

Perceived Changes in Teachers' Knowledge and Practice: The Impact on Classroom Teachers from Leader Participation in Whole-School Reform of Mathematics Teaching and Learning

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Thirty primary classroom teachers quantified perceived changes in their practice and knowledge attributed to their school leaders' participation in a six-day course focused on leaders designing and implementing a whole-school reform of mathematics teaching and learning, and the school-based professional learning that followed. The project and framework underpinning the reform are outlined, and the teachers' reported changes in pedagogical practices are described. Teachers identified many changes in pedagogy and growth in knowledge. Not surprisingly, changes in pedagogical practices were even greater for specialist mathematics teachers who had also participated in a separate six-day course.

Teachers' mathematical knowledge and instructional practice are keys in improving student outcomes (Artz & Armour-Thomas, 1999; Hill, Rowan, & Ball, 2005). Previous research has helped to describe the nuances of effective mathematics' teaching that facilitates learning for all students (Anthony & Walshaw, 2009; Clarke et al., 2002; Siraj, Taggart, Melhuish, Sammons, & Sylva, 2014). The instructional leadership of principals and other school leaders has also been shown to have an impact on teacher change and, ultimately, improvements in student learning (e.g., Hallinger & Leithwood, 1994; Leithwood, Louis, Anderson, & Wahlstrom, 2004; Robinson, Lloyd, & Rowe, 2008). In particular, Robinson et al. (2008) found a strong link between leaders' who promote and participate in teacher professional learning and improved student academic outcomes, and concluded that, "the more leaders focus their relationships, their work, and their learning on the core business of teaching and learning, the greater their influence on student outcomes" (p. 636). Leithwood, Harris, and Hopkins (2008) contended that "school leadership is second only to classroom teaching as an influence on pupil learning" (p. 27). However, leading and initiating school reform is complex and takes time (Desimone, 2002; Fullan & Steigelbauer, 1991).

Professional learning models take many forms, but Fullan (2001) suggested that "learning in the setting where you work, or learning in context, is the learning with the greatest payoff because it is more specific (customized to the situation) and because it is social (involves the group)" (p. 14). However, this can lead to models where key teachers in a school participate in professional learning with an expert in the field, and then attempt to replicate and apply the experience for colleagues at school. Notably, this "train-the-trainer" model has been reported to lead to variations in the quality of the professional development delivered to teachers and "shallow training experiences" (Watt, 2015, p. 87).

In this study, we aim to describe the impact on teacher and student learning associated with a professional learning program that prepared school leaders to support and initiate whole-school reform in mathematics teaching and learning. The school leaders became the professional learning providers for their teaching staff, with the benefit of teacher learning occurring in context and focused on impact for their own students. However, the quality of the professional learning for teachers was dependent on the capacity of their leaders to translate and reproduce the key messages and quality of the original professional learning.

The Interconnected Model of Teacher Professional Growth (IMTPG, Clarke & Hollingsworth, 2002; see Figure 1) built upon previous change models by adding more detail, distinguishing the processes of reflection and enactment, and broadening changes in student outcomes to include all aspects that teachers believe to be salient in their context.

