RESEARCH PAPER

Preparing Job-embedded Primary Mathematics Specialists to Lead in Australian Schools

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The description *primary mathematics specialist* has become more frequently used in Australia in the past 10 years, suggesting sustained interest in deepening teacher expertise. Despite this, there is limited contextual research about how to prepare in-service teachers for such roles, and the organising structures needed to facilitate their progress. This paper describes background and emerging insights from a project offering sustained and supported learning experiences for in-service teachers to become primary mathematics specialist teachers in and across their school. Curriculum and contextual experiences designed around a theoretical framework of leadership development implemented over 2 years are described. Early insights include the *priming* influence of an extended focus on mathematical content and pedagogical knowledge on participants' confidence to lead others, and the benefits of being explicit about enabling structures that promote sustainable growth and change.

Literature and Research Problem

Increased mathematical content and pedagogical expectations of primary teachers and student mathematical performance challenges regularly appear in the national educational system narrative. A range of strategies have been trialled to address these issues, including the concept of specialisation or subject expertise in mathematics. For example, in 2010, participation in a new government-funded Primary Mathematics Science Specialist (PMSS) project was offered to Victorian schools with low NAPLAN results. This project has been sustained but with no publicly available research literature on how its implementation impacts individual teachers, their schools, and communities. In 2015, the Australian Institute of Teaching and School Leadership (AITSL) introduced primary teacher subject specialisation mandates for all initial teacher education courses. Priority was given to mathematics, science, and languages. In 2016, NSW government ministers proposed primary mathematics specialisation for in-service teachers to address declining student performance in this subject. Delays have meant that mathematics specialist preparation in NSW is in its early stages.

Developing individual teacher subject expertise across all Australian primary schools is a system challenge that borders on unrealistic. It may be helpful then, to look at the experiences of other countries who recognised the need decades ago to prepare in-service mathematics specialists to support their primary colleagues via "job-embedded professional development" (Nickerson, 2010, p. 54). More than 40 years ago, the National Council of Teachers of Mathematics (USA) board of directors recommended that state certification agencies offer teaching credentials for primary teachers that include mathematics specialist endorsements. The importance of mathematics teacher leadership and specialisation in the US was raised regularly in the following decades, echoed by calls for research into the impact of mathematics specialists on teacher practices and student achievement (Dossey, 1984; National Research Council, 1989; Reys & Fennel, 2003). The continued focus on the potential of this role led to the development of *Standards for Elementary Mathematics Specialists* in 2010, outlining standards for credentialing and degree programs (Association of Mathematics Teachers Educators, AMTE). These programs focus on content, pedagogical content, and leadership knowledge, and involve at least 24 semester hours and a supervised practicum. The US research agenda of primary mathematics specialisation and its impact on teacher and student learning

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continues to grow, with prompts for further international research on specialists as "hidden players in professional development" (Hjalmarson & Baker, 2020, p. 51).

Literature on effective professional learning emphasises a concurrent focus on content, duration, coherence, collective participation, and active learning to promote teacher growth and change (Desimone, 2009). In the mathematics education literature, this includes a focus on issues central to instruction, the promotion of "high-leverage practices" (Cobb et al., 2018, p. 71) and sustained support of two to three years (Sztajn et al., 2017). The intention to prepare primary mathematics specialists is present in Australia but there is limited education system and research literature on which to build this initiative. Recent research in Australia related to preparing teachers and leaders to generate whole school reform of mathematics teaching and learning has focused on the perceptions of mathematics leaders' successes and challenges (Sexton & Downton, 2014), principals' views about the preparation of primary pre-service teachers with a mathematics specialisation (McMaster et al., 2018), the nature of the school mathematics leader role (Driscoll, 2017), and changes in knowledge and beliefs of teachers attending short (6 days) and continuous professional learning (Roche & Gervasoni, 2017). These studies varied in their approach and emphasis, not yet providing a clear picture of how to prepare and support specialisation in Australian primary schools. The most recent research in Australia related to mathematics specialisation offers the concept of a "learning architecture" (Burrows et al., 2020, p. 1), the design and implementation of which can be effective or inhibitive in promoting deep and enduring mathematics professional learning in a school. As mentioned previously, however, there is no supporting research evidence to explicate its application.

