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Modelling lessons for more than imitation: investigating teachers' reactions and decompositions of unfamiliar practices

Louise M. Hodgson[1] · **Karina J. Wilkie**[2]

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Abstract
The literature highlights differing views on the efficacy of modelling lessons for teacher professional learning. In this study we draw on dissonance theory to discuss lesson modelling that seeks to transcend 'do as I do' imitation and provoke teachers' attention to intended teaching practices: a necessary pre-cursor for changes to practice. A collective case study investigated the experiences and perceptions of 18 practising primary teachers from four school contexts participating in the process of: collectively observing modelling of mathematics lessons in their classrooms, analysing different parts of those practices with the modeller, and enacting them. It was found that modelling lessons associated with inquiry-oriented approaches for developing students' problem-solving and reasoning in teachers' own classrooms appeared to confront their assumptions about traditional approaches to teaching and learning mathematics. The teachers' surprise at their students' engagement in the challenging learning experiences conflicted with their existing views of teaching and impelled them to reflect on and set goals for improving their practice. Suggestions for pre- and post-lesson protocols for stimulating productive discussions are proposed, along with implications for designing school-based professional learning processes using lesson modelling.

Keywords Teacher professional learning · Modelling · Instructional coaching · Cognitive dissonance · Primary mathematics

✉ Louise M. Hodgson
louise.hodgson@education.tas.gov.au

Karina J. Wilkie
karina.wilkie@monash.edu

[1] Support and Development, Tasmania Department of Education, Based at Rokeby Primary School, 73 Burtonia St, Rokeby, TAS 7018, Australia

[2] Mathematics Education, Monash University, Melbourne, 47-49 Moorooduc Highway, Frankston, VIC 3199, Australia

Introduction

Classroom teaching that engages students in the active construction of knowledge is complex (Ball, 2017; Ball & Forzani, 2009; Hammerness et al., 2005). Each episode of instruction requires many decisions and teaching moves requiring high levels of coordination (Ball, 2017; Ball & Forzani, 2009). Such student-centred practice, also termed inquiry-oriented or ambitious (Cobb et al., 2018; Lampert et al., 2010), is different from the traditional and still widespread teacher-centred instruction of 'telling' students how to proceed (Kisa & Stein, 2015). Importantly, learning to teach student-centred practices often requires teachers to think about teaching in new ways, different from their own experiences learning mathematics at school (Chapman, 2012; Feiman-Nemser, 2001; Hammerness et al., 2005). The recent emphasis on practice-based teacher professional development (e.g. Ball et al., 2014; Desimone & Pak, 2017; Gibbons & Cobb, 2017) suggests that learning situated in teachers' classroom contexts, such as through lesson study, can support them to enact such new practices.

Researchers have highlighted that new practices first need to be made visible to novice teachers before they learn to implement them, and that observing more expert others' teaching practice facilitates this process (Goodwin, 1994). It can be argued that making new practices visible also applies to in-service teachers. There are several studies in the literature on the use of video exemplars of teaching practice for in-service teacher education (Karsenty & Sherin, 2017). Studies on in-service teachers actually being present in the classroom observing a modelled lesson are much less common (Naik & Ball, 2014). Some researchers have advocated for observing teaching modelled in real time so that teachers can visualise and explore new practices in more interactional ways (Clarke et al., 2013; Grierson & Gallagher, 2009; Higgins & Parsons, 2011). Some have warned that simply seeing representations of practice, such as a video or even a modelled lesson, is insufficient in and of itself to guarantee teacher learning (Grossman et al., 2009): analysing and deconstructing the representation is needed, as well as opportunity to experiment with the new practices (Boerst et al., 2011; Clarke & Hollingsworth, 2002; Grossman et al., 2009).

This article discusses the findings of a multiple case study (Creswell, 2013) exploring the experiences of 18 teachers in four school contexts as they engaged over several weeks in observing, deconstructing, and enacting inquiry-oriented practices for developing students' reasoning and problem-solving, proficiencies prescribed in their national curriculum (Australian Curriculum, Assessment, and Reporting Authority [ACARA], 2016). In the study we sought to examine their experiences during and after their participation in the intervention using an accounts-of-practice methodology (Simon & Tzur, 1999). Cognitive dissonance theory provided a lens for making sense of the teachers' reactions and actions throughout the intervention (Thompson & Zeuli, 1999). We applied Grossman et al.'s (2009) processual framework for teacher preparation in designing a school-based intervention with practising teachers as a way to analyse relationships among three components of complex relational practice development: representation, decomposition, and enactment. This paper focusses on the data about the teachers' observations and decomposition. The following section presents details on the context for the study and the theoretical framework on teacher professional learning that informed the design and data analysis.

Background literature

The literature on teacher education highlights a noticeable shift from 'one-shot' (often deficit-view) training-mastery professional development to school-community-based professional learning as a complex, cyclical, and continuing process of growth (Clarke & Hollingsworth, 2002). This section starts with overviewing approaches to professional learning in the literature, including perspectives on lesson modelling, and follows with an outline of the theoretical framework. The next sub-section describes the curriculum context for the research and the teaching practices that were chosen for modelling in the study.

