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Middle Level Mathematics Teachers' Self-Efficacy Growth through Professional Development: Differences Based on Mathematical Background

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Abstract: Profile analyses were used to investigate differences in the self-efficacy growth of teachers with more and less mathematics background as the teachers participated in professional development across two summers. Professional development activities were associated with increases in teachers' self-efficacy; however, without considering mathematics knowledge for teaching, teachers with more math background tended to benefit more than those with less background. Nonetheless, teachers with less math background had higher levels of teacher self-efficacy although this gap was closed by the last measurement. Such considerations are important when designing professional development as teachers may have different needs based on specific characteristics such as preparation in their teaching domain.

Around the world, interest in professional development for mathematics teachers has increased in response to the need for highly qualified educators who can successfully implement changing curriculum (Garet, Porter, Desimone, Birman, & Yoon, 2001; Huang & Bao, 2006). The emphasis on professional development has resulted in not only improved development models (Loucks-Horsley et al., 2010) but the demand for quality evaluation. Borko (2004) described the research strategies typically used to evaluate professional development and made suggestions for future investigations. Borko recommended that researchers explore whether professional development programs designed for teachers of one academic level, such as grades, years, or stages are appropriate for use with teachers who teach other levels. Borko also encouraged this exploration between academic domains to investigate whether professional development strategies used with teachers of one academic subject, for example, mathematics, are just as effective as when they are used with teachers of another subject, such as science. Because U.S. mathematics teachers vary in their levels of content expertise and background, one should also ask if professional development is effective for teachers at the same grade level but who have differing levels of mathematical background. The purpose of the present study was to compare teachers' reported self-efficacy as they advanced through a professional development program with that of other teachers who had received less formalised training in mathematical content knowledge.

Teachers' Mathematical Preparation

Ball, Lubienski, and Mewborn (2001) speculated that teachers taking more advanced university mathematics courses are predominately exposed to conventional approaches of teaching mathematics that emphasize procedure over conceptual understanding. According to Ball et al., the teachers then enter public school classrooms teaching mathematics with little to no benefit of models for teaching methods and strategies relevant for students at the middle level. Thus, they questioned the ability of these teachers to cognitively “unpack” the advanced content needed to develop appropriate mathematical models, examples, and questioning that can be understood by children. Instead of focusing on mathematical background as defined by the number of mathematics courses taken in college, Ball, Hill, and Bass (2005) highlighted the importance of teachers' pedagogical methods and how they use them in education specific situations and environments (Appleton 1995; Palmer 2001). Thus, teachers likely start with understanding the same basic mathematics that anyone else needs for a math-related career but teachers must also develop knowledge specific to teaching mathematics or mathematics knowledge for teaching (MKT) to become successful educators.

Good teaching demands that teachers should know many things about teaching, including knowledge about their students and about the cultural, political, and social context within which they work (Ball & McDiarmid 1990). Teachers who understand mathematics concepts are able to answer students' questions about the meaning behind procedures. For example, when teaching how to divide fractions, they are able to explain why the reciprocal of the denominator can be multiplied by the numerator to yield the answer. Content matter knowledge is not enough to achieve this goal. The mathematical knowledge required for teaching mathematics extends beyond a simple understanding of the content or common mathematical knowledge (Hill, Rowan, & Ball 2005). In their study of mathematics knowledge for teaching, Hill et al. found a significant and positive relationship between teachers' mathematical knowledge and student achievement in first- and third-grade. This relationship indicates that educators must be able to provide definitions and explanations, generate multiple representative examples for student understanding, and identify the various algorithms students use to solve the same problem to fully meet students' educational needs. For example, this concrete-representational-abstract sequence has been used to effectively teach children at risk for failure to subtract with regrouping (Flores, 2010). Additionally, teachers must demonstrate the ability to perform these skills efficiently in the classroom environment if they are to be effective educators.

Teachers' Self-Efficacy as an Outcome of Professional Development

Bandura (1986) described self-efficacy as domain specific and emerging from mastery experiences in a particular domain. Content knowledge in mathematics, although related to one's mathematics knowledge for teaching, represents a different domain associated with different types of tasks. Teachers might feel efficacious in their ability to solve advanced mathematical problems; however, they might not feel efficacious in their ability to instruct and engage students in the same content.

Current evidence suggests that there is an increasing interest in how professional development positively influences the self-efficacy of mathematics teachers (e.g., Ingvarson, Meiers, & Beavis, 2005; Ross & Bruce 2007; Swackhamer et al. 2009; Watson 2006). Woolfolk

and Hoy (1990) defined teachers' self-efficacy as the belief a teacher holds concerning his/her ability to effectively influence the engagement and learning of all students, regardless of motivation or behavior, to lead to positive educational outcomes. Evidence for the similarity of teachers' self-efficacy across Western and Eastern cultures has been documented (Ho & Hau, 2004), but the interest in this research based evidence appears to be generated more from Western populations. The investigation of teachers' self-efficacy has been fueled by its relation to many positive student outcomes. The self-efficacy of teachers is the one characteristic consistently related to the behaviour and learning of students, albeit the measurement and definition of the construct has varied over the past 30 years (Woolfolk & Hoy, 1990). Higher levels of teacher self-efficacy have been associated with higher students' standardised test scores and achievement (Anderson, Greene, & Loewen 1988; Cannon & Scharmann, 1996; Ross, 1992; Ross, Hogaboam-Gray, & Hannay, 2001) and higher motivation (Midgley, Feldlaufer, & Eccles, 1989). Higher levels of teacher self-efficacy are related to higher levels of flexibility and exploration in teaching (Allinder, 1994; Guskey, 1988; Stein & Wang, 1988). Efficacious teachers tend to exhibit resiliency in the face of classroom challenges evidenced by their less frequent use of criticism in response to student errors (Ashton & Webb, 1986) and lesser tendency to refer struggling students for special education services (Meijer & Foster, 1988; Podell & Soodak, 1993; Soodak & Podell, 1993). With such important benefits, teacher self-efficacy has increasingly become of interest in the design and evaluation of professional development programs.

Ross and Bruce (2007) found professional development specifically designed to increase teachers' self-efficacy to be successful. However, others have also documented that professional development targeting a number of characteristics, including content knowledge and pedagogical skill, is also linked to improved teacher self-efficacy (Ingvarson et al., 2005; Watson, 2006). Ingvarson et al. (2005) found that professional development for Australian teachers centered on opportunities to learn, especially those that promoted active learning, was strongly associated with teacher self-efficacy. Furthermore, after an intensive, long-term professional development experience designed to increase knowledge related to technology and computer use, teachers' self-efficacy not only increased but also maintained its post professional development levels for the subsequent six years (Watson, 2006).