It is acknowledged that no single strategy will support instructional improvement for large numbers of teachers, a broad perspective from the classroom to system coordinators is needed (Cobb et al., 2018). Embedded in this perspective are questions about how to prepare job-embedded change agents like mathematics specialists, and the possible structures through which they can learn to lead. If the proposal to prepare mathematics specialists is to progress as a national initiative to address the challenges of teaching and learning mathematics, it is reasonable to ask: are there innovative approaches that build the capacity of in-service teachers to fulfil such roles, and can the theoretical underpinning of these initiatives be used to generate a coherent model for change?

Methodology

The major research question for this study is:

> *How does implementing an innovative specialist expertise approach provide stimulus for teacher professional learning?*

The theoretical perspective rests within an interpretive design and case study methodology as it is concerned with gaining insight into the lived experiences of the participants, and their school context (Merriam, 1998). Case study methodology provided a systematic way of exploring themes through the collection and analysis of the multiple forms of data, including questionnaires, documents, observations, and semi-structured interviews. The tension of qualitative and quantitative data generation was managed, providing a clearer picture of how a teacher's mathematical and leadership knowledge had been impacted. The author was a curriculum designer, regular presenter as well as participating mathematics specialist. Being participant-observer and primary instrument for collection and analysis, opportunities for gathering meaningful data were maximised (Creswell, 2008). Systematic research procedures were maintained, and all participants were informed of the researcher's status.

The Primary Mathematics Specialist Initiative (PMSI)

An unrealised commitment by the NSW Department of Education in their 2016–2020 strategy to recruit primary mathematics specialist teachers was the stimulus for the author starting the Primary Mathematics Specialist Initiative (PMSI) in 2020. The first cohort (2020–2021) finished their 2-year project, and the next cohort (2021–2022) are in their second year. Initiated, developed, and implemented in 13 schools across Sydney, the long-term goal is to build the capacity of in-service teachers to lead the teaching and learning of mathematics across their school. The structure of PMSI is based on the "learning architecture" (Burrows et al., 2020, p. 1) of the PMSS run by the Victorian Department of Education and Training. This structure, appropriately adapted, was adopted as the theoretical framework of the project and the study presented (see Figure 1).

The three main areas of focus of the PMSI theoretical framework are *understanding and leading self*, *working with and influencing others*, and *being catalysts for change*. The first suggests mathematics specialist (MS) professional learning should involve building curricular and pedagogical capability. Increasing the confidence of the MS provides a basis for the development of collaborative practices, and finally whole-school change. Enabling structures in the original PMSS (Victoria) model included *slowing down to go deeper* and *cultivating professional discernment*, ensuring the deliberate scaffolding of time to reflect, analyse, discuss, and apply new learning.

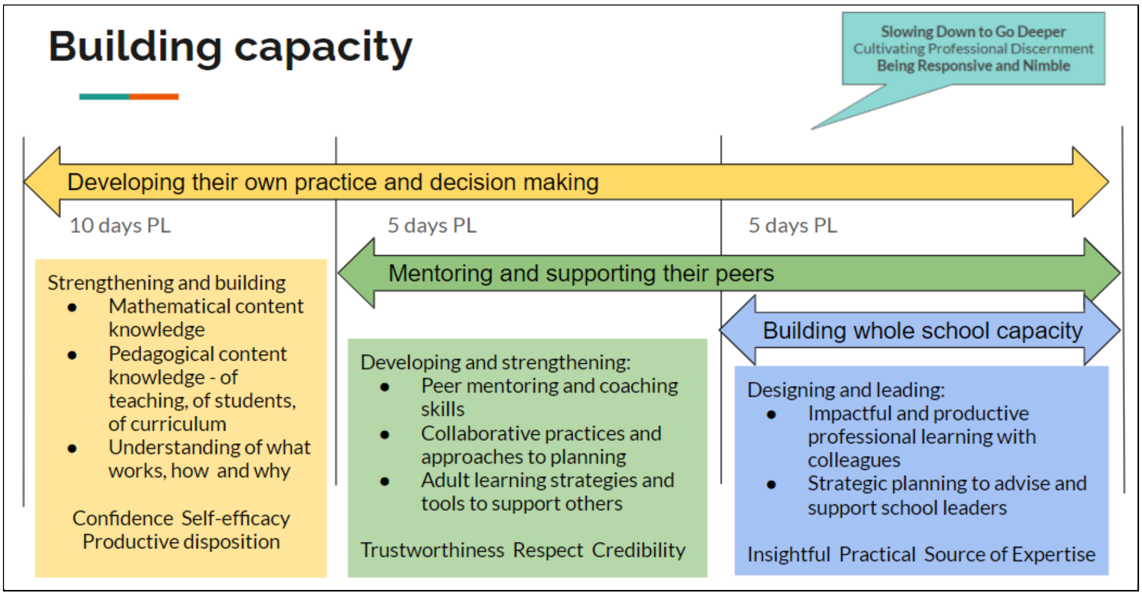

Figure 1. Primary Mathematics Specialists Initiative Learning Architecture (adapted from Burrows et al., 2020).

