	5.27(3.12)	5.86(2.67)*	.72(1.11)	.70(.24)**	.05(.36)	1.77(3.00)
Experienced (>15 yrs)	1.07(2.47)	3.44(2.89)	-3.69(1.64)*	.33(.84)	-.16 (.13)	-.28 (.47)	2.6(2.47)
Math Certification	2.80(2.61)	-1.47(3.62)	-2.11(2.51)	-.16(1.18)	-.17(.28)	-.02(.48)	-8.00(2.92)**
Masters' Degree	-.81(2.23)	.99(2.67)	.36(1.78)	-.65(.98)	-.25(.18)	-.43(.40)	-.21(2.63)
Math Major	-3.08(3.11)	-2.78(4.21)	6.31(2.89)*	-1.40(.94)	.46(.30)	.53 (.52)	3.42(3.01)
Math Ed Major	2.89(2.53)	1.69(3.63)	-1.11(1.95)	1.23(.71)	-.02 (.19)	.69 (.36)	2.76(1.74)
Level 2: (N=117)							
District Characteristics							
Poverty Level (% FRL)	.27(.12)*	-.25(.20)	-.05(.08)	.08(.06)	.02 (.01)*	-.01(.02)	.03(.09)
Ethnic Minority (%)	.23(.10)*	.53(.15)**	.07(.08)	-.02(.03)	.04(.01)**	.02(.01)	.11(.07)
District Size (in 100)	.03(.02)	-.02(.04)	.00(.01)	-.01(.01)	-.00 (.00)	-.00(.00)	.00(.02)
Math Achievement	.31(.21)	.33(.28)	-.19(.16)	.06(.09)	.04(.02)	.04(.03)	-.00(.14)
Variance Component							
Fully unconditional							
Level 1	676.8 (80.6%)	1110.5 (79.1%)	468.3 (94.0%)	87.8 (76.4%)	4.3 (79.9%)	16.1 (93.5%)	605.5 (97.3%)
Level 2	163.3 (19.4%)	293.3 (20.9%)	30.1 (6.0%)	27.1 (23.6%)	1.1 (20.1%)	1.1 (6.5%)	17.0 (2.7%)
Conditional							
Level 1	688.0	1110.7	454.1	87.1	4.1	16.0	600.5
Level 2	115.5	235.1	29.1	30.0	0.5	1.1	13.2
% Variance Explained							
Level 1	0.0	0.0	3.0	0.7	3.4	0.6	0.8
Level 2	29.3	19.9	3.3	0.0	51.1	5.0	22.7

*p< .05, **p < .01, ***p < .001

activities. Three types of professional learning activities significantly associated with poverty and/or diversity level were professional development programs, teacher collaboration, and mentoring/coaching, all of which are relatively structured activities that involve interactions with other teachers.

The teachers in high-poverty and diverse districts may feel a greater need to engage in professional learning than the teachers in wealthy, white-dominant districts. They may be experiencing the gap between their training in teacher education programs and the reality of teaching in high-poverty, diverse school settings as most teacher education programs tend not to focus on diversity. Previous studies have shown that multicultural teacher education occupies a small part of the teacher education curriculum, with most preparation programs offering a single diversity course or other add-on components to the main curriculum (Akiba, 2011; Ladson-Billings, 1995; Larkin & Sleeter, 1995; Sleeter, 2001). Instead of informally asking their colleagues for advice or engaging in individual learning activities, these teachers may have turned to formal learning activities. Beginning teachers tended to seek help from their mentors, and other teachers participated in collaboration and professional development programs. Although the effectiveness of these formal learning activities are beyond the scope of this study, the greater amount of time devoted to learning activities among mathematics teachers in high-poverty, diverse districts may indicate the greater professional learning needs among these teachers.

At level 2, the percentage of variation explained by district characteristics varied significantly across the seven types of professional learning activities. Four district characteristics (poverty level, percentage of ethnic minority students, district size, and mathematics achievement) explained only 3.3% and 5.0% of the district-level variations in the amount of time teachers spent taking university courses and engaging in informal communications with their colleagues respectively. These four district characteristics did not explain any variation in the amount of time teachers spent attending professional conferences. In contrast, these four district characteristics explained large percentages of district-level variations in the amount of time teachers spent receiving mentoring/coaching (51.1%,), participating in professional development programs (29.3%), engaging in individual learning activities (22.7%), and participating in teacher collaboration (19.9%). Despite these relatively large percentages of variations explained, district-level variations constitute only 2.7% to 23.6% of the total variations (sum of teacher- and district-level variations) for the amount of time teachers spent in seven types of professional learning activities. Therefore, it is important to note that most of the total variations in the amounts of time teachers spent in seven types of professional learning activities are left unexplained.