Taken in the context of social cognitive theory and the sources of efficacy (Bandura, 1986), high quality professional development, such as programs that require teachers' collective involvement and learning over extended periods of time (Garet et al., 2001) target the four sources of efficacy. The sources include positive feedback, vicarious experiences, mastery experiences, and physiological feedback (Bandura, 1986). Extended professional development allows teachers opportunities for positive feedback about their shared teaching experiences; vicarious learning through interactions with peers teaching similar classes across school districts; and feelings of mastery upon the creation and implementation of new teaching strategies and organized lessons. A final benefit is the less pressured nature of professional development, which serves as positive physiological feedback. Unlike formal university coursework that can emphasize performance outcomes, such as testing and grades, typically, the emphasis of professional development is participation (Corcoran, 2006). Therefore, professional development that focuses on knowledge alone is not sufficient in building teachers' self-efficacy.

Mathematics Background, Knowledge for Teaching, and Self-Efficacy

A review of the research literature revealed few investigations into the relationship between advanced mathematics coursework and teachers' self-efficacy. Furthermore, an investigation into the association between mathematics knowledge for teaching and teachers' self-efficacy was also limited. Although Swackhamer et al. (2009) found that the number of mathematics and sciences courses taken by teachers as part of a professional development project was positively associated with the teachers' self-efficacy, the courses did not target only content knowledge. The courses were co-taught by natural sciences and mathematics faculty, mathematics and science education faculty, and K-12 partners to allow for the discussion of content applications and pedagogy. Thus, the coursework more likely helped participants to translate mathematical content knowledge into knowledge for teaching.

Morrell and Carroll (2003) investigated the contributions of the different types of coursework to preservice teachers' development of self-efficacy. They separated the influence of pedagogically based methods courses from content courses by evaluating preservice teachers' self-efficacy before they enrolled in methods courses. The self-efficacy of the preservice teachers was first evaluated at the start and completion of content courses, which were taken in the first two years of the program, and then at the start and completion of methods courses, which were taken in the latter two years. The authors found no statistically significant increases in teaching self-efficacy from pretest to posttest for preservice teachers in content courses. When evaluating only those preservice teachers who started with very low scores, a statistically significant increase in self-efficacy was observed; however, the growth was less than two points and the practical significance was questioned. In contrast, the authors found statistically significant increases in teaching efficacy for all methods courses. Unfortunately, the authors did not follow the preservice teachers longitudinally from content through methods courses to evaluate self-efficacy growth over multiple semesters. Evaluation of the trajectory of self-efficacy over time could indicate a steady increase in growth, related to both content and methods courses that simply did not reach statistical significance until the end of the preservice teachers' educational program.

Because preservice teachers often report higher levels of self-efficacy than inservice teachers (Midgley, Anderman, & Hicks, 1995) and their self-efficacy for teaching tends to be more malleable (Hoy & Woolfolk, 1990), generalising the Morrell and Carroll results to inservice teachers is questionable. Nonetheless, considering these results in the context of Bandura's (1986) definition of efficacy as domain specific suggests that mathematics content courses may not positively influence teachers' efficacy. If this is the case, then teachers entering professional development with differing levels of mathematics knowledge might also enter with differing levels of teachers' self-efficacy, which could influence their efficacy growth throughout the program.

To shed light on this issue, the present study investigated differences in the self-efficacy development of two groups, the first with more mathematical background and the second with less, in association with their participation in ongoing professional development. Coursework beyond algebra is typically not taught at the middle school level in the United States yet algebraic concepts are relevant at the middle level; therefore, teachers' completion of college algebra was used to divide the teachers into two groups. The self-efficacy of a cohort of middle level mathematics teachers engaged in the West Texas Middle School Math Partnership (WTMSMP), a multiyear professional development project funded by the National Science

Foundation, was measured at four time points across two years to understand if teaching self-efficacy develops in unique ways for teachers depending on their mathematical background.

The WTMSMP design is consistent with recommendations for extended time and duration of teacher development as well as collaboration (see Loucks-Horsely et al., 2010). Participants attend one three-week long course in each of three consecutive summers, participate in at least one WTMSMP scheduled day-long conference during each regular academic year, and interact with peers online using a social networking platform. The focus on deep conceptual understanding of mathematical content taught at the middle level is also tied to professional development recommendations as well as the WTMSMP emphasis on active learning. Because deep conceptual understanding of mathematics can be defined in multiple ways, the project developers selected Hill, Schilling, & Ball (2004) construct of mathematics knowledge for teaching as their focus. Therefore, courses were supplemented with pedagogical discussion. Because the WTMSMP is only starting its third year, the present findings are based on data collected during years one and two.

To determine the extent to which teachers with more or less mathematical backgrounds have unique self-efficacy development over time, parallelism, equality of means, and flatness are investigated. The specific research questions include the following:

- Do the two groups of teachers have the same pattern of gains in teaching self-efficacy associated with WTMSMP professional development? (parallelism)
- Does one group of teachers, on average, have higher scores on teaching self-efficacy measures than the other after participating in WTMSMP professional development? (equality of means)
- Did the participants' self-efficacy increase throughout their participation? (flatness)

The first research question addresses whether or not the profiles of teacher self-efficacy growth was the same (or parallel) for the two groups; the second addresses whether or not the overall self efficacy means (or equality of means) were the same between the two groups; and the third addresses whether the overall profile of self-efficacy was flat (or flatness) to indicate no growth.

Method

Context and Participants

Participants were teachers completing the West Texas Middle School Math Partnership (WTMSMP) project. A core component of the WTMSMP project is the development of graduate level mathematics courses delivered during the summers for selected middle school mathematics teachers across three education service centre regions in the State of Texas. Each course covers, in depth, a particular mathematics topic (e.g., algebraic structure, measurement, probability) taught in 5th, 6th, 7th, and 8th grade and is offered at four different institutions of higher education that are fairly evenly distributed across 84,000 square miles of southwest Texas. Participants are able to attend the course at the institution closest to their home and, thus, with other middle level mathematics teachers who either teach at their school or in their area.

Sixty-five middle level mathematics teachers volunteered after receiving flyers about the project and were selected to participate in the WTMSMP. Of the original 65 participants, 83.1% were women (n=54) and 15.4% were men (n=10). One person failed to report his/her gender. Participants reported an average of 10.46 years of teaching experience; however the standard

deviation of 7.35 indicated a wide range of experience. For example, one individual reported teaching less than one year, whereas another reported teaching 32 years. Participants reported teaching in the subject area of mathematics for an average of 9.26 years ($SD=6.59$), again widely spread with a minimum report of 0 years and a maximum report of 27 years. At the start of the second year course (summer 2010), 3 participants left the project. A fourth participant withdrew prior to the completion of the second course. Due to some participants' submission of incomplete measures at certain time points, the data analyses included 58 participants.