Adaptations of the theoretical framework for this project included an extension of time for the *understanding and leading self* phase, i.e., from February to December, rather than February to August. This change was informed by research related to the *intensity* of professional learning, including the number of hours and length of time of professional learning, as well as the volume of information addressed (Kennedy, 2016). Such intensity appears to be more effective in promoting teacher learning when the professional learning is aimed at developing teachers' insights into enacting new ideas. Following this line of thinking, it was conjectured that the longer the participating teachers had to trial and reflect on content and pedagogical content knowledge offered in PMSI's first phase, the greater the potential for growth and change. The second adaptation was the addition of a third enabling structure, *being* *responsive and nimble* to reflect the flexible, approachable, and receptive nature needed in such leadership positions.

Launched and facilitated by the author, PMSI started with a pilot group of six primary schools, and 12 teachers. The 2021 intake grew based on positive recommendations from the first group of schools, taking the full project to 14 (one withdrew owing to funding changes). For definitional clarity in this study, the intended role of a primary mathematics specialist is a generalist primary teacher who has specialised knowledge of teaching and learning mathematics, and leading colleagues. They work with students and teachers, team teach with other generalist teachers, and lead whole school reform in mathematics. In this, they may be considered a combination of the disciplinary expert teacher model terms such as Instructional Coach and Generalist Teacher with a Specialisation (Mills et al., 2020).

The PMSI curriculum reflects the overlapping emphasis of each phase of the theoretical framework. There were at least 20 days of professional learning in sequence blocks of two and three days over two school years. Between each of the learning sequences, school-based Applied Learning tasks were provided to deepen the mathematics specialists' contextual understanding of new knowledge and strategies gained, thereby increasing the opportunity to learn beyond the scheduled learning sequences. Applied learning was shared with the rest of the group with a view to generate opportunity for reflection with like-peers and provide opportunities to hone the professional discernment skills. Professional learning sessions were presented by leading primary mathematics researchers and educators, as well as the author who has been working in a primary mathematics specialist teacher role for more than 15 years. Opportunities were created for the cohorts to meet and create connections during Crossover days in the second year of PMSI, thereby strengthening the growing community of specialising teachers.

Method

At the end of 2019, the local community of schools were accessed with the support of the Director of Educational Leadership, and the permission of the central Director of Early Learning and Primary Education schools. A small funding base meant schools would not have to pay for administrative or professional learning costs. The 2-year commitment for two teachers to train as MS with a release time of 0.5 full time employee (FTE) load was outlined. The introductory document included information about the project's goals and the structure of the professional learning curriculum. Schools undertook a selection process, choosing a current teacher to remain with their class for a 0.5 FTE, and be released for the other 0.5 FTE to work with teachers, the other specialist, and leadership team.

Prior to the implementation of professional learning, a background survey was completed by all participants, including MS and principals in an allocated session. Among the data generated were participants' goals for PMSI, and the sub-strands they were confident to teach. These informed the structure of the first-year curriculum focus. Question prompts asked for confidence levels in relation to the teaching of mathematics, content knowledge of mathematics, knowledge of curriculum support resources and understanding of the Working Mathematically processes, addressing the needs of low attaining and high attaining students, planning a mathematics unit of work, assessing and interpreting students' learning needs, making connections across content areas in mathematics, and leading others in the planning and teaching of mathematics. These data were generated using a Likert scale from 0 (no confidence) to 10 (highly confident).

As the first year of professional learning focused on strengthening and building mathematical and pedagogical content knowledge and an understanding of effective teaching and learning strategies, the confidence scale was returned halfway through the 2-year project to MS and principals with their original responses. On it, they indicated any changes on the

Likert scale, qualifying the reasons for such change and identified changes in their Mathematical Knowledge for Teaching (MKT, Ball et al., 2008). At regular intervals participants responded to a variety of reflective surveys to describe growth and change. Making sense of the data in this study drew upon direct interpretation and categorical aggregation, whereby themes and codes were condensed and organised as data were generated (Stake, 1995). The theoretical framework of this study provided initial focus for this analysis.

