Exploring Ways to Improve Teachers' Mathematical Knowledge for Teaching with Effective Team Planning Practices

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The process of planning mathematics lessons is complex and presents challenges for teachers, specifically in their Mathematical Knowledge for Teaching (MKT). In this paper, I describe findings from case study research in which a Year 1 teaching team engaged in professional reading and used a specific planning proforma to enhance their MKT. Teachers reported feeling more informed in their planning decisions and overall, reported positive changes to their team planning practices which impacted their classroom teaching.

The implementation of the Australian Curriculum: Mathematics (AC:M) offers an opportunity to promote a reform teaching and learning environment that gives students opportunities to develop robust mathematical understandings. In implementing the AC:M, teachers enact an important responsibility in making decisions about "how best to introduce concepts and processes, and how to progressively deepen understanding to maximise the engagement and learning of every student" (Australian Curriculum Assessment and Reporting Authority [ACARA], 2012 p. 19). These decisions, which are often made during planning include, but are not limited to the consideration given to curriculum, tasks, pedagogy, assessment and differentiation. Furthermore, these decisions have the power to directly impact student thinking and learning about mathematics (Kilpatrick, Swafford, & Findell, 2001).

Connected to these decisions is the view that Australian primary mathematics teachers are faced with ever-increasing demands on their planning (Clarke, Clarke, & Sullivan, 2012a). Despite efforts by teachers to plan experiences that encompass the complexities of mathematics teaching, the day-to-day realities of planning for such reform teaching is a difficult task that brings additional challenges, part of which are connected to teachers' MKT (Davidson, 2016). This is especially important given the links between teacher knowledge, effective teaching and student outcomes (Clarke et al., 2002).

An assumption underpinning the research reported here is that effective teaching is preceded by effective planning. That is, teachers are best able to cater for students' needs when they have a clear vision of what they want their students to learn and how they will come to learn it (Hattie & Timperley, 2007). More specifically, teachers' planning decisions are informed by their MKT. In this paper, I describe the findings of a case-study of a Year 1 teaching team's planning practices that supported this group of teachers to improve their MKT and subsequent classroom teaching.

The Connection between Planning and Mathematical Knowledge for Teaching

When planning units of work, Australian teachers often engage in four preparatory actions: (1) reviewing curriculum documents to identify the important ideas, (2) checking available resources, (3) drawing on assessments of student readiness, and (4) drawing on the experience of colleagues (Sullivan, Clarke, & Clarke, 2012b). Based on these four actions, teachers establish specific learning goals that inform teachers' choice and

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sequence of learning tasks which informs their decisions about teaching and assessment. It is reasonable to assume that each of these stages is complex and is shaped, in part, by teachers' MKT. MKT describes the knowledge used by teachers for the teaching of mathematics (Ball, Thames, & Phelps, 2008). It includes two major categories: subject-matter knowledge and pedagogical content knowledge, that is, teachers' knowledge *of* mathematics and their knowledge of *ways* of teaching mathematics.

One aspect of teachers' MKT is the planning decisions that teachers make in selecting the tasks they will teach (Ball, Thames, & Phelps, 2008). While tasks are often viewed as critical in creating potential for student learning (Anthony & Walshaw, 2007), it appears the parameters for selecting such tasks and teachers' capacity to decide on the relevance of tasks is varied (Sullivan et al., 2012a). Furthermore, some teachers experience difficulties in articulating the "big ideas" that inform their teaching (Clarke et al., 2012b). Difficulties by teachers in articulating 'big ideas' was also found by Roche, Clarke, Clarke, and Sullivan's (2014) extensive analysis of primary teachers' unit plans, which showed a high level of variation in the identification and phrasing of key ideas for units of work: an inference being that teachers' understanding of key mathematical ideas will also impact their selection and use of appropriate tasks.

Connected to the way MKT influences planning decisions is the suggestion that teachers may feel constrained to teach in certain ways or use particular tasks if they anticipate negative student responses such as a lack of persistence or risk-taking (Sullivan, Walker, Borcek, & Rennie, 2015b). In response to these anticipated reactions, it has been proposed that teachers may reduce the cognitive demands of the task which has implications for classroom culture (Rollard, 2012) and student dispositions (Dweck, 2000).