Approaches to collaborative teacher professional learning

There are differing views on which learning approaches are effective for long-term professional growth, but widespread consensus that changing teaching practice is difficult (Clarke & Hollingsworth, 2002; Wilkie, 2019). How the learning of teachers is conceptualised, for example, from a behavioural, constructivist, or sociocultural perspective—influences the design, implementation and evaluation of professional learning. Studies drawing on cognitive theories of learning attend to individual teachers' knowledge and skills development (for example, Hill et al., 2008; Shulman, 1986). Research that resonates with situated perspectives on learning focus on teachers' participation in socially situated practices (Lave & Wenger, 1991). Some studies have identified with a cognitive paradigm yet have involved collaborative activities for teachers (for example, Zwiep & Benken, 2013). Some studies have framed their research from a situated perspective yet have also studied each individual teacher's learning (for example, Kazemi & Franke, 2004; Putnam & Borko, 2000).

One approach to collaborative teacher professional learning that has received international interest is lesson study (Groves & Doig, 2014), practised in Japan by over 98% of public elementary and junior high schools and more than 94% of public high schools (Lewis & Perry, 2014). Lesson study involves ongoing iterations of: a group of teachers planning a lesson; an individual teaching the lesson while the others observe; the group reviewing the lesson; and planning the next cycle (e.g. Fernandez, 2005; Lewis et al., 2006). Researchers have tried to replicate lesson study in other contexts to support a shift toward student-centred teaching practice. However few studies have definitively found strong evidence of success, arguably because of a lack of experience with the approach, short duration or missing elements, such as omitting the support of a knowledgeable other, which is a critical component for improving teacher learning (Takahashi & McDougal, 2015). In an Australian context, teacher reluctance to teach in front of and receive feedback from observers—key features of lesson study—has been attributed to an individualistic culture (Groves & Doig, 2010; Sullivan, 2011). A scaffolded strategy in such a context, to help teachers learn to be more comfortable with collaborative professional learning involving observation of their practice, is a more knowledgeable 'other' or instructional coach modelling lessons for teachers as a first step in building teacher trust (Higgins & Parsons, 2009). In this study we drew on constructivist and situated views to investigate practising teachers' learning through lessons modelled for them in their own classrooms and focussed on student-centred problem-solving and reasoning practices (e.g. Smith & Stein, 2011).

Perspectives on lesson modelling

Teachers directly observing modelled lessons taught by a knowledgeable other in their own classrooms is uncommon in the literature (Naik & Ball, 2014). However, a small number of studies have suggested that observing lessons modelled by a more experienced teacher might be a first step in assisting teachers to visualise teaching in more interactional ways and make knowledge, skills, and teaching practices meaningful and accessible within their own contexts. (Clarke et al., 2013; Grierson & Gallagher, 2009; Higgins & Parsons, 2011).

A modelled lesson is a professional learning strategy designed to support teachers to improve instructional practice and outcomes for diverse learners. Teachers gather together to observe instructional practice, which is usually modelled by a more experienced teacher and situated within a real classroom. The aim is to make new knowledge, skills, and practices explicit to teachers and manageable within their practice contexts. The focus of the teachers' observation can vary depending on the purpose of the professional learning; for example, it may include lesson structure, a particular pedagogy, teacher actions, or student learning (Aguilar, 2013; Bruce et al., 2009; Knight, 2018).

Some studies have suggested that lesson modelling has the potential to develop teacher capacity to inquire into their own practice by visualising how new practices work with their own students (Gibbons & Cobb, 2017; Grierson & Gallagher, 2009). Others have criticised modelling as an exercise in learning to imitate rather than learning to understand (Feiman-Nemser, 2012). Yet Loughran (2006) argued that viewing modelling as "a mock teaching demonstration or a tacit call to 'teach like me" is a misconception, and that observation is needed for developing understanding of the purposes for a teaching practice (p. 95). Bass and Ball (2014) maintained that without opportunities to see teaching in action, teachers may have difficulties in assigning tangible meaning to practices, such as mathematical discourse, and to develop distinct images of what it could mean to teach with them. This implies that direct observation of teaching might be more meaningful to teachers than other forms of professional learning that focus on less visible aspects of teaching.

Bruce et al. (2009) compared the implementation of lesson study and lesson modelling approaches in Ontario schools. They found that modelled lessons were particularly helpful for early-career teachers and suggested their findings would also apply to other teachers experiencing difficulty understanding new or unfamiliar practices. We hypothesised that experienced teachers using traditional teacher-centred practices might learn to implement new student-centred practices through observing modelled lessons and constructing new visions of their own teaching practice.

One concern raised in the literature is that if a modelled lesson is deliberately 'exemplary' for showcasing 'best practice' to others (Loucks-Horsley et al., 2009), observers will misconstrue how complex student-centred practices are, and struggle later in their own implementation of such lessons. Lefstein and Snell (2014) asserted that exemplary modelling "shuts down possibilities for critical discussions on the complexities of teaching" (p. 3). Conversely, Loughran (2006) argued that a deliberate focus on illuminating the modeller's pedagogical reasoning and deconstructing the practices observed in a lesson will actually *highlight* the complexity of teaching.