Conclusion and Discussion

This statewide survey of 577 middle school mathematics teachers in Missouri documented and analyzed the amounts of seven types of professional learning activities teachers participated in during the previous 12 months or a typical school month. Before discussing the results, it is important to point out the limitations of this study. First, the data came from a sample of Missouri middle school mathematics teachers and cannot be generalized to the entire country. Although Missouri has the average characteristics in the levels of student achievement and educational opportunities of the nation as a whole according to the 2011 Quality Counts report (Editorial Projects in Education, 2011), the average qualifications of teachers and background characteristics of schools and districts where they work are different from those of a nationally representative sample of teachers. Second, only a small percentage of the variation in the amount of teachers' participation in professional learning activities at teacher level was explained by teacher qualifications. Future

studies may investigate other teacher characteristics such as learning motivation and attitudes, ability for reflection, and self-efficacy, as well as individual-level factors related to teachers' work contexts such as working conditions and relationships with other teachers as possible predictors of the amount of time teachers spend in professional learning activities. Finally, the study focused on the amounts of seven types of professional learning activities teachers engaged in, but did not assess the quality of these activities. Future studies should examine both the amount and quality of these professional learning activities to examine which types of activities are most effective in improving teachers' knowledge and instruction and student learning.

Despite these limitations, this is the first study to quantitatively identify the amount of teachers' participation in various types of professional learning activities using statewide teacher survey data. The study found that the most common types of formal professional learning activities were professional development programs and teacher collaboration. However, on average, they spent only 26.8 hours for professional development programs and 30.5 hours for teacher collaboration during the previous 12 months. The study also found that mathematics teachers spent 36.1 hours per month (or about 2 hours each day) on individual learning activities. A further analysis of the content of individual learning activities revealed that they spent 66.8% of their individual learning time engaging in two activities: 1) studying and analyzing student work such as homework, worksheet, and student responses in class (45.2%) and 2) studying and developing student assessment tools and materials (21.6%). This suggests that the focus of teachers' individual learning activities is on understanding students' mathematical knowledge and thinking. This finding is well supported by the case studies conducted by Scribner (2003), who found that students are the core context for teacher learning. Teachers' focus on individual learning activities is also supported by Kauffman, Johnson, Kardos, Liu, and Peske (2002) who found that, because of a lack of curriculum materials and support, teachers spend a great amount of time studying and developing daily lessons in isolation with limited opportunities to reflect on their teaching practice.

The analysis also showed that teacher qualifications do not explain the amount of teachers' participation in professional learning activities. Because the previous empirical studies have shown statistically significant relationships between teacher qualifications and student achievement (Akiba, et al., 2007; Darling-Hammond & Youngs, 2002; Rice, 2003; Wayne & Youngs, 2003; Wilson, et al., 2002), I expected that this relationship would be mediated by professional learning activities. However, the data showed that common teacher qualifications (mathematics certification, master's degree or above, mathematics major, mathematics education major, and teaching experience) were not significantly associated with the amount of professional learning activities teachers engaged in.

The only exception to this pattern was that mathematics teachers without a mathematics certification were more likely to engage in individual learning activities. In addition, mathematics teachers with a mathematics major were more likely to take university courses. This is consistent with the finding by Desimone at al. (2006) on the significant relationship between majoring or minoring in mathematics or mathematics education and a greater amount of participation in university courses or professional development programs based on the teacher survey data in the 2000 NAEP dataset. However, unlike the studies by Smith and Desimone (2003) and Birman et al. (2009) that found a significant relationship between teaching experience and professional development hours, this study based on a Missouri sample did not find the hours for professional development program to differ by teaching experience. Overall, no more than 3.4% of the teacher-level variation was explained by these qualification variables, and there is a need to examine other teacher-level factors that may explain the amount of professional learning activities teachers engage in.