Participants were divided into two groups based on whether or not they had taken coursework beyond college algebra, a course that typically includes the study of inequalities, determinants, theory of equations, binomial theorem, progressions, and mathematical induction. Mathematical background was determined in year 1 by asking participants to identify mathematics courses of a certain type taken in college (e.g., college algebra, calculus, trigonometry, statistics, analytic geometry, linear algebra, differential equations). An average total sum of 3.63 ($SD = 2.50$) courses was calculated, with a minimum of 0 and maximum of 8. Group 1 ($n = 15$) was comprised of those who had taken only college algebra or no mathematics courses beyond those with a pedagogical focus. Teachers in group 1 reported an average of 13.20 years ($SD = 8.83$) teaching and 10.73 years ($SD = 7.48$) teaching mathematics. Group 2 ($n = 43$) was comprised of those who had taken college mathematics courses in addition to algebra. Teachers in group 2 reported an average of 9.36 years ($SD = 6.12$) teaching and 8.73 years ($SD = 5.72$) teaching mathematics. No statistically significant differences were found for overall years teaching or years teaching mathematics between the two groups. A statistically significant difference was found between the group's self-efficacy for WTMSMP math content, with teachers with more mathematics background reporting greater levels of confidence in being able to solve WTMSMP related mathematics problems ($t(56) = -2.10, p = .04$).

Instruments

Mathematics Knowledge for Teaching

The Mathematical Knowledge for Teaching (MKT) scales developed for the Study of Instructional Improvement (SII) and Learning Mathematics for Teaching (LMT) projects located at the University of Michigan were administered to assess teachers' mathematics knowledge for teaching at the start of their professional development participation in the WTMSMP. The MKT items were developed from interview data and ongoing feedback from public school teachers and university level mathematicians. The measures assess knowledge for teaching Number Concepts and Operations, Algebra, and Geometry (Hill, Schilling, & Ball, 2004; Schilling & Hill, 2007). Released items can be retrieved from the test developers' website at http://sitemaker.umich.edu/lmt/files/LMT_sample_items.pdf.

To evaluate validity associated with MKT scores, studies included cognitive interviews (Hill, Dean, & Goffney, 2007), unidimensional and multidimensional Item Response Theory (IRT) mapping (Schilling, 2007) and associations between the MKT scales and student outcomes as well as mathematics instruction (Hill, Ball, Blunk, Goffney, & Rowan 2007). Although structural evidence that supports differentiation between the mathematics knowledge specific to teachers and common mathematics knowledge is lacking (Schilling, Blunk, & Hill, 2007), higher teacher MKT scores have been found to be positively related to higher-quality mathematics instruction (Hill et al., 2007) and gains in student learning (Hill et al., 2005).

The reader should note that the MKT tests include items that range from easy to difficult in level, with the expectation that difficult items will be answered correctly by only a small number of test takers. Thus, an IRT score of 0 indicates that a participant solved about 50% of the problems correctly; however, a score of 0 does not necessarily indicate that the participant scored in the average range as the test is not norm referenced. The results only provide information concerning how well participants performed on the present administrations of the MKT. The IRT scores for the Number Concepts and Operations, Algebra, and Geometry tests were totaled to provide an initial estimate of participants' mathematical knowledge for teaching.

Teachers' Self-Efficacy

The 24-item Teachers' Sense of Efficacy Scale or TSES (Tschannen-Moran & Woolfolk-Hoy, 2001) was used to assess teachers' self-efficacy at four time points during their two-summer participation in WTMSMP professional development. In comparison to other measures of teaching self-efficacy, the TSES focuses on "both personal competence and an analysis of the task in terms of the resources and constraints in particular teaching contexts" (p. 2001). Furthermore, Tschannen-Moran and Woolfolk-Hoy posited that the TSES items tend to be more representative of actual tasks in which teachers regularly engage and strike a balance between being highly specific and highly general to encourage generalizability. Therefore, the TSES evaluates teachers' self-efficacy with a total score and three subscales; instruction, engagement, and classroom management. Teachers are asked to rate how much they can do to address specific student and classroom issues using a scale ranging from 1 or "nothing" to 9 or "a great deal." For example, the first item asks, "How much can you do to get through to the most difficult students" to assess engagement efficacy. The item, "How much can you use a variety of assessment strategies" is an example of an item assessing instruction efficacy. Finally, "How much can you do to control disruptive behavior in the classroom" assesses efficacy for classroom management.

Tschannen-Moran and Woolfolk-Hoy (2001) initially evaluated the validity and reliability of TSES using three independent samples, with the first two samples used in instrument development. Factor analysis of the third sample revealed support for the three subscales and the total score, and the internal consistency estimate for the 24-item instrument reached .94. More recently, Fives and Buehl (2010) found similar results in their analysis of the 24-item instrument's factor structure. They reported support for a three factor structure (i.e., instruction, engagement, and classroom management) and internal reliability estimates reaching .95. Internal reliability estimates for the present sample at each of the four time points ranged from $\alpha = .94$ to .97.

Procedure

Participants completed the TSES, which was emailed to participants and returned electronically upon completion, at four time points across the first two years of the project. The Mathematics Knowledge for Teaching (MKT) tests were also administered electronically but only the pretest was used to control for initial differences in the present study. The TSES was administered as pre- and post-testing for the two WTMSMP summer courses. That is, prior to the first WTMSMP course, participants completed the TSES and a version of the Mathematics Knowledge for Teaching (MKT) and subsequent to the WTMSMP course or three weeks later,

participants again completed the TSES. During the next summer, the TSES was administered using the same time interval as a pretest and posttest for the second course.

Analyses

Profile analyses were used to evaluate the parallelism, equality of levels, and flatness of profiles for participants' total TSES scores as well as each subscale (i.e., instruction, engagement, and classroom management) and conducted using SPSS 18. Participants with less mathematics background were included in one group ($n = 15$) and those with more were included in the second group ($n = 43$). Unequal samples sizes usually do not present problems for profile analysis as "each hypothesis is tested as if in a one-way design" and the present analysis included only one between-subjects independent variable (Tabachnick & Fidell, 2007, p. 315). Analyses for each measure were conducted with the scores of the four time points treated as multiple dependent variables. Profile analyses for each measure were also conducted twice; first without MKT as a covariate and second with initial MKT scores used as a covariate.

Results

A review of mean scores by group (see Tables 1 & 2) and preliminary independent measures *t*-tests for each efficacy measure across all time points (see Table 3) revealed increasing efficacy scores as well as statistically significant differences between the two groups at earlier time points. Participants who had less mathematics background started with significantly higher levels of teachers' self-efficacy measured by the total score ($t(56) = 3.40, p = .001$) as well as by each subscale; instruction ($t(56) = 2.39, p = .02$), engagement ($t(56) = 3.90, p < .001$), and classroom management ($t(56) = 2.50, p = .02$). Also of interest was the statistically significant difference between the MKT scores for the two groups ($t(56) = -3.56, p = .001$), which indicated that those participants who took more university mathematics courses scored higher on the MKT measures. Because participants' levels of MKT differed at the outset of the study and the influence of participants' mathematics knowledge for teaching on self-efficacy growth was of interest, profile analyses were conducted twice, with and without MKT scores used as a covariate in the profile analyses.

