Collaboration and Connections among Middle School Teachers of Mathematics: Enhancing Efficacy through Professional Learning Communities

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With the increasing demand for improved student achievement in mathematics, few studies have been conducted examining teacher efficacy when continuously supported through a collaborative professional learning community (PLC) structure. This study examined teacher efficacy within PLC activities in a middle school. Both the belief that mathematics instruction would result in student learning and the belief to effectively teach mathematics statistically significantly increased after one year of participation with large effects (1.15 and 1.30, respectively). The correlations between belief that mathematics instruction would result in improved student learning and in their ability to effectively teach mathematics were very strong and positive.

The need to improve student outcomes in mathematics has been demonstrated consistently. Assessment results of fourth-graders showed no measurable gain in mathematics in recent years (National Center for Education Statistics; NCES, 2017). In addition, by the eighth grade, U.S. students had slipped to the middle of the list of nations and under-performed even students from several less-developed nations (NCES, 2017). The current focus is content knowledge in mathematics as a theory-based activity leading to a conceptual understanding of symbol manipulation. Given the focus on theory-based learning leading to conceptual understanding (National Mathematics Advisory Panel, 2008), the development of these understandings and pedagogies by teachers is needed.

The intersection of content and pedagogy transforms content knowledge into instructional methods necessary to address diverse student abilities and backgrounds (Darling-Hammond, Hyler, & Gardner, 2017). Pedagogical content knowledge (Shulman, 1986) is a domain of teacher knowledge linking content with pedagogy within the context of student learning. Development of pedagogical content knowledge includes apprenticeship of observation, subject matter knowledge, sustained professional development, and classroom experience (Fink & Markhold, 2011; Fisher, Frey, & Pumpian, 2012). Acquiring this sophisticated knowledge and developing a practice that is different from what teachers themselves experienced as students and as teachers requires learning opportunities for teachers that are more powerful than simply reading and talking about new pedagogical ideas (Darling-Hammond, Hyler, & Gardner, 2017). However, secondary teachers attended professional development focused on in-depth study of mathematics, and only 10% spent more than 24 hours on sustained professional development (Yoon, Garet, Birman, & Jacobson, 2007). The criteria established for high-quality professional development for teachers include: (1) sustained, intensive, content-focused; (2) aligned with content standards and assessments; (3) resulted in improved teacher knowledge; (4) based on research and instructional strategies; and (5)produced teacher effectiveness and student achievement (Bryk, 2010; Croft, Coggshall, Dolan, & Powers, 2010). Within this context, professional learning for teachers is critical to improving classroom instruction and student achievement (Fisher, Frey, & Pumpian, 2012; Hattie, 2012).

Substantial, sustained professional development was shown to increase students' performance by about 21 percentile points (Yoon, Garet, Birman, & Jacobson, 2007). In fact, over the last 15 years, teacher effectiveness has become the subject of considerable quantitative and qualitative research, with a growing body of literature suggesting that the classroom teacher can have a significant impact on student learning and achievement (Hattie, 2012). Given these insights—that teachers are a primary school-based link to student achievement, and that pedagogical decision-making is a key lever in the teacher-student dynamic—teacher professional learning, efficacy, and continuous improvement represents a logical and important focus.

Professional Learning Communities and Professional Development Features

Professional learning communities (PLCs) are described as a model of professional development that focuses on student learning related to teaching, collaborative work, and accountability for results for more than a decade (DuFour & Eaker, 2008). PLCs are sustained, job-embedded professional development for teachers that address the learning needs of their students to improve results (DuFour & Eaker, 2008). Through collaboration and conversations about new learning and approaches, PLCs offer an ongoing professional development structure to assure continued learning for teachers and other school educators as they implement new curricula, materials, and strategies to meet the needs of their students in mathematics.

Educators within PLCs recognize that they must work together to achieve their collective purpose for all by promoting a collaborative school culture. The powerful collaboration that characterizes PLCs is a systematic process in which teachers work together to analyze and improve their classroom instructional practices. Teachers work in teams, engaging in a cycle of continuous improvement, based upon student learning (Knight, 2016). These collaborative conversations and discussions enhance learning of all professionals engaged in the PLC.

Efficacy

Teacher efficacy has been described as teachers' confidence in their ability to positively affect student learning and behavior (Tschannen-Moran & Hoy, 2007). An important factor in the determination of a teacher's sense of self-efficacy is experience through performance accomplishment. Bandura's (1986) social cognitive theory (SCT) posited an individual's perception of abilities has a major effect on self-efficacy, defined as what you believe that you can do with what you have under a variety of circumstances (Bandura, 1986). Beliefs of self-efficacy continuously impact teaching behaviors and beliefs. Increased efficacy generally leads to increased effort and levels of performance. Although some of the most powerful influences on the development of personal teaching efficacy are mastery experiences during student teaching and the initial induction year (Hoy, 2000), a complementary construct of collective teacher efficacy describes the self-efficacy of the entire faculty (Zee & Koomen, 2016).

Purpose of Study

Little research has been conducted on the effects of professional learning structures (e.g., study groups, professional learning communities, etc.) among veteran teachers who are again novices when learning new curriculum and instructional strategies. Knight (2016) found that teachers who participated in study groups and coaching were significantly more likely than nonparticipants to maintain a high level of general teaching efficacy. This study explored the PLC structure as a method of teacher-sustained professional learning on teacher efficacy during the initiation of enhanced instructional pedagogical methods in mathematics.

Method

Participants and Setting

The study site was located in a large school district in the southeastern U.S. and served a diverse population of 990 middle school students in a Title 1 school. A convenience sample of nine teachers of mathematics in the middle school agreed to participate in this study. Of these teachers, all held a bachelor's degree, and about 44% (n = 4) had received their bachelor's degree within the past five years. Two teachers indicated their field of study for their bachelor's degree, and these were elementary education (n = 1, 11%) and secondary education (n = 1, 11%). Two of the teachers (n=2, 22%) were first year teachers. Four teachers (44%) also held a master's degree, and three of the four teachers had received their master's degree within the past three years. About 75% of the teachers were female (n = 7). The majority of teachers were White (n = 8, 89%), not of Hispanic, Latino, or Spanish origin (n = 8, 89%), and spoke English as their primary language (n = 8, 89%).

Instrument

The *Mathematics Teaching Efficacy Beliefs Instrument* (MTEBI) is a 21-item instrument designed to measure mathematics teaching self-efficacy, one's belief in their own ability to effectively teach mathematics, and outcome expectancy, one's expectation that their mathematics instruction will result in student mathematics learning (Enochs, Smith, & Huinker, 2000). The instrument has two subscales: a) Personal Mathematics Teaching Efficacy (PMTE), 13 items; and b) Mathematics Teaching Outcome Expectancy (MTOE), 8 items. Items are measured on a five-point Likert scale (strongly agree to strongly disagree). Scores on the PMTE can range from 13 to 65, and scores on the MTOE can range from 8 to 40. Previous reliability for the PMTE was found to be .88 and for the MTOE, .75. The two-factor structure of the MTEBI was determined using confirmatory factor analysis, lending evidence to construct validity.

Procedures

The nine mathematics teachers met weekly for 30 minutes before school within the PLC structure (DuFour, & Eaker, 2008). At times, the school's curriculum specialist, assistant principal, and university liaison attended the PLC meeting. During the first session, the vision, goals, and norms were established by the members of the PLC. The content of subsequent sessions focused on implementation of various instructional strategies and technology to teach mathematics. Individual mathematics teachers rotated the role of facilitator, depending on the content to be highlighted and demonstrated instructional techniques related to classroom implementation of the standards. In addition, four sessions were "data meetings," in which specific student achievement data from school-administered benchmark assessments were disseminated and discussed by individual teachers within their PLC. There were 32 total PLC meetings of 30 minutes each throughout the school year and duration of this study.

Data Analysis and Results

As stated previously, scores on the Personal Mathematics Teaching Efficacy (PMTE) can range from 13 to 65, and scores on the Mathematics Teaching Outcome Expectancy (MTOE) can range from 8 to 40. Although the authors of the instrument indicate the scores for the subscales should be computed as a simple sum (Enochs et al., 2000), a subscale score creating from the mean sum of the items may be more interpretable as it puts it back to the scale of the original items (1 = strongly disagree to 5 = strongly disagree). The results for the mean sum PMTE and MTOE subscales are presented in Table 1. The range of *pretest* PMTE and MTOE scores were similar, however teachers had slightly greater average *pretest* outcome expectancy scores (*M* = 3.22, *SD* = 1.08) as compared to *pretest* mathematics teaching self-efficacy scores (*M* = 3.01, *SD* = .93). This pattern continued after completion of the PLC implementation. Teachers *posttest* outcome expectancy scores (*M* = 3.85, *SD* = .71) remained greater as compared to *posttest* mathematics teaching self-efficacy scores (*M* = 3.41, *SD* = .88). This suggests that, on average, *both before and after* participating in the PLCs, teachers had greater expectation that their mathematics instruction would result in student mathematics learning.

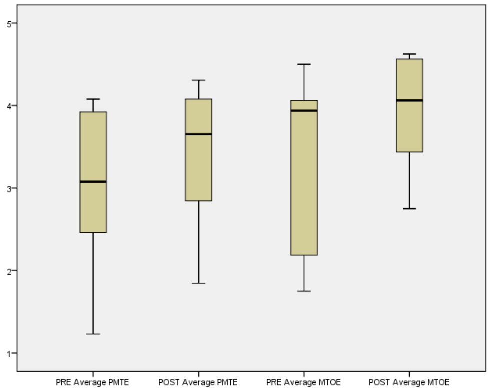
Table 1
Descriptive Statistics for the Mean Sum Pre and Post PMTE and MTOE Subscales

	Personal Mathematics Teaching Efficacy (PMTE)		Mathematics Teaching Outcome Expectancy (MTOE)	
	Pre	*Post*	*Pre*	*Post*
Mean	3.01	3.41	3.22	3.85
Median	2.85	3.65	3.88	3.75
Standard deviation	.93	.88	1.08	.71
Range	2.85	2.46	2.75	1.88
Minimum	1.23	1.85	1.75	2.75
Maximum	4.08	4.31	4.50	4.63
Percentiles 25	2.46	2.62	2.13	3.25
Percentiles 50	2.85	3.65	3.88	3.75
Percentiles 75	3.92	4.15	4.06	4.56

The median Mathematics Teaching Outcome Expectancy (MTOE) was greater relative to the Personal Mathematics Teaching Efficacy (PMTE), and this was evident for both pre and post scores. As seen in Figure 1, about one-half of teachers had pre outcome expectancy scores that were greater than 75% of the scores on the pre mathematics teaching self-efficacy, and this was evidenced for both pre and post scores. These results suggest that teachers more strongly perceived their mathematics instruction would result in student mathematics learning (as reflected in the higher pre and post MTOE) and perceived to a lesser degree in their own ability to effectively teach mathematics.

Figure 1

PMTE and MTOE distributions



Correlations

The correlations between Mathematics Teaching Outcome Expectancy (MTOE) and Personal Mathematics Teaching Efficacy (PMTE) scores were very strong (pre r = .865, p = .003; post r = .804, p = .016) suggesting that the more teachers perceived in their own ability to effectively teach mathematics, the more they also perceived their mathematics instruction would result in student mathematics learning (and vice versa). All correlations were statistically significant at alpha of .05. See Table 2.