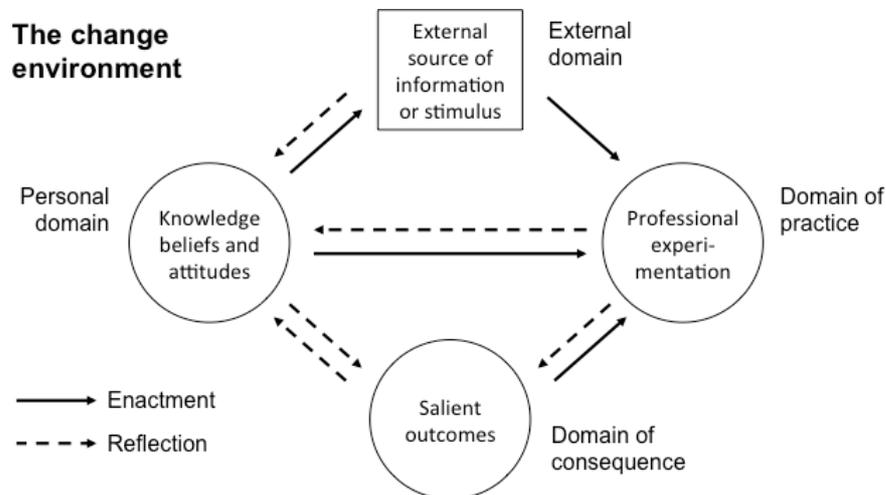


Figure 1. The Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002).

The IMTPG provided a framework for understanding the professional growth process in this study, with the external source of information or stimulus being the teachers' professional learning provided by their school leaders and the change in knowledge (and practice) being influenced by professional learning, professional experimentation, and salient outcomes. The professional experimentation was the opportunity for teachers to implement new or refined teaching strategies and assessments and the salient outcomes were the benefits they derived and valued from these influences.

Background to Leading Mathematics Learning and Teaching Course

From 2010 to 2017, all primary school leaders from four Catholic Dioceses in New South Wales have participated in a course aimed at developing their instructional leadership in mathematics so that they might implement a whole-school approach (Fullen, Hill, & Crévola, 2006) to improving mathematics learning for all. In each Diocese, this has been a system-wide and well supported initiative. The Leading Mathematics Learning and Teaching (LMLT) Course, developed by the second author, included six full days of professional learning spaced over a year, and targeted school leaders including principals and those staff with a mathematics or pedagogical leadership role.

The research cited earlier highlighted the positive impact of principals being instructional leaders, and participating in professional development alongside their staff in their own school context. These were key factors in deciding to engage leaders in the LMLT course rather than the classroom teachers. The participants' role was to consider insights from the research, scholarship, and experiences explored during the course, and then, as a leadership team, to design and implement an action plan that would initiate or extend positive changes to the teaching and learning of mathematics in their school. This required designing and delivering a program of contextualised teacher professional learning. The professional learning provided by leaders was often informed by, or replicated, aspects of the LMLT course. For example, all school leaders introduced the Mathematics Assessment

Interview (MAI) and associated growth point framework (Gervasoni et al., 2011) as an assessment tool, and designed and implemented professional learning so that all teachers could learn about and use this assessment tool. The LMLT course focused on the school leaders first learning about the MAI and growth point framework so that they could design and lead the associated teacher learning at their school. The course content also included: exploring the features of high quality learning environments; mathematics inclusion within a social justice framework; and effective pedagogical practices associated with whole number learning (e.g., Clarke et al., 2002; Siraj et al., 2014). It was anticipated that the learning activities, critique of research and scholarship, and professional discussion during the course, would inform the leaders' approaches to designing and implementing relevant professional learning for their school community and context.

All leaders introduced the MAI to their school to monitor all students' developing knowledge and strategies across four whole number domains (Counting, Place Value, Addition and Subtraction Strategies, and Multiplication and Division Strategies). Analysis of these assessment data was used to inform the school leaders' school action plan and the professional learning and support they would provide for their teachers.

Ultimately, the aim of the LMLT Course was to support school leaders to improve and sustain improvement in mathematics outcomes for all primary students in their school. In conjunction with strategies to support all students, each school employed a specialist teacher who had participated in the Extending Mathematical Understanding (EMU) Specialist Teacher course to support students who were identified as vulnerable in learning mathematics. These specialists were qualified to conduct the EMU intervention program (Gervasoni, 2004) for these students, who were identified as mathematically vulnerable and who may not fully benefit from the classroom mathematics program. The EMU specialist also had a role in supporting the professional learning of staff with leaders during the change process.