	Group 1				Group 2			
	Pretest		Posttest		Pretest		Posttest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Instructional practices	57.00	3.95	60.27	5.70	52.05	7.64	57.00	6.57
Student engagement	55.93	4.74	57.67	5.68	48.16	7.17	53.12	6.38
Classroom Management	62.87	6.90	63.53	6.27	57.19	7.81	58.79	7.21
Total score	175.80	13.52	181.47	14.97	157.40	19.31	168.91	17.25

Table 1: Group descriptive statistics in Year 1

	Group 1				Group 2			
	Pretest		Posttest		Pretest		Posttest	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Instructional practices	57.93	4.80	58.13	5.57	56.42	6.86	58.67	7.73
Student engagement	55.33	6.08	56.53	6.84	51.88	6.53	55.42	6.59
Classroom Management	63.27	5.85	62.93	6.17	59.07	7.85	60.91	7.86
Total score	176.53	13.84	177.6	16.84	167.37	17.31	175.00	20.30

Table 2: Group descriptive statistics in Year 2

		Year 1		Year 2	
		<i>t</i> -test	<i>p</i> value	<i>t</i> -test	<i>p</i> value
MKT	Pretest	-3.56	.001		
	Posttest				
Instructional practices	Pretest	2.39	.02	.79	.43
	Posttest	1.71	.09	-.25	.80
Student engagement	Pretest	3.90	<.01	1.79	.08
	Posttest	2.44	.02	.56	.58
Classroom Management	Pretest	2.50	.02	1.89	.06
	Posttest	2.26	.03	.90	.37
Total score	Pretest	3.40	<.01	1.85	.07
	Posttest	2.51	.02	.45	.66

Table 3: Independent sample *t*-test results

Teachers' Sense of Efficacy Scale

A profile analysis of the four TSES scores with MKT scores not included as a covariate revealed nonparallel profiles for the two groups of participants ($F = 2.76(3, 54)$, $p = .05$, partial $\eta^2 = .19$) to suggest that the two groups had different patterns of self-efficacy growth and at least one of the groups was not flat. Thus, a test of flatness was not necessary (see Tabachnick & Fidell 2007). A test of the equality of levels also indicated a statistically significant difference between the two groups' averaged TSES scores ($F = 5.95(1, 56)$, $p = .02$, partial $\eta^2 = .10$), with participants with less mathematics background reporting higher levels of teacher self-efficacy. A review of profile plots suggested the deviation from flatness was the result of linear growth. The

profile analysis of the four TSES scores with MKT scores as a covariate differed from the original analyses in only one aspect. The parallel profiles for the two groups of participants ($F = 1.89(3, 53)$, $p = .14$, partial $\eta^2 = .10$) suggested a similar pattern of growth over time (see Figure 1).

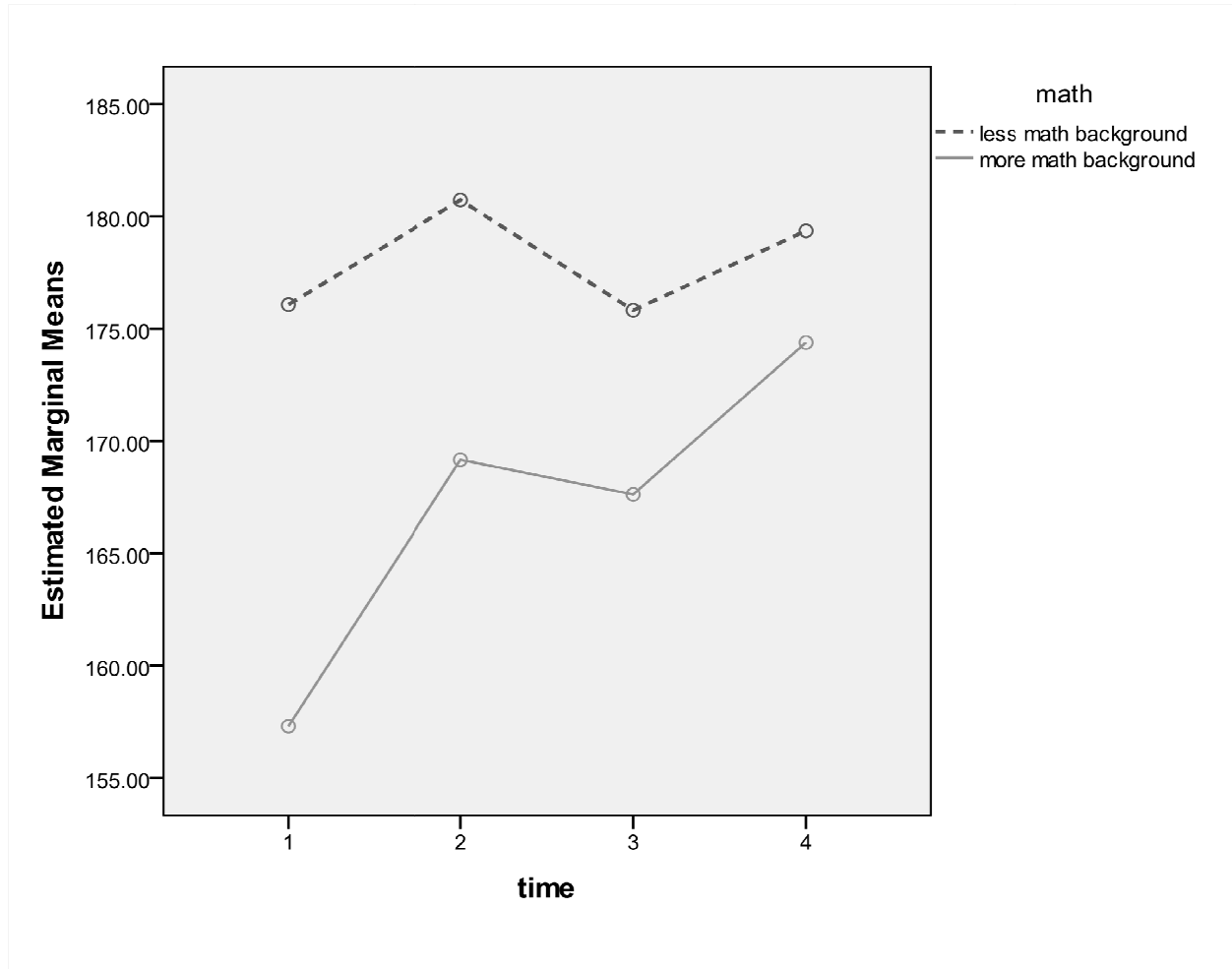


Figure 1: Teachers' Sense of Efficacy Scale (TSES) scores across the four time points with MKT as a covariate