While there is no question that individual characteristics such as learning motivation and attitudes, ability for reflection, and self-efficacy would influence teachers' participation in professional learning activities, individual-level organizational factors such as working conditions and relationships with other teachers would also play an important role in determining how much time teachers spend in professional learning activities. Previous case studies on teacher learning have documented the lack of time as a critical hindrance to teacher learning (Little, 1999; Scribner, 1999). If so, heavy instructional and non-instructional load may prevent teachers from participating in professional learning activities. In contrast, those teachers who receive teaching release time to engage in professional development activities and who are assigned scheduled time to collaborate with other teachers would be more likely to participate in professional learning activities (King, 2004; Spillane and Thompson, 1997). In addition, the teachers who perceive that their colleagues are knowledgeable and who have a trusting relationship with them would be more likely to spend time in formally or informally collaborating and interacting to learn from one another (Gamoran, et al., 2003; Little, 1999; Spillane & Thompson, 1997). Teachers' working conditions and relationships among teachers would be important factors for future investigations as possible predictors of the amount of teachers' participation in professional learning activities.

The examination of the relationships between district characteristics and the amount of professional learning activities showed that teachers in high-poverty and ethnically diverse districts spend more time participating in professional development programs, engaging in teacher collaboration, and receiving mentoring or coaching. This finding is consistent with the studies by Smith and Desimone (2003) and Garet et al. (2001). However, district mathematics achievement level measured by the percentage of students achieving at the proficient level and district size were not significantly associated with the time teachers spent in professional learning activities. This lack of a significant relationship between district mathematics achievement and the amount of time teachers spent in formal professional learning activities could be due to the limitation of the measure and there is a need for measuring the actual amount of Title I funds and other types of funds used for professional learning activities in future studies.

About 80% of the total variations in the amounts of time teachers spent participating in professional development programs, engaging in teacher collaboration, and receiving mentoring is coaching is explained at teacher level rather than at the district level. Therefore, it is likely that most of these structured learning activities are not district-sponsored programs where all teachers are required to participate and spend the same amount of time. However, school districts may also require teachers to choose professional learning activities from a list of professional development programs, which would also result in variation among teachers in their levels of participation.

Whether it is through district requirements or individual choice, mathematics teachers in high-poverty and ethnically diverse districts are more likely to participate in structured learning activities (professional development, teacher collaboration, and mentoring/coaching), probably because of their professional learning needs for teaching socio-economically and ethnically diverse students. The challenges faced by teachers, and in particular middle-class white teachers working in high-poverty, ethnically diverse schools are well documented in various case studies (Johnson, Kardos, Kauffman, Liu, & Donaldson, 2004; Michie, 1999). Other studies also suggest that most teachers do not receive sufficient preparation in teacher education programs for teaching mathematics to socioeconomically and ethnically diverse students (Akiba, 2011; Ladson-Billings, 1995; Larkin & Sleeter, 1995; Sleeter, 2001), and there is an urgent need for them to connect mathematics content with their students' prior experience and knowledge. Furthermore, the current accountability climate with standardized curricula and assessments may pose a unique challenge to teachers who seek to make mathematics relevant to lives of students with diverse socioeconomic

and ethnic backgrounds (Darling-Hammond & McLaughlin, 1999; Schultz, Jones-Walker, & Chikkatur, 2008).

While these teachers spend a similar amount of time in individual learning activities as other teachers, they spend more time participating in structured learning activities. Future research should investigate what these teachers in socio-economically and ethnically diverse districts learn through structured learning activities compared to individual learning activities and how these activities influence their perceptions, knowledge, and practice of teaching mathematics to diverse students.

Policy Implications

This study documented mathematics teachers' participation in various types of professional learning activities, including both formal and informal activities. It is important for policymakers and district and school administrators to know how much time teachers spend in each type of learning activity. Although teachers spend 26.8 hours participating in professional development programs and 30.5 hours engaging in teacher collaboration per year, they also spend 36.1 hours each month in individual learning activities. The influence of individual learning activities on teachers' professional learning cannot be ignored when a district or a school is trying to implement a reform for improving instruction and student learning. Because individual learning activities usually do not offer the opportunities for mutual learning and reflection (Kauffman, et al., 2002; Scribner, 2003) and may not be necessarily aligned with the district or school's reform goals or directions, it is important for policymakers and district and school leaders to promote a higher level of teachers' participation in coherent, sustained, collaborative, and reflective professional learning activities.

As this study highlights, while mathematics teachers invest a significant amount of time in understanding their own students' mathematical thinking and knowledge through individual learning activities, they would also value formal learning activities that focus on students in actual classroom settings. Indeed, various studies have indicated that professional development opportunities are most effective in influencing teacher practice when such opportunities focus on teaching practices and student learning in the context of actual classrooms (Borasi & Fonzi, 2002; Clarke, 1994; Elmore, 2002; Hawley & Valli, 1999; Loucks-Horsley, Hewson, Love, & Stiles, 1998; Wilson & Berne, 1999).