In this paper, we address the research question: What changes in professional knowledge and practice do classroom teachers attribute to the professional learning and support offered by their school leaders as a result of their leaders' participating in a six-day course focused on whole-school reform of mathematics teaching and learning?

Method

After two years of implementing the whole-school approach for the teaching and learning of mathematics, classroom teachers in 26 schools across two New South Wales Catholic Dioceses were invited to complete an online survey that addressed the effectiveness of the LMLT course and its impact on a whole-school approach for enhancing mathematics learning for all students. School leaders, EMU specialist teachers, classroom teachers, parents, and children completed the surveys in late 2016. In this paper, we focus on the results of two items from the classroom teacher survey that explored the impact on classroom teachers' mathematics teaching and knowledge.

Participants

Thirty teachers responded to the two survey questions. Their school leaders had participated in the LMLT course in 2015. Teaching experience ranged from 1 to 37 years, with a mean of 14.2 years, and a mean of 10.9 years in their present school. They taught mathematics on average 4.7 days per week and 5.5 hours per week, and taught a range of

year levels from the first year of school (Kindergarten) to Year 6, and some taught composite year levels (e.g., Year 1/2).

Online Survey Items

Previous surveys and discussions with teachers by researchers indicated that they felt that they had learned a great deal and their teaching of mathematics had changed. To explore this further, we posed the following two questions in an online survey:

1. We are interested in your perceptions of the *amount of change in your teaching practice* since you commenced professional learning aligned with [their whole-school] approach. Please indicate the extent to which these aspects were/are a part of *your* teaching of mathematics (*prior to* the implementation of [their whole-school reform] and *now*) using the scale below. [The scale was from 0 = Not at all and 10 = A great deal.]

2. We are interested in the extent to which the recent focus of mathematics in your school has contributed to a change in your knowledge about the teaching of mathematics. Please rate your understanding of this content (*prior to* the implementation of the [their whole-school reform] and *now*) using the scale below. [The scale was from 0 = No understanding and 10 = A thorough understanding.]

The statements in Tables 1 and 2 were developed as a reflection of the recommended aspects of pedagogy and knowledge that were addressed in the course with the exception of items l, m, and n, which we anticipated may have reduced as a result of the reform.

Data Analysis

Mean scores and standard deviations were calculated for each item, as was the change in means. Paired t-tests were performed to assess the statistical significance of the changes for each item. Statistical significance was set at 0.05 and all tests were two-sided.

Results

In Tables 1 and 2, we report the mean ratings from teachers of the stated practices and knowledge, before and during the reform, respectively and the associated change in means. In Table 1, *p* values for paired t-tests are given to indicate the statistical significance of the change. No *p* values are given in Table 2, as all changes were significant at the 0.05 level.

Change in Teachers' Instructional Practice

For teachers' instructional practice, the positive change of mean (see Table 1) varied from 0.6 to 2.9, indicating there was substantial variation between the amount of change for each activity across this group of teachers. Out of the 16 statements provided, the practice for which there was the greatest mean change (2.9) was (b) "I use open tasks in mathematics lessons." Other practices with considerable perceived change were (j) "I expect students to explain their thinking and reasoning" (2.0) and (i) "I allow wait time for students to think prior to answering questions" (1.9). These data may indicate that teachers initiated a greater use of discourse in mathematics lessons than was previously employed.

Table 1
Means, Standard Deviations, Changes in Means, and p values for Teacher Practice Ratings Prior to and During the Implementation of a Whole-School Reform