Efficacy for Instruction, Efficacy for Engagement

Profile analyses of the four instruction subscale scores and the four engagement subscale scores revealed nonparallel profiles for the two groups of participants ($F = 2.74(3, 54)$, $p = .05$, partial $\eta^2 = .13$; $F = 2.77(3, 54)$, $p = .05$, partial $\eta^2 = .13$; respectively). The results suggest the two groups did not experience the same patterns of gains in efficacy for instruction or efficacy for engagement and at least one of the two groups was not flat. A test of the equality of levels, however, did not indicate a statistically significant difference between the two groups' averaged instruction subscale scores ($F = 1.85(1, 56)$, $p = .18$, partial $\eta^2 = .03$). A review of profile plots suggested linear growth. The test of equality of levels for engagement subscale scores did indicate a statistically significant difference between the two groups' averaged engagement

subscale scores ($F = 7.81(1, 56), p = .01, \text{partial } \eta^2 = .12$) with participants with less mathematics background reporting higher levels of engagement self-efficacy than those with more mathematics background. Profile analyses of the four instruction subscale scores and the four engagement subscale scores with initial MKT scores as a covariate revealed one difference. Parallel profiles for the two groups of participants was found ($F = .65(3, 53), p = .59, \text{partial } \eta^2 = .04$; $F = 1.25(3, 53), p = .30, \text{partial } \eta^2 = .07$; respectively; see Figures 2 and 3).

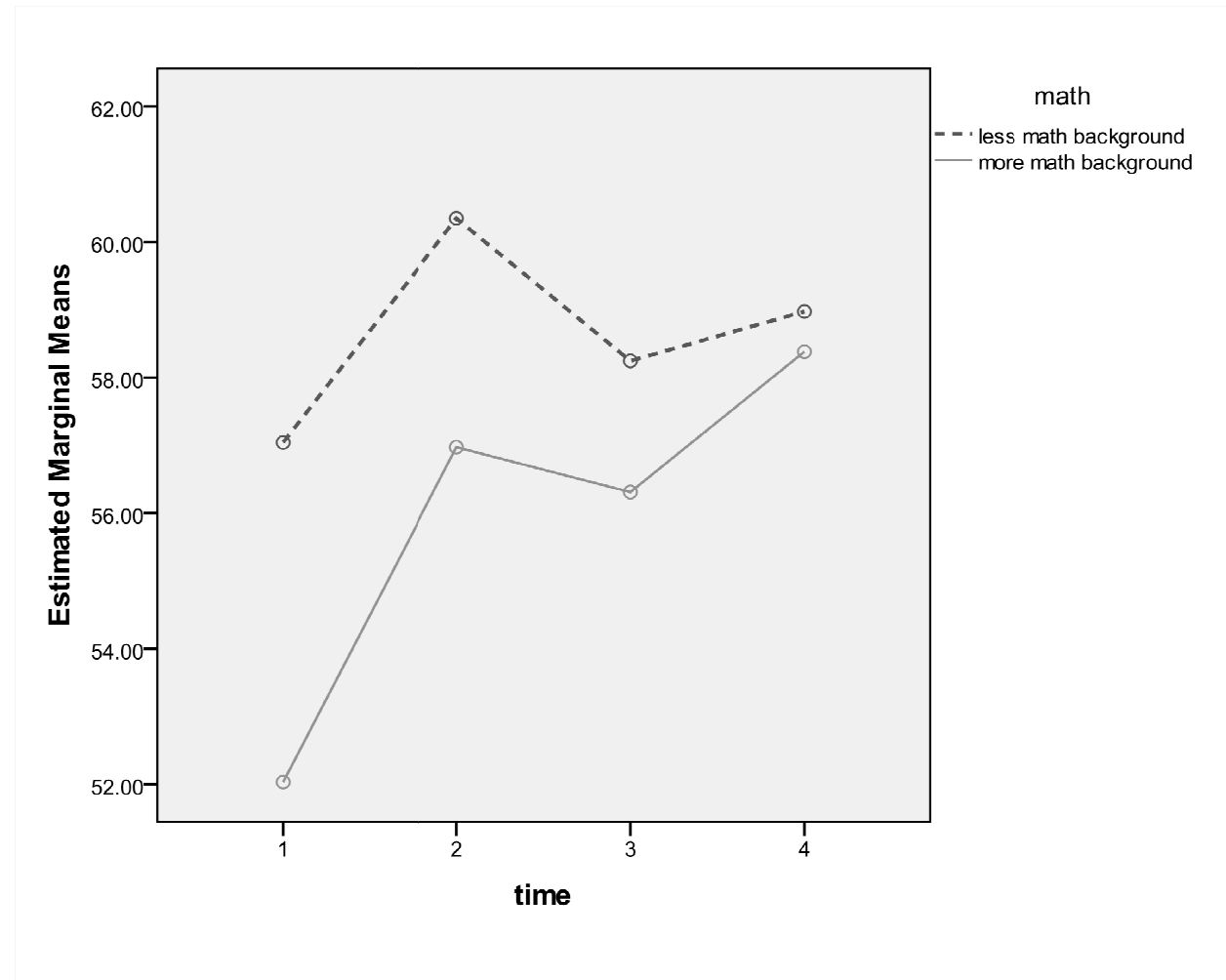


Figure 2: Instructional practices scores across the four time points with MKT as a covariate