There are several professional development models that focus on studying student understanding and teaching based on in-depth analysis of student thinking. Some of these models are Lesson Study (Lewis, 2002; Lewis, Perry, & Hurd, 2009) and Cognitively Guided Instruction (Carpenter & Fennema, 1992; Carpenter, Fennema, & Franke, 1999; Carpenter & Moser, 1983; Fennema, et al., 1996). In a Lesson Study, teachers work collaboratively to plan a lesson, observe the lesson in an actual classroom with students, and analyze and discuss student work and reactions to the lesson (Lewis, 2002; Lewis, et al., 2009). The focus of Lesson Study is on understanding student thinking and identifying instructional approaches that enhance student learning through teacher collaboration. In a professional development on Cognitively Guided Instruction, elementary school teachers learn to recognize strategies used by their students to solve addition and subtraction problems and to choose mathematics problems that promote their students' mathematical thinking (Carpenter & Fennema, 1992; Carpenter, et al., 1999; Carpenter & Moser, 1983; Fennema, et al., 1996).

In these professional development programs, mathematics teachers are given ample opportunities to work with other teachers to analyze students' mathematical thinking, reflect on their own beliefs and ideas about teaching and learning, and discuss various instructional approaches that promote student learning. It is likely that mathematics teachers will participate in such activities

as they value learning opportunities focused on student thinking and knowledge. To promote instructional improvement and student learning growth, it is important for district and school administrators to offer activities that are not only coherent, sustained, and collaborative, but also the activities that meet mathematics teachers' learning needs for understanding student learning.

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Appendix A

Survey items on professional learning activities

Definition	Survey Items	Original Coding	Final Coding
Professional development program is an organized activity for the purpose of learning and improving mathematics teaching and student learning (E.g., school- , district- , or Regional Professional Development Center (RPDC)-sponsored workshop).	**Professional Development Program** 1A. During the past 12 months, have you participated in a professional development program related to mathematics teaching or learning?	1=Yes 2=No [Skip to 2A]	1=Yes 0=No
	1B. How many hours of professional development programs on mathematics teaching or learning in total have you participated in during the past 12 months? Please include hours spent for a take-home task or a project required by the professional development programs. *Choose one response.*	1=1-2 hrs 2=3-5 hrs 3=6-10 hrs 4=11-20 hrs 5=21-40 hrs 6=41-60 hrs 7=61-80 hrs 8=> 80 hrs	0=None (No to 1A) 1.5=1.2 hrs 4=3-5 hrs 8=6-10 hrs 15=11-20 hrs 30=21-40 hrs 50=41-60 hrs 70=61-80 hrs 90=> 80 hrs
Teacher collaboration is an ongoing activity such as a study group, Professional Learning Community, teacher network, group action research, and any other form of interaction among teachers for the purpose of improving mathematics teaching and learning. Mentoring or coaching is <u>not</u> teacher collaboration. Teacher collaboration can be formally organized by professional developers <u>or</u> informally practiced by a group of teachers.	**Teacher Collaboration** 2A. Have you participated in an ongoing teacher collaboration on mathematics teaching and learning during the past 12 months?	1=Yes 2=No[Skip to 3A]	1=Yes 0=No[Skip to 3A]
	2B. How many hours in total did you spend in teacher collaboration(s) during the past 12 months? *Choose one response.*	1=1-10 hrs 2=11-20 hrs 3=21-40 hrs 4=41-60 hrs 5=61-80 hrs 6=81-100 hrs 7=101-120hrs 8= >120 hrs	0=None (No to 2A) 5=1-10 hrs 15=11-20 hrs 30=21-40 hrs 50=41-60 hrs 70=61-80 hrs 90=81-100hrs 110=101-120hrs 130=>120 hrs
University/College courses may be taken for a degree or professional development credits.	**University/College Courses** 3A. Have you taken university or college courses in mathematics or mathematics education for credit during the previous 12 months?	1=Yes 2=No [Skip to 4A]	1=Yes 0=No [Skip to 4A]
	3B. How many actual hours (not credit hours) have you spent attending university courses on the following topics during the past 12 months? *Choose one response for each item.* a. Mathematics contents b. Mathematics instruction/pedagogy c. Foundations (e.g., diversity, social contexts of schools) d. Research on mathematics education e. Other	1=None 2=1-5 hrs 3=6-10 hrs 4=11-20 hrs 5=21-40 hrs 6=> 40 hrs	0=None 3=1-5 hrs 8=6-10 hrs 15=11-20 hrs 30=21-40 hrs 50=> 40 hrs