Table 2
Correlations Between Pre and Post PMTE and MTOE Subscales

	Pre MTOE	Post PMTE	Post MTOE
Pre PMTE	.865	.957	.674
Pre MTOE	--	.942	.896
Post PMTE		--	.804

Pre to Post differences

Dependent samples t tests were conducted to determine if there were mean differences in pre and post PMTE and MTOE. The results were statistically significant. Both PMTE (t = -3.67, df = 7, p = .008) and MTOE (t = -3.441, df = 8, p = .009) were statistically significantly *greater* at the conclusion of the project. This provides evidence that both personal mathematics teaching efficacy beliefs (PMTE) and mathematics teaching outcome expectancy (MTOE) increased for teachers after participating in the professional learning community. In other words, both the belief that mathematics instruction would result in student mathematics learning (MTOE) and the belief in their ability to effectively teach mathematics (PMTE) increased, on average, after participation in the Math PLC for a year. The effect size, *d,* (in absolute value terms) was 1.15 for MTOE and 1.30 for PMTE, both indicating a large effect with more than one standard deviation difference from pre to post. For the PMTE, for example, there is more than 1-1/4 standard deviation difference in teachers' perceived ability to effectively teach mathematics after participating in the PLCs.

Discussion

This study investigated the effects of sustained professional learning and support on efficacy within a professional learning community in mathematics with teachers. The results of this study showed significant differences and large effects in teachers' reported efficacy after a year of implementation of instructional methods with the weekly collaboration with colleagues in the PLC. From the results of this study, it appears that both the social framework and the demonstration of learning activities of PLCs may have positively impacted teacher self-efficacy. Teacher discussions within professional learning communities provided a venue and structure for learning as participants investigated curriculum, instructional practices and strategies. Part of this process was developing a set of common formative assessments that were used to collect, analyze, and interpret results of student learning. Individual teachers had access to the ideas, materials, strategies, and talents of the entire team, including other mathematics teachers and curriculum specialists. Teachers' positive self efficacy is critically important as they must believe they can teach students (Fisher et al 2012). This initial research investigating the effects of support of teacher learning through PLCs appeared to also improve teacher self-efficacy.

Limitations

The current research includes several limitations. Given that this research occurred at one middle school, additional research needs to be completed across multiple sites, multiple content areas, and with teachers with various backgrounds. Sources of additional professional learning opportunities during the time of this research and student results were not collected. In addition, logs of actual teacher learning in the PLC and implementation within classrooms would also enhance the current findings. Lastly, as with any self-report research, answers may be influenced by the desire of the respondents to respond positively for social desirability purposes.

Implications

With increased and changing curriculum standards, instructional strategies, and greater diversity of students within classrooms, veteran teachers are faced with continuously changing content, pedagogy, and educational contexts. Bandura (1986) delineated social persuasion and mastery experiences as primary sources of the development of self-efficacy. The structure and activities of PLCs (e.g., teacher discussions focused on improved student learning, use of student data, and peer feedback) appear to provide the impetus for developing efficacious teachers within the context of professional learning. The results of this study, albeit limited due to sample, support sustained professional learning, including apprenticeship of observation, subject matter knowledge, sustained professional development and connections (Knight, 2016; Yoon, Garet, Birman, & Jacobson, 2007). Acquiring and supporting pedagogical content knowledge and practices in mathematics may not only result in improved student outcomes (Darling-Hammond, Hyler, & Gardner, 2017), but may also increase teacher's self-efficacy.

Knowledge and skills of current mandates, procedures and methods of curriculum, instruction and assessment improve the functioning and student results of participants as content and pedagogy. Members of PLCs determine their effectiveness based on the results of students in their classrooms. Possibly when PLCs are adopted school-wide, mathematics teachers participate in an ongoing process of identifying the current level of student achievement, establishing a goal to improve the current level, working together to achieve that goal, and providing periodic evidence of progress through the development teacher communities (Bryk, 2010). Through these sustained professional learning activities, teachers' efficacy will also improve. Within the current educational context of changing pedagogical knowledge, content standards, and pedagogy, professional learning must be planned to sustain professional learning to support and retain teachers as professionals (Joyce & Calhoun, 2015).

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