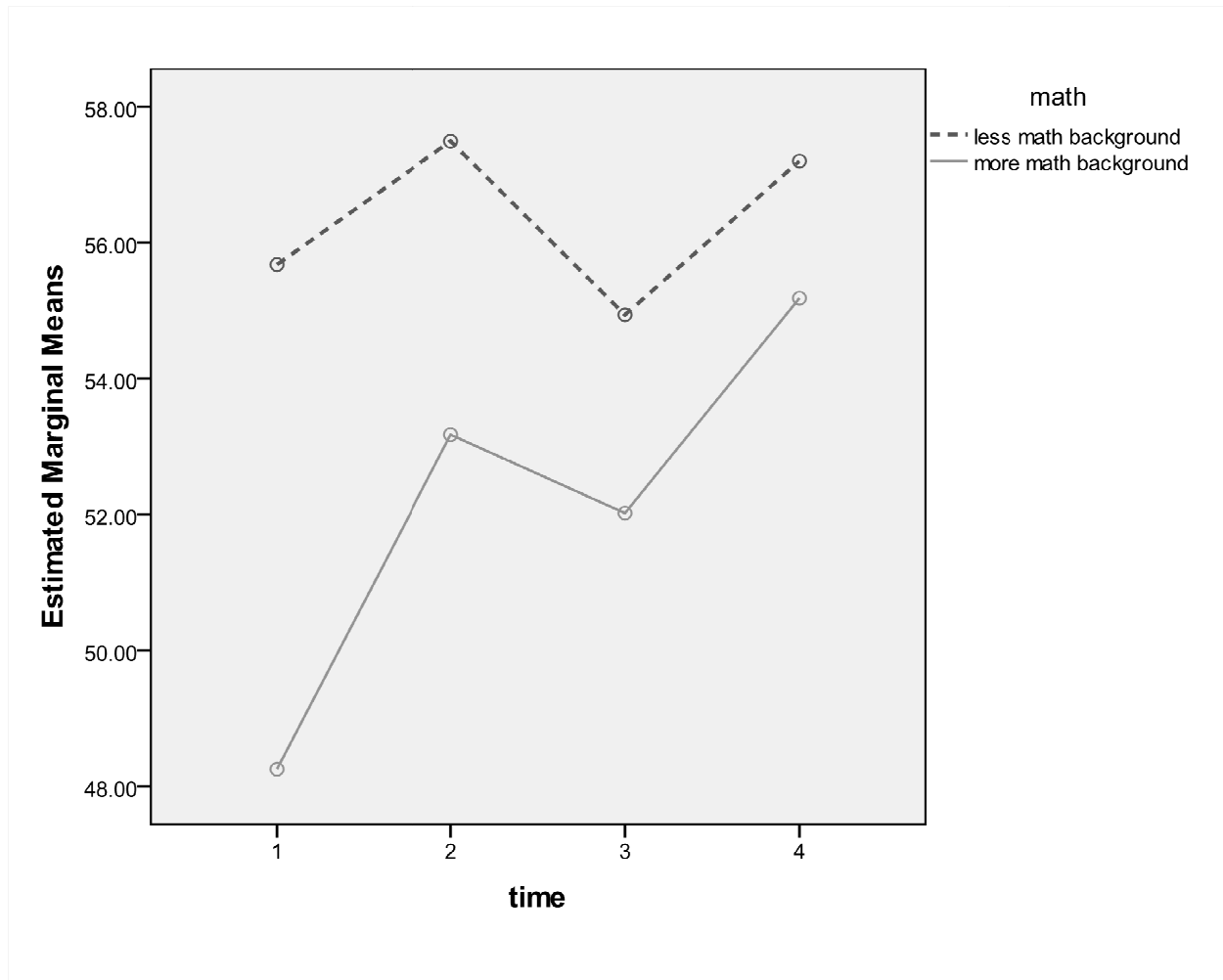


Figure 3: Student engagement scores across the four time points with MKT as a covariate

Efficacy for Classroom Management

A profile analysis of the four management subscale scores revealed parallel profiles for the two groups of participants ($F = 1.36(3, 54)$, $p = .26$, partial $\eta^2 = .07$) to suggest similar patterns of gains. However, a test of the equality of levels did indicate a statistically significant difference between the two groups' averaged management subscale scores ($F = 5.07(1, 56)$, $p = .03$, partial $\eta^2 = .08$) favoring the group with less mathematics background. When averaged over groups, the management subscale scores were not found to significantly deviate from flatness ($F = .93(3, 54)$, $p = .44$, partial $\eta^2 = .05$). One difference was found when profile analysis was conducted with initial MKT scores included as a covariate. A test of the equality of levels did not indicate a statistically significant difference between the two groups' averaged management subscale scores ($F = 3.71(1, 55)$, $p = .06$, partial $\eta^2 = .06$; see Figure 4).

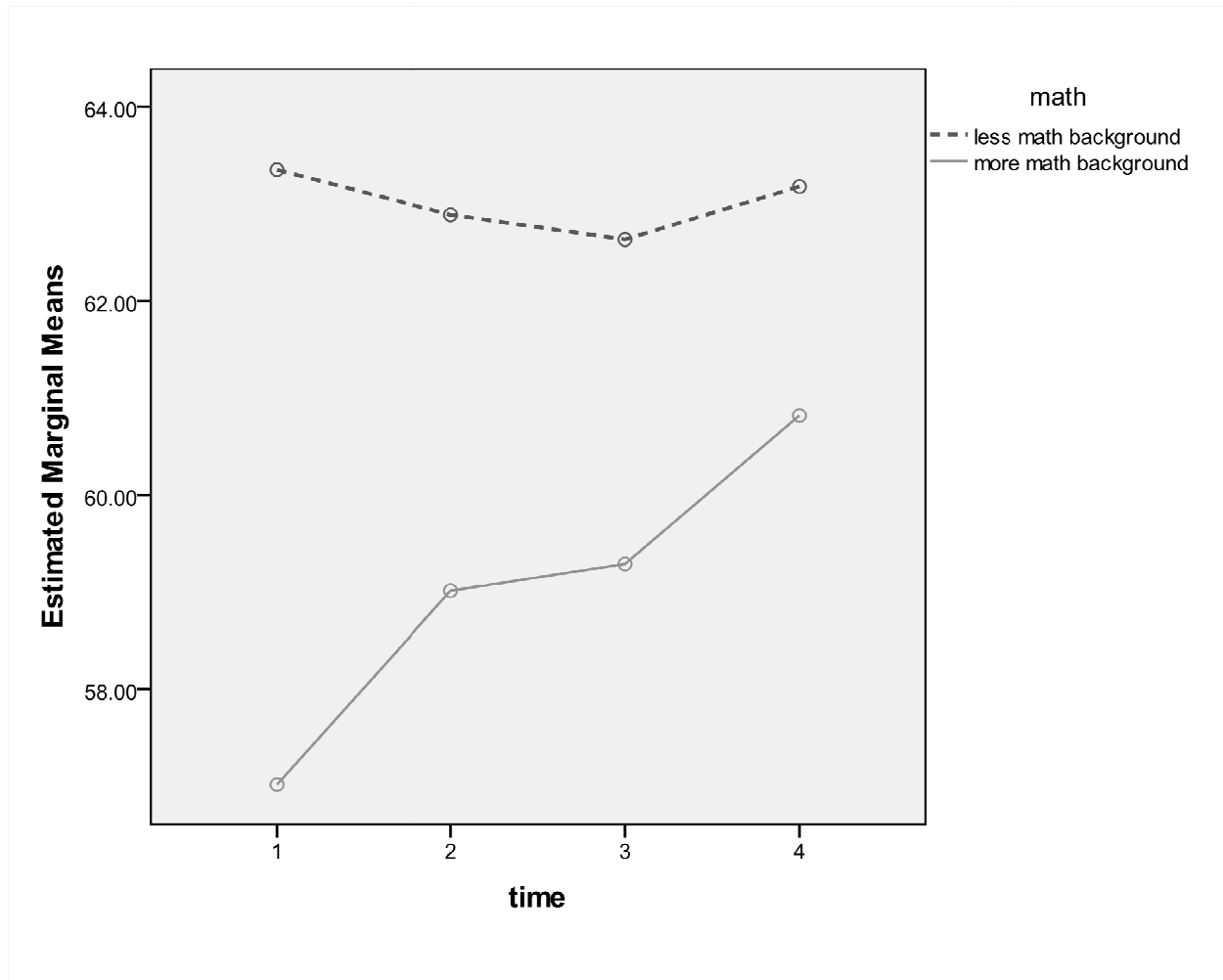


Figure 4. Classroom management scores across the four time points with MKT as a covariate