However, the provision of lesson planning documentation has shown potential to support teachers in dealing with such constraints (Sullivan et al., 2015a). Sullivan and colleagues (2015a) provided written lesson suggestions to teachers including curriculum links, pedagogical considerations, and task modifications, with teachers reporting that such advice was helpful to their planning and teaching. It should be noted the provision of such documentation was not intended to act as a script but rather to support teachers in anticipating possible directions a lesson might take. Mutton, Hagger, and Burn (2011) refer to this type of planning as "visualisation, rather than planning as a template" (p. 408), and this a focus of the research reported below.

The findings reported below are intended to address the following research question: What approaches effectively support teachers' Mathematical Knowledge for Teaching during team planning and subsequent teaching?

Research Design

The overall project is informed by a conceptual framework that proposes that teacher planning and classroom teaching are a function of their beliefs about mathematics, their knowledge about mathematics and pedagogy, and anticipated constraints (Sullivan et al., 2015b). The focus of the findings presented below is on the aspect of the model regarding the connection between teachers' MKT and their planning decisions.

This study is framed by an instrumental case study design (Stake, 2005) as it is intended to "provide insight into an issue…[and] facilitate our understanding of something else" (p.437). The issue in this case is primary teachers' planning processes, with a focus on team planning. It should also be noted that this case-study is located within the social-constructivist perspective which emphasises the role of personal and shared experiences in the learning process, and assumes a unique relationship between researcher and

participants where reality, or "findings", are co-created between the two and subject to individual interpretations (Creswell, 2007).

Given the complex and idiosyncratic nature of planning, specific criteria were not applied in selecting the case; rather, I sought a team of teachers from the same year level who worked together to plan mathematics on a regular basis, and who were committed to engaging with me as a researcher, in order to explore and improve their mathematics planning. The case in this study consists of the five teachers, most of whom were in their first four years of teaching, in the Year 1 teaching team at a large metropolitan government school servicing a diverse middle to upper class population.

I attended the Year 1 team's mathematics planning meetings over a six-month period between the end of Term 2 (May) to end of Term 4 (November) as a participant-observer, with each meeting lasting one hour on average. My role consisted of asking questions, providing support, and suggesting approaches to the team's mathematics planning. Here, I focus on two approaches: professional reading and the use of a specific planning proforma.

In addition to my participation in these meetings and the collection of relevant documentation that formed part of teachers' everyday work, two surveys (June and November) and a one-on-one semi-structured interview (August) were conducted with each participant. All meetings and interviews were audio-recorded and transcribed. Detailed field notes and a researcher journal were also maintained. These data sources were coded and triangulated to identify emerging themes and provide thick description of the case (Stake, 2005). In terms of survey data, fixed items were analysed with the number of teachers presented as raw figures to give a sense of individual team members' perceptions about their mathematics planning. Open responses were coded to identify emerging themes. The research questions and conceptual framework were also used to frame the analysis for the various datasets.

Findings

In this paper, I report on the findings in three sections: the first being preliminary findings that led to the identification and trialling of the two approaches that are reported on in the second section. The third section describes teachers' reactions to the suggested approaches.

The Year 1 Team Before the Intervention

My work with the Year 1 Team commenced during a unit on patterns. During these initial meetings, much time was spent clarifying mathematical language and concepts. For example, in one meeting, approximately 15 minutes was spent clarifying the term "core": Some teachers referred to it as a "stem", while others referred to it as a "rule" or "the pattern". Inconsistent use of terminology added to further confusion about whether the term "core" was intended for both repeating and growing patterns with the team making reference to numerical patterns only such as "2, 4, 6, 8". It was at this point that I decided to intervene and provide clarification. In turn, this led to a team brainstorm about tasks, with teachers giving examples of tasks they had previously used.

Team members were also invited to complete a preliminary survey of their planning practices. In one item, I asked teachers to identify the most and least helpful aspects of the way their team plans mathematics. In terms of the most helpful aspects, the majority of responses centred on the team's sense of collegiality. For example, one teacher wrote:

> Everyone on the team is enthusiastic about planning and creating the best lessons for students.

In terms of least helpful, time and MKT were two most salient issues. For example, teachers wrote:

> Not always sure of learning sequences and order of areas to teach.
>
> Getting side-tracked with other discussions.

Overall, what I observed in my initial visits was a "brainstorm, document, reflect" cycle of planning. While these discussions were well-intended, they were often ad hoc, task-centric and mainly informed by teachers' own experiences and web resources, rather than other available text resources such as text books and teacher reference materials.