A strategy for giving teachers a window into a modeller's reasoning and the opportunity to deconstruct practices is the use of briefings before and after lesson modelling. They are considered to raise teacher awareness of key mathematical ideas and

curriculum content for a lesson and of desired teaching actions (Loucks-Horsley et al., 2009). Bruce et al. (2009) described pre-briefings for discussing the lesson plan and learning objectives, and anticipated responses from the students. During the post-briefing, teachers shared their observations and discussed implications for their own practice. Clarke et al. (2013) in a large-scale five-year research project[1] included demonstration lessons by researchers in schools along with pre- and post-lesson briefings. After each modeller shared the lesson plan and objectives, the teachers were asked to choose a student learning focus for their observations and later reflect on them. They found that although teachers did attend to various teaching practices, in the post-lesson briefings they tended to discuss their evaluations of the modeller's teaching rather than focus on students' learning. McGrew et al. (2018) argued that seeing a modelled lesson is insufficient for teacher learning. They emphasised the need for establishing norms for discussions, but also the centrality of decomposing the modelled practices with the observing teachers. Modelling can be considered a form of representation that, alongside decomposition of the modeller's pedagogical choices, makes otherwise invisible complex cognitive work visible.

Modelling involves a level of emotional risk since the actions of the modeller, perceptions of learning, and assumptions about teaching are under examination. Confidence for all participants—observers and modeller—is "dependent upon laying out the practice for critique and being involved in the learning whilst maintaining the integrity of the individual" (Loughran, 2006, p. 42). Lefstein and Snell (2014) highlighted the importance of an approach that is "sensitive of and appreciative of the tensions and dilemmas inherent to teaching and learning in classrooms" (p. 3). In this study we incorporated pre- and post-lesson briefing processes to study their relationship to teachers learning to decompose new practices and additionally enact them in subsequent practice (Grossman et al., 2009).

Important questions remain about what can be learned by teachers from direct observation of teaching practice (Ball et al., 2014). More research is needed to ascertain how knowledgeable others might support teachers to notice the effect of particular teaching practices on their students and the types of processes they can use to facilitate such attention (Gibbons & Cobb, 2017).

Theoretical framework

In this study we drew on cognitive dissonance theory (Thompson & Zeuli, 1999) and a cross-disciplinary conceptualisation of collaborative professional learning processes (Grossman et al., 2009) to investigate lesson modelling for in-service primary teachers learning new inquiry-oriented practices for mathematics learning. These are presented in the following two sub-sections.

Perspectives on dissonance

In the psychology literature Leon Festinger's (1957) theory of cognitive dissonance has been drawn on in hundreds of studies to research attitudes and beliefs, the internalisation of values, decision making, and disagreement among people (Harmon-Jones & Mills,

[1] The Contemporary Teaching and Learning of Mathematics (CTLM) project involving 82 primary schools in the Australian state of Victoria 2008 to 2012.

2019). Despite differing views on mechanisms underlying an individual's motivation, there is consensus that psychological discomfort stimulates dissonance processes that can result in cognitive changes (Harmon-Jones & Mills, 2019). Dissonance theory has also been widely drawn on in educational research to investigate processes for teacher learning. Golombek and Doran (2014) highlighted the role of negative emotions experienced by a teacher as an index of dissonance: to signal gaps between the ideal and real—to point to areas for their professional growth. They qualified that dissonance of itself doesn't guarantee change but is a catalyst for it. In science and mathematics education, Thompson and Zeuli (1999) argued that for teacher learning to be transformative, cognitive dissonance needs to be *deliberately* evoked, reflected on, and resolved through activities that develop new practices. Their research on practice-based professional learning with middle-years mathematics teachers found three potential contexts in which dissonance arises: trying to solve a challenging mathematics problem; comparing one's own teaching practice with that of another; and experimenting with new teaching practices. In this study, we analysed the teachers' perceptions of their experiences for evidence of dissonance evocation, reflection and resolution (Thompson & Zeuli, 1999) throughout their participation.

A processual framework for learning relational practices

Drawing on sociocultural theory and the literature on learning from experience, Grossman et al. (2009) theorised three key aspects of *representations, decomposition,* and *approximations of practice* as underpinning common pathways to teaching practice across a range of relational professions.

Representations of practice comprise the different ways practice is made visible and include artefacts such as: lesson plans, student work samples, videos of practice, direct observation of practice and case studies of practice. Specific features of each representation are considered to have consequences for what novices can see and learn about practice (Grossman, 2011). For example, video representations may enable them to see interactions between teacher and students, but they do not highlight the planning that occurs before the lesson, or include discussions that influenced the planning (Grossman, 2011). Lefstein and Snell (2014) maintained that "videos wash the dynamic complexity out of teaching" (p. 6). Grossman (2011) highlighted the importance of considering which aspects of practice are visible and invisible when thinking about the nature, range, and use of representations for teacher learning. The challenge