School context was considered part of the curriculum design, including visits by the author at the beginning of the project, and with all MS during the second year as part of the scheduled professional learning. School demographics and observation of their 4-year plan were viewed as part of the planning process. As the first year's focus was on *understanding and leading self*, each session was planned for a central non-school based location to promote physical and conceptual focus on the MS themselves, and as a new learning community. In the following two phases, where the focus was on mentoring and supporting their peers and being catalysts for schoolwide change, the professional learning sessions were rotated across the participating schools.

The first COVID19 pandemic interruption to PMSI occurred after the first learning sequence block in February 2020 as teachers were no longer able to meet across schools. Cohort 1 had limited face to face meetings in their first year as a result. In order to continue the project, full day presentations were conducted via Zoom and practical materials sent to the participants.

Results

Reflections on early findings and analysis of this emerging research project have been organised into two sections. The first section reflects observations on the first phase of the theoretical framework. The second section analyses data from the second and third phases.

Implementation and Growth in the First Phase: Focus on Self

The purpose of analysing growth data generated by the entry survey was to gain an emerging picture of how the participants respond to the curriculum designed around the theoretical framework. Analysis of the (mean) growth data suggests the greatest changes in confidence for Cohort 1 were: an understanding of the Working Mathematically processes of the NSW syllabus, making connections across content areas in mathematics, and knowledge of resources. For Cohort 2 the greatest increase in confidence related to making connections across content areas and knowledge of resources, and the confidence to ask questions during class discussion. The specialists' narrative analysis of these changes in confidence provided important qualitative context to the quantitative data, revealing self-reported incidences of the Dunning-Kruger effect (Dunning, 2011). For example:

> Whilst many of the "ticks" on my reflection did not shift a huge amount, I still feel enormous growth in each area. I think this points to so much new knowledge and understanding that I did not have before. I think I could have easily moved my original crosses back 3 or 4 steps at the beginning of the year.

In this same reflection, participants described the subdomains of the MKT model (Ball et al., 2008) in which they had experienced the most change. Across Cohort 1 and 2, the greatest overall nominated growth in relation to MKT (percentage of responses) was Knowledge of Content and Students followed by Subject Matter Knowledge then Knowledge of Content and Teaching. Reflection on changes in beliefs and attitudes were evident at the end of the first year, as specialists reflected on misconceptions about what mathematics was and how to teach it. For example: "I have a much better understanding of multiple approaches or strategies when teaching a concept. There were subjects in mathematics (e.g., fractions) where I previously thought there really was only one way to teach it/approach it."

Phase one data demonstrates evidence of the enabling structures *slowing down to go deeper,* c*ultivating professional discernment*, and *being responsive and nimble*. Regular reflections referred to "allowing" themselves time to think. This included the benefits of "having the time and using enabling prompts has allowed me to anticipate student struggles so I am prepared to extend on ideas or provide enabling prompts." At this stage, most of the references made by MS about change in confidence related to *professional discernment* referred to their interactions with students in class, for example: "I now feel more confident in my ability to make informed decisions about where to develop and lead students, based on their responses, understanding, and ideas."

Of particular interest is the survey growth reported by all participants to "lead others in the planning and teaching of mathematics" as this was not an explicit focus of the theoretical framework phase of the first year. Growth in MKT seemed to have a *priming* effect on their confidence to lead others. This may have been related to the changes in student responses. Specialists reported changes in their practice. As a result, their students were "excited" and "more engaged" with an increased willingness to take risks and experiment with mathematical explanations. This change in student behaviour and attitude led to conversations with their school colleagues who were now taking an interest in how they were teaching mathematics, and the new resources they were trialling.

Overall, these data suggest an intensive one-year focus on strengthening and building mathematical and pedagogical content knowledge increased the confidence, self-efficacy, and productive disposition of participants to lead others.

Implementation and Growth in the Second and Third Phases: Focus on Others

The second and third phases of the theoretical framework focus on working with and influencing others and being catalysts for change. By this stage MS were working alongside colleagues to plan, implement, and reflect on lessons with others, creating scope and sequences of learning, learning trajectories, analysing data, and generating a whole school vision. Professional learning sessions focused on trialling lesson observation frameworks, programming and planning, developing connective practices to support the learning of colleagues, and leading others through change.