The Intervening Period

The next stage in the study was to suggest approaches with potential in supporting the Year 1 teaching team in overcoming identified challenges in their MKT. The focus of this paper is exploring the potential of teachers engaging in professional reading prior to planning and the provision of a team planning proforma to promote anticipatory thinking (Mutton et al., 2011).

To inform their upcoming unit on shape the team agreed to read the chapter "Developing Geometric Reasoning and Concepts" (Van de Walle, Lovin, Karp, & Bay-Williams, 2014). This text was selected as it is commonly used in teacher education courses. It is written in a teacher-friendly manner and provides a balance of theory and practice: explaining key ideas and trajectories of learning, as well as providing task suggestions.

To support the team in unpacking the content of the professional reading, a specific planning proforma, intended as a working document, was used. The proforma contained the following sections:

- Key mathematical ideas (Students know and understand…)
- Key skills and strategies (Students are able to…)
- Rich assessment task
- Language focus
- Curriculum standards and relevant proficiencies (Below, At, Above)
- Sequence of development (Summary of learning trajectory)
- Lesson structure
- Individual Lessons including: learning intention, success criteria, launch (introduction), explore (main task with enabling and extending prompts), summary (ways to conclude the lesson) and required materials

The meeting commenced with a general conversation about the reading. Some teachers made comments about their own knowledge including:

> It's that thinking when you're starting to get into this level of thinking, unless you're a really spatial thinker, it takes quite a lot to, I mean, it's not my style of learning. I'm in the zone of confusion.

Comments were also made about the interconnectedness of concepts:

> It was very interesting…Well, just things that I wouldn't have necessarily connected with shape that ended up coming into it. Like, direction and thinking about angles. We're not even calling them angles - calling them square corners and things like that for the younger kids. I would never have thought that we would touch on that.

Discussions on language were also prominent, such as:

> So, it just depends how deep it would go - using that informal language. So, some kids might be using parallel, but some kids might just be saying side-by-side or next to each other.

From these discussions, a natural progression into unpacking relevant curriculum statements and identifying the key ideas and skills ensued. The AC:M (ACARA, 2014) content descriptor for Shape at Year 1 states:

> Recognise and classify familiar two-dimensional shapes and three-dimensional objects using obvious features (ACMMG022)

Taken at face value, this statement can appear quite simplistic. However, upon reflecting on the reading, the team identified the following key ideas which formed the foundation of their unit. These were listed as:

> Properties: We can describe shapes by their features.
>
> Visualisation: Shapes can have the same name but look different.
>
> Transformation: We can change the way a shape looks by pushing, flipping or turning it.

Teachers then identified key skills that supported them in gaining clarity on what they would see their students doing such as:

> Students can sort shapes that are similar and different, and explain why it belongs/doesn't belong to that group.

The team also developed a detailed language section including a list of terms such as circle, triangle, orientation, and horizontal, as well as definitions that arose from the discussion. For example, an online maths dictionary was consulted to clarify the following:

> In geometry, term 'face' refers to a flat surface with only straight edges, as in prisms and pyramids (e.g., a cube has six faces). Curved surfaces, such as those found in cones, cylinders, and spheres, are not classified as faces. (Eather, 2017).

This was followed by the development of a two-part assessment task to identify student learning needs and was described as follows:

> (1) Use at least 2 pattern blocks to make a bigger shape. Draw your shape. Tell me everything you know about your shape. (2) Using some pattern blocks, how would you sort and group these shapes? Explain your groups.

The team conducted the assessment and discussed student responses at the following week's meeting, using the reading to guide the analysis of student responses. These discussions were critical in informing subsequent decisions on task selection and sequence: in particular, focusing the initial phase of the unit on 2D shapes, rather than teaching 2D and 3D shapes simultaneously. For example, based on the reading and student responses to the pre-assessment, the team decided to focus the first four lessons on exploring properties of 2D shapes in depth, such as properties of quadrilaterals and triangles, which came under the key ideas of "Properties" and "Visualisation".

As the unit progressed, there was a noticeable shift in the focus of teacher conversations during their planning meetings. For example, by our fifth meeting together, the team was thinking carefully about curriculum statements, together with the key ideas to make careful decision about task-types and accompanying resources. For instance, while discussing a potential lesson on composing and decomposing shapes, the team was experimenting with the available pattern blocks to anticipate student responses and it became apparent that the triangles in the set of pattern blocks could be made to form

shapes such as trapeziums and hexagons rather than squares as the team had originally intended.