| Teacher instructional practices (<i>n</i> = 30) | Mean (SD) Prior to reform | Mean (SD) Now | Change of mean | <i>p</i> value |
|--|---------------------------------|---------------------|-------------------|----------------|
| a. I use assessment data to inform planning and teaching. | 7.0 (2.3) | 8.5 (1.5) | 1.5 | <0.001 |
| b. I use open tasks in maths lessons. | 5.2 (1.7) | 8.1 (1.2) | 2.9 | <0.001 |
| c. I use concrete materials to assist students' learning. | 7.5 (1.9) | 9.0 (1.2) | 1.5 | <0.001 |
| d. I'm enthusiastic about teaching maths. | 7.1 (2.3) | 8.1 (1.7) | 1.0 | 0.015 |
| e. I plan collaboratively. | 7.2 (2.4) | 8.0 (2.3) | 0.8 | 0.001 |
| f. I discuss my successes and challenges about my maths teaching with others. | 7.1 (1.9) | 8.3 (1.3) | 1.2 | <0.001 |
| g. I address individual learning needs. | 7.0 (1.7) | 8.3 (1.1) | 1.3 | <0.001 |
| h. I do professional reading about the teaching and learning of mathematics. | 5.6 (2.0) | 6.9 (1.6) | 1.3 | <0.001 |
| i. I allow wait time for students to think prior to them answering questions | 6.5 (2.4) | 8.4 (1.4) | 1.9 | <0.001 |
| j. I expect students to explain their thinking and reasoning. | 6.7 (2.3) | 8.7 (1.5) | 2.0 | <0.001 |
| k. I use questioning to support students' learning and promote thinking. | 7.0 (1.9) | 8.5 (1.3) | 1.5 | <0.001 |
| l. I use assessment data to group students into like ability groups. | 7.2 (1.9) | 8.3 (1.8) | 1.1 | 0.002 |
| m. I provide opportunities for students to learn and practise formal written algorithms. | 7.1 (1.6) | 6.8 (2.5) | -0.3 | 0.463 |
| n. I use worksheets in mathematics lessons. | 6.1 (2.1) | 4.4 (2.3) | -1.7 | <0.001 |
| o. I prepare enabling and extending prompts before the lesson begins. | 5.8 (1.9) | 6.4 (2.5) | 0.6 | 0.032 |
| p. I spend time talking to individuals about their thinking and understanding. | 6.5 (1.6) | 8.0 (1.6) | 1.5 | <0.001 |

Only two statements revealed perceptions of negative change. These were (n) “I use worksheets in mathematics lesson” (-1.7) and (m) “I provide opportunities for my students to learn and practise formal written algorithms” (-0.3). This may suggest that teachers now implemented less of the “drill and practice” that might be associated with more traditional mathematics teaching. However, the change in item m was not statistically significant. While nine teachers had a reduced rate for (m), 11 teachers indicated their practice had not changed. The mean score for these 11 teachers was 7.5, which might suggest learning and practising formal written algorithms was, and still is, a common practice for these teachers. Also, 10 teachers indicated an increased rate, suggesting that this practice was occurring more often. The highest mean response for an item at the time of completing the survey was for item (c) “I use concrete materials to assist students’ learning” (9.0). However, this item also had the highest mean response (7.5) prior to the reform, indicating that for some teachers, this may have been a well-established practice prior to the reform.

Change in Teachers’ Knowledge for Teaching Mathematics

The teachers were also asked to rate their professional knowledge in relation to certain statements both prior to the reform process, and at the time of completing the survey. While we cannot be sure of the basis of teacher judgements about the extent to which their knowledge had changed, they clearly indicated that their knowledge had increased, and in all cases these changes were statistically significant (Table 2).

Table 2

Means, Standard Deviations, and Changes in Means for Teacher and EMU Specialist Knowledge Ratings Prior to and During the Implementation of a Whole-School Reform