Discussion

Borko (2004) encouraged professional development researchers to investigate programs based on program adaptability to different grade levels or academic subjects. Because the mathematical background of teachers of the WTMSMP was quite variable despite all teachers being certified to teach at the middle school, the project developers questioned if teachers' math background would be related to how the teachers benefited from the project. The purpose of the present study was to investigate differences in teachers' self-efficacy development in response to participation in ongoing professional development between teachers with more and less mathematical background. Initial differences revealed teachers with more mathematics background scored higher on the MKT scales in comparison to those teachers with less. This finding is in contrast to the Ball et al. (2001) supposition that teachers who take more advanced mathematics classes might possess lower levels of MKT. Mathematics teaching at the university level typically does not lend itself to teaching in middle level classrooms, and greater exposure to this teaching would likely limit teachers' opportunity to observe effective teaching models. Although the relation between more mathematical background and higher MKT scores could be

specific to the present sample, teachers' knowledge of mathematics likely provides a strong foundation for MKT. Teachers with less mathematics background might also not have benefited from quality teaching models. Further investigation is needed to understand how MKT develops through teacher preparation. For the present study, profile analysis was conducted twice for each self-efficacy measure; first without MKT as a covariate and second with initial MKT scores as a covariate.

Initial differences in teachers' self-efficacy were also found, with teachers with less mathematics background scoring higher on all TSES measures in comparison to teachers with more mathematics background. The assumption could be made that because these teachers had taken pedagogical courses in place of mathematics and they therefore possessed better preparation for classroom practice. However, information concerning the number of pedagogical or methods courses taken by participants was not collected, and obtaining an understanding of how pedagogical coursework influences professional development was not the focus of the present study. For the present study, initial differences in teachers' self-efficacy were not controlled as the emphasis was on identifying and understanding the differences between the two groups of teachers, or, more specifically evaluating the self-efficacy profiles of the two groups to understand their growth over a two-year period of professional development involvement.

Do Teachers' with Different Levels of Mathematical Background Have the Same Pattern of Gains in Teaching Self-Efficacy associated with WTMSMP Professional Development?

Teachers with different mathematical background showed different patterns of self-efficacy gains as they participated in the WTMSMP professional development. The present results indicated nonparallel profiles across the TSES total scores as well as instruction and engagement measures without MKT scores included as a covariate but parallel profiles across measures when MKT scores were statistically controlled. Profile analysis of the efficacy for classroom management subscale yielded parallel groups regardless of the inclusion of the covariate. This was expected as the WTMSMP professional development courses do not include content specifically related to classroom management. Thus, the expectation was that both groups would have similar, flat profiles that indicate no growth for this measure.

Nonparallel profiles suggest that the self-efficacy of the two groups of teachers developed differently during the teachers' two-year participation in the WTMSMP. A review of profile plots for the self-efficacy measures with nonparallel profiles revealed greater overall growth in self-efficacy for teachers with more mathematics background in comparison to teachers with less. This greater growth was evident in that although the teachers with a stronger mathematics background started with significantly lower levels of self-efficacy than their peers, they made up the difference by the end of the second year of WTMSMP participation. In the case of self-efficacy for instruction, at the fourth time point teachers with more mathematics background reported higher levels of efficacy than did teachers with less mathematics background.

A review of the individual segments of profile plots revealed that both groups of teachers experienced some decline between the second and third time points. This period reflects the time between the first year posttest when teachers returned to their classrooms with the knowledge learned through the first professional development course and the second year pretest. Forgotten content as well as challenges in implementing and integrating new knowledge in a practical setting likely resulted in this self-efficacy decline, which has been observed in other longitudinal studies of teachers' self-efficacy (e.g., Authors 2009). At the fourth time point, teachers' self-efficacy rebounded to reach or exceed the initial growth observed at the second

time point. However, only the efficacy scores for teachers with more mathematics background exceeded their efficacy scores for time point two. The efficacy scores of teachers with less mathematics background rebounded at the fourth time point but they did not exceed the scores recorded at time point two.

The difference between the self-efficacy growth patterns of teachers depending on their mathematics background was observed with and without mathematics knowledge teaching (MKT) scores used as a covariate. However, the lack of statistical significance found for parallelism with MKT as a covariate indicates that by accounting for initial levels of teachers' mathematics knowledge for teaching the difference between the two group's patterns was not as pronounced and not beyond that expected by chance alone. Because teachers with more mathematics background had significantly higher initial levels of mathematics knowledge for teaching in comparison to teachers with less mathematics background, mathematics knowledge for teaching may possibly even out the growth in self-efficacy. Teachers with higher levels of MKT likely found implementing WTMSMP principles in their classrooms to be easier than those with lower levels, which could have facilitated their efficacy growth. Therefore, the difference in profiles might not have been due to the teachers' differences in mathematical background but due to their differences in MKT. When they return to their classrooms, teachers may use MKT to address the challenges of implementing and integrating WTMSMP into their teaching practices. According to Ball et al. (2005), mathematical content knowledge is only one element of successful teaching. Teachers must be able to translate this knowledge into student examples and models as well as draw from it to understand student errors and developing mathematical cognition. The investigation of how mathematics knowledge for teaching is related to self-efficacy over time should, therefore, be the focus of future research.

Does One Group of Teachers, On Average, Have Higher Scores on Teaching Self-Efficacy Measures than the Other After Participating in WTMSMP Professional Development?

Taking the average of the self-efficacy scores collected over time, differences between teachers with more mathematics background and those with less were observed for the Teachers' Sense of Self-Efficacy scores and the subscales for classroom management and engagement. These differences were present for the TSES and engagement subscale with and without MKT controlled. In the case of classroom management differences were found only without MKT controlled. Teachers with less mathematics background reported significantly higher levels of self-efficacy on each of these measures. These differences were present at the initial pretest. Because of preexisting differences and the correlational nature of the study's design, differences between teacher groups should not be attributed to participation in the WTMSMP. A review of independent measures *t*- tests revealed that significant differences in teachers' self-efficacy were not present at later time points, which indicates that the initial differences between groups diminished as participation in the WTMSMP continued. Therefore, the between group differences were most likely due to the preexisting differences observed in the earlier data collection points.