Teachers also began commenting on how they had been surprised at some of the student learning they had observed. For example:

> …it's quite nice because my kids are really - well most of them are really kind of getting parallel lines and it's…well I never would've thought to introduce like – "that's a *parallel* line…"

The planning cycle evolved over the six-month period, with the team continuing to reference professional readings and make use of a planning proforma to inform their understanding of curriculum statements, key ideas, student assessments, task types, and lesson sequences.

The Year 1 Team After the Intervention

Towards the end of my time working with the Year 1 teaching team, the teachers were invited to complete an exit survey. The survey comprised of both Likert scale-type items and free format questions to which teachers could respond. In one of the survey items, I asked teachers to think about the way their team plans mathematics and indicate the extent of their agreement from strongly disagree (SD) to strongly agree (SA) with the statements before and after their involvement in the project. In Table 1, I present the responses to some of the statements pertaining to MKT and documentation. Given the small number of responses, the numbers of SD, disagree (D), and unsure (U) responses were aggregated as were the responses to agree (A) and SA.

Table 1
Teacher Exit Survey: Response to Survey Items About Teachers' Planning Practices (n=5)

Statement		SD, D, U	SA, A
The way my team plans is helpful to my teaching.	Before	3	2
	After	0	5
The documentation my team produces is clear and helpful to my teaching.	Before	3	2
	After	0	5
I am confident in my understandings of the big ideas I am about to teach.	Before	3	2
	After	0	5
My knowledge of mathematics is good enough that I can plan whatever types of lessons I like for this level.	Before	3	2
	After	1	4
My knowledge of ways of teaching mathematics is good enough that I can plan whatever types of lessons I like for this level.	Before	4	1
	After	1	4

The most positive responses can be seen in the changes to the team's perceptions about how helpful their mathematics planning is to their teaching including the documentation their team produced. Such positive changes were also noted in teachers' confidence in their understanding of the big ideas they were going teach. It is also encouraging to see positive shifts in teachers' perceptions about their MKT, that is, teachers' knowledge of mathematics and ways of teaching mathematics.

Teachers were also invited to describe the impact, if any, their participation in this research project had on their team and individual mathematics planning. All five participants responded, and interestingly, each team member described, amongst other

things, the impact of professional reading and documentation as well as feeling more confident in their teaching practice. Such comments included:

> The new planner helps to organise and identify exactly what is happening in each math unit. Raising awareness to use textbooks has also been very beneficial for planning. Also, having a working document helps to keep the team up-to-date.

> I now feel a lot more confident in teaching mathematics and understanding that simple smart activities end up being more beneficial and helpful to me and the students rather than glitzy fun crafty ones.

Overall, teachers' responses indicate their perceived improvements in the way they planned mathematics as a team, which had a positive impact on their perceived success as teachers. These improvements can be partly attributed to their engagement with professional reading and the use of a planning proforma.

Discussion and Conclusion

The findings reported above provide some insights into the ways members of a Year 1 teaching team were able to develop their MKT through effective team planning practices. For this particular group of teachers, engaging in professional reading prior to commencing planning an upcoming unit of work and the use of a specific planning proforma supported teachers in making more informed planning decisions. Teachers also reported positive changes to their classroom teaching.

In terms of the research question, the provision of professional reading and an accompanying planning proforma supported teachers in shifting from a task-centric planning approach to engaging in anticipatory planning practices. Unpacking curriculum statements and key ideas, including mathematical language supported teachers in thinking more critically about student assessments, task-selection, resources and lesson sequence. Most significant were teachers' perceived growth in their MKT, which is an important finding given being "confident in the knowledge of mathematics at the level they are teaching" (Clarke et al., 2002, p. 13) contributes to improved student achievement.

It was also pleasing to hear teachers commenting about their surprises about the sophisticated language their students were using, such as "parallel" and "symmetrical", which has implications for the ways such planning practices can facilitate teachers' high expectations of their students and promote a reform teaching and learning environment.

While two approaches, professional reading and a planning proforma are discussed here, it is important to bear in mind the idiosyncratic nature of planning both to schools and the teams of teachers who work together in those schools. Various factors such as school culture and leadership contribute to any team's ability to plan in an effective and sustainable manner (DuFour & Eaker, 1998). It is also important to consider the "ownership" this team had over their mathematics planning and the implications this might have in a new school year with a new team of teachers.

Given the current priority schools are placing on teachers planning in teams, further research into exploring approaches that optimise this process is recommended.

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