| Teacher knowledge (T) (<i>n</i> = 30) EMU specialist knowledge (ES) (<i>n</i> = 13) | | Mean (SD) Prior | Mean (SD) Now | Mean change (<i>n</i> = 30) |
|--|----|--------------------|------------------|---------------------------------|
| a. Knowledge of the key steps that describe children’s progress in whole number learning | T | 5.7 (1.7) | 7.6 (1.4) | 1.9 |
| | ES | 4.3 (1.7) | 8.2 (0.7) | 3.9 |
| b. Knowledge of students’ mathematical understandings/abilities | T | 6.4 (1.4) | 8.1 (1.2) | 1.7 |
| | ES | 4.9 (1.8) | 8.2 (0.7) | 3.3 |
| c. Knowledge of appropriate questions to extend mathematical understanding | T | 5.9 (1.4) | 7.7 (1.4) | 1.8 |
| | ES | 4.0 (1.6) | 8.5 (0.8) | 4.5 |
| d. Knowledge of features of high quality tasks | T | 5.8 (1.6) | 7.5 (1.6) | 1.7 |
| | ES | 4.8 (1.9) | 8.3 (0.6) | 3.5 |
| e. Knowledge of common misconceptions or difficulties in mathematics learning | T | 5.7 (1.6) | 7.0 (1.9) | 1.3 |
| | ES | 4.4 (1.9) | 8.2 (0.9) | 3.8 |
| f. Knowledge of students’ mental and invented calculating strategies | T | 6.4 (1.8) | 7.7 (1.4) | 1.3 |
| | ES | 4.5 (1.5) | 7.8 (0.6) | 3.3 |

We also compared their responses to those of the EMU specialists who were from the same cohort of schools as the teachers. The EMU specialists had participated in a six-day course focusing on effective teaching strategies for students who are vulnerable in learning mathematics. These specialists also conducted an intervention program for young students (aged 5-7) during the year while participating in the course, allowing them substantial opportunity to refine and implement new pedagogies and understandings.

The mean change in scores for the EMU specialists was just over double the mean change for classroom teachers' for the same set of statements. This is not surprising given their extensive professional learning opportunities when compared with the classroom teachers. The difference in reported change of knowledge between these two groups may provide some evidence that the teachers were rating the extent of their knowledge in a thoughtful way.

Conclusion

In this study, teachers' responses to survey items suggest that aspects of their practice and knowledge for teaching mathematics changed as a result of their schools' implementation of a whole-school reform for the teaching and learning of mathematics that was initiated through their school leaders participating in the LMLT Course. In some cases, this reflected an increased use of a particular practice; in others, a decrease. The amount of change varied across aspects of practice and knowledge. Classroom teachers' self-reported change of knowledge was on average less than that of the intervention specialist teachers who had experienced substantially more professional learning directly with an expert.

With respect to the IMTPG model, changes in the Personal Domain (knowledge) and the Domain of Practice (instructional practice) were initially influenced by the External Domain (the professional learning). Through enactment and reflection, it appears that changes in teachers' knowledge may have been influenced by outcomes which they regarded as salient, such as student opportunities to reveal their understanding. For example, consider those perceived changes in practice that were reported as greatest, such as the use of open tasks (item b) and expecting students to explain their thinking and reasoning (item j). Both practices enable students to demonstrate to the teacher what they knew and could do, and were reflected in the considerable change identified in their response to item b in Table 2.

Financial and organisational issues often drive the decision to provide external professional learning for a select group of teachers as compared to all school staff. Our findings suggest that the leaders were able to implement professional learning that led to important changes in teachers' practices. However, perceived change was greatest for the specialist teachers who participated in professional learning at its original source.

Overall, there are features of this professional learning approach that appear to contribute to developing and sustaining teacher capacity to enhance student learning. These include:

- Principals and other leaders participating in the professional learning (Robinson et al., 2008).
- Professional learning for classroom teachers was situated in their own school and classroom contexts (Elmore, 2004; Stoll, 1999).
- Data-based decision-making was utilised to inform the school action plan. This has been shown elsewhere to improve the quality of teacher instruction and therefore student performance (van Geel, Keuning, Visscher, & Fox, 2016).

Further analysis of the survey data and future focused case studies will enable the project team to determine the impact of the professional learning for leaders, specialist teachers, and children, and make recommendations for those creating school reforms in mathematics that includes building school leaders' capacity to support teachers' professional learning.

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