Professional conference is an opportunity to present your practice or research, and learn from presentations about new ideas for mathematics teaching or learning.	**Professional Conference** 4A. Have you attended a local, regional, state, or national conference(s) on mathematics teaching or learning during the previous 12 months?	1=Yes 2=No[Skip to 5A]	1=Yes 0=No[Skip to 5A]
	4B. How many hours have you spent for each of the following activities at a conference(s) on mathematics teaching or learning during the past 12 months? *Choose one response for each item.* a. Conference audience member b. Conference presenter	1=None 2=1-2 hrs 3=3-5 hrs 4=6-10 hrs 5=11-20 hrs 6=21-40 hrs 7=> 40 hrs	0=None 1.5=1-2 hrs 4=3-5 hrs 8=6-10 hrs 15=11-20 hrs 30=21-40 hrs 50=> 40 hrs
Mentoring/Coaching is a formal district or school sponsored activity to provide new teachers with induction experiences and professional development.	**Mentoring/Coaching** 5A. Do you currently have a formal mentor or a coach assigned by your district or school?	1=Yes 2=No [Skip to 6A]	1=Yes 0=No [Skip to 6A]
	The following questions are about a formal mentor or coach. If you have multiple formal mentors or coaches, please choose the mentor or coach who most influenced your mathematics teaching and learning.	1=< 1 hr 2=1-3 hrs 3=4-5 hrs 4=6-10 hrs 5=> 10 hrs	0.5=< 1 hr 2=1-3 hrs 4.5=4-5 hrs 8=6-10 hrs 12=>10 hrs
	5B. How many hours do you spend communicating with your formal mentor or coach during a typical month? Please include both the face-to-face time and the communication through phone or email. *Choose one response.*		
Informal communication refers to planned or unplanned interactions with colleagues or friends outside of the above-listed activities.	**Informal Communication** 6A. Do you have someone other than a formal mentor or coach whom you informally rely on and communicate with for your professional learning of mathematics teaching?	1=Yes 2=No [Skip to 7A]	1=Yes 0=No [Skip to 7A]
	The following questions are about this person. If you have multiple persons on whom you communicate with for your professional learning of mathematics teaching, please choose the person who most influenced your mathematics teaching. 6B. How many hours do you spend communicating with this person during a typical month? Please include both the face-to-face time and the communication through phone or email. *Choose one response.*	1=Less than 1 2=1-3 3=4-5 4=6-10 5=More than 10	0.5=Less than 1 2=1-3 4.5=4-5 8=6-10 12=More than 10
Individual learning activities refer to activities you engage in by yourself outside of the above-listed activities such as reading professional journals and analyzing	**Individual Learning Activities** 7A. How many hours during a typical month do you usually spend on your own for …*Choose one response for each item.*	1=Never 2=1-2 hrs 3=3-5 hrs 4=6-10 hrs 5=11-20 hrs	0=Never 1.5=1-2 hrs 4=3-5 hrs 8=6-10 hrs 15=11-20 hrs

student work.		6=21-30 hrs 7=>30 hrs	25=21-30 hrs 35=>30 hrs
	a. Studying and analyzing student work (e.g., homework, worksheet, student responses to your questions in class) b. Reading teachers' manual for adopted textbook c. Studying and developing student assessment tools and materials d. Searching web-based resources for curriculum and instruction e. Reading professional journals or books on mathematics teaching and learning (e.g., Mathematics Teaching in the Middle School, Mathematics Teacher) f. Other (please specify)		

Appendix B

Correlation matrix among independent variables (based on Kendall's tau b)

	1	2	3	4	5	6	7	8	9
1. Beginning Teacher									
2. Experienced Teacher	-.405**								
3. Math Certificate	.075	-.094*							
4. Master's Degree	-.279**	.266**	.037						
5. Math Major	-.027	.117**	.148**	.024					
6. Math Ed Major	.137**	-.088*	.267**	-.072	.291**				
7. Poverty Level	.095**	-.065	-.028	-.068*	.049	-.064			
8. Ethnic Minority	.027	-.021	.076*	.006	.079*	.047	.116**		
9. District Size	.026	-.083*	.056	.031	.029	.071*	-.163**	.343**	
10. Math Achievement	-.082*	.081*	.016	.083*	-.033	.087*	-.579**	-.105**	.080**

N=577 for all the variables.

*p< .05, **p < .01

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