Data generated at the end of the initiative for Cohort 1 provided insight into the impact of the specialists on their peers. These included changes in lesson structure and the incorporation of rich tasks to differentiate learning experiences and provide assessment information. Many MS reported a greater emphasis on mathematical language, classroom dialogue, and reasoning strategies. Changes in attitudes of their peers were also documented, including an increase in "interest and desire" for information about rich tasks, and that "people are keen to come on board and learn" and are "more willing to discuss mathematics, the lessons they are trialling and how it went." One MS was proud that their interactions with peers had built the confidence and capacity of their colleagues to "lead their own grade in implementing quality tasks." Such distributive leadership is promising for principals looking to begin the process of whole school change.

Principal responses recorded in surveys across cohorts from 2020–2021 included reflections on the "renewed energy towards the teaching of mathematics" in their school, and the move to "open tasks and varying levels of questioning" to cater for a range of students. Two mentioned changes in whole school beliefs and practices related to ability grouping for mathematics as a result of collaborative practices by MS. Shifting such entrenched cultural practices suggests the positive leadership impact of the MS on teachers, and other leaders at their school. All but one of the MS from Cohort 1 indicated their position was being maintained and self-funded by their school at the end of the project, suggesting the potential vision each of these principals had for this role in future school plans.

Evident in the comments from specialists and their principals was the supportive nature of the specialist community created as a result of their involvement in PMSI. Regular reflections referred to their involvement in a “learning community” that had created a “network who are so supportive and incredible.” Due to the uniqueness of the role, preparing specialists were pleased to work with other teachers in this position.

These data suggest that the specialists’ potential to lead colleagues, and across their school was observed in the second and third phases of the theoretical framework. Reflections on difference in knowledge, beliefs, attitudes, and behaviour included inferences about the enabling structures of *slowing down to go deeper*, and *professional discernment*. Reflections on *being responsive and nimble* generally referred to the MS capacity to work around and through the challenges presented by COVID school interruptions, and their increased capacity to manage peers who were “resistant” to new ideas they were introducing.

Summary and Implications

Research on the impact of primary mathematics specialists highlights the promise it holds as a lever to support teaching and learning (Kutaka et al., 2017). Data generated during the 2-year PMSI aligns with this research. Insights to date suggest teacher professional learning was stimulated through curriculum and enabling structures that adhered to the underlying principles of the chosen theoretical framework. Growth and change were observed in three connected areas: individual knowledge of mathematics and teaching mathematics, strategies to mentor and support peers, and building whole school capacity.

An emerging insight from this research includes the *priming* influence of deepening and strengthening MKT to lead others in the same. This attends to the enabling structure of *slowing down to go deeper* and the positive benefits of an extended focus on the *understanding and leading self* phase of the framework. Such insights have positive implications for schools and systems providing continuous high-quality professional learning for teachers preparing to specialise and take leadership positions in their school. It does not suggest, however, that an equal investment in time to build on this leadership capacity should not be given; the year following this *priming* effect provides opportunity to embed and experiment with leadership practices that are beginning to take shape.

Another interesting observation is the frequent appreciation of an extended period of time to make long term and sustainable change in communities of teachers. Both MS and Principals referred to the association between “time” and “deep/er” learning, suggesting the 2-year period set out in the theoretical framework was positively influencing the change process. This frequency of reference may also have been related to the reinforcement in professional learning sessions of the enabling structure, *slowing down to go deeper*. If this is the case, being explicit about such conditions has the potential to make them more noticeable, and more effective.

The organising structures needed to manage the sustained and supportive professional learning of projects like PMSI included a near-vision view of participants, their individual growth and teaching context complemented by a wider perspective on the theoretical underpinnings and curriculum focus. This may have implications for those designing coherent systems and support structures that address the complexity of preparing in-service specialist teachers who lead others and be challenging for large education systems.

This paper aims to address the scarcity of Australian literature related to the fusion of disciplinary and leadership expertise in the primary school context. It aligns with effective professional learning research proposing intensive and lengthy concentration on issues central to instruction to promote MKT growth (Desimone, 2009; Cobb et al., 2018). It goes further by offering descriptive insight into the application of a theoretical framework and associated curriculum designed to promote sustained and supportive structures that prepare mathematics specialists to lead in and across their school. While no claim of generalisation is made about this case, it can be said that the theoretical framework has demonstrated potential and further research of its application would be constructive in building contextual literature.

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