These findings indicate that teachers with less mathematical background were confident in their ability to succeed in their daily work. At least at the start of the project, these teachers reported greater confidence than teachers with more mathematical background in getting their students to do schoolwork well, helping students value learning, motivating students with low interest, and getting through to difficult students. Additionally, they reported greater confidence

in controlling disruptive classroom behavior and keeping classroom activities running smoothly. Although one could argue that a solid knowledge of mathematical content might allow teachers to focus more on student engagement and classroom management, the present findings suggest that the teachers with a stronger mathematics background may not have had the benefit of good models for such skills in their mathematics content courses. Also, if content courses replaced methods courses, these teachers may not have had the opportunity to study and develop these necessary teaching skills.

Interestingly, no statistically significant differences were found between the two groups of teachers on the self-efficacy for instruction subscale. Regardless of mathematical background, both groups of teachers perceived themselves as capable in implementing instructional strategies. That is, both groups of teachers reported they were confident they could provide alternative explanations to promote student understanding, respond to difficult questions from students, and use a variety of assessment strategies. These findings suggest that teachers who approach professional development activities with a stronger mathematical background may have the confidence that they can translate their mathematics knowledge into instructional strategies even though they may lack confidence in engaging and managing students. Designers of professional development for mathematics teachers should focus on the inclusion of activities that target both content and pedagogical issues with a balance depending upon the mathematical backgrounds of their participants.

Did the Participants' Self-Efficacy Increase Throughout Their Participation?

Because the profile analyses conducted with MKT as a covariate indicated parallel profiles, the investigation of the overall flatness was conducted to evaluate teachers' change in self-efficacy over time in relationship to teachers' involvement in the WTMSMP. Results revealed that even when accounting for teachers' mathematics knowledge for teaching, overall growth in self-efficacy was observed for all self-efficacy measures with the exception of classroom management, which was not the target of the present study. As teachers participated in the WTMSMP, their teaching self-efficacy increased. Without a comparison group, this finding cannot be directly attributed to teachers' WTMSMP participation; however, the association is promising and suggests the need to further investigate this relationship using experimental designs.

The presence of linear growth over time in the current study is particularly important as increases in self-efficacy scores are often limited by ceiling effects (Roberts, Henson, Tharp, & Moreno, 2001). That is, individuals who initially score high fail to show improvement in response to an intervention or, in the present case, in association with participation in the WTMSMP because their scores can grow only slightly or not at all. Although overall growth was observed, the differences found between the profiles of the two groups could be a result of the participants with less mathematics background scoring higher on the self-efficacy measures at the start of the study and, therefore, limited in their ability to score any higher despite possible increases in their beliefs.

The present study was further limited by its selection process. Because participants volunteered to attend the WTMSMP, which required a commitment of summer course attendance across three summers (only two were completed at the time of the current investigation), the present findings might not be generalizable for teachers who attend

professional development mandated by their school districts. The commitment required of the WTMSMP may have resulted in a sample of teachers without family obligations or teachers who were already confident in their teaching and content skills and ready to learn new content to facilitate their teaching.

Finally, allocating teachers into groups according to the number of college mathematics courses taken is a crude strategy that does not take into account what teachers actually know or how they incorporate this knowledge into their teaching. Even so, this method is an easily identified characteristic that can be used to determine the most appropriate professional development strategies for different groups of teachers. Without controlling for participants' mathematics knowledge for teaching, differences in self-efficacy growth patterns were observed between teachers with different levels of mathematical background. With MKT accounted for, overall differences remained between the two groups. Therefore, evidence is present to suggest that even as a general characteristic, designers of professional development could benefit from considering the mathematical background of participants based on the number of university mathematics courses taken. Of course, collecting estimates of teachers' mathematics knowledge for teaching in addition to their mathematical background would be an even better strategy; however, administering MKT measures at the start of professional development activities would not likely be practical or feasible.

Implications

Self-efficacy is domain specific (Bandura, 1986). Although the WTMSMP teacher participants with more mathematics background had higher levels of math self-efficacy, they had lower levels of teaching efficacy. According to Hill et al. (2005) simply understanding mathematics does not guarantee successful teaching, and the lower levels of teaching efficacy in teachers with more mathematics knowledge support this conclusion. Thus, professional development programs should be focused on participants' teaching self-efficacy, especially due to the association of self-efficacy with positive student outcomes (Anderson et al., 1988; Cannon & Scharmann, 1996; Ross, 1992; Ross et al., 2001) and actual classroom practice (Allinder, 1994; Ashton & Webb, 1986; Guskey, 1988; Stein & Wang, 1988).

Professional development programs for mathematics teachers are often called upon to develop teachers' conceptual knowledge for mathematics, and the WTMSMP is no exception. However, the focus on conceptual knowledge might overlook the needs of teachers who already possess mathematics knowledge but struggle with developing engaging instruction for their students. The WTMSMP focuses on conceptual mathematics knowledge but provides active learning experiences, ongoing interaction with both mathematicians and mathematics education faculty, and a longitudinal design that allows teachers to return to WTMSMP coursework after implementing course content into their classrooms. For example, participants identified common student misperceptions about specific mathematics content and shared their responses in small groups during the first year of the project. Project faculty used these student misperceptions to develop course content for the second course. When participants received this instruction, they had already returned to their classrooms and implemented what they had learned from the first year experience of sharing ideas with peers. During the second course, teachers were able to therefore reflect upon their first year experiences and receive feedback from faculty and peers. Although no school-level structure was in place to support teacher development, the WTMSMP

provided a supportive environment to reorganize ideas and make adjustments for the coming school year. The present results cannot confirm the supposition that this design allows all participant teachers regardless of mathematics knowledge to develop their teaching efficacy but they do support it.

Borko (2004) clearly outlined the directions that future researchers should take in research concerning professional development but noted that her recommendations are not comprehensive. For example, she discussed investigating how professional development programs can be adapted for use across grade levels and domains while maintaining the fidelity of implementation. The present study supports that these investigations should also include how professional development is experienced by teachers with certain background characteristics.

In conclusion, regardless of teachers' mathematical background, their self-efficacy developed as they participated in WTMSMP professional developmental activities. The two groups of teachers did have different characteristics that could have influenced the way they approached professional development. Although teachers with more mathematics background displayed higher levels of mathematics knowledge for teaching when compared to teachers with less mathematics background, they initially reported lower levels of teaching self-efficacy. Because they started with lower self-efficacy, teachers with more mathematics had the opportunity for greater gains, which was evident in review of the group's profile analysis. Teachers with different characteristics have different needs when they enter professional development. Knowledge of these differences can help improve professional development activities to ensure the greatest benefit for all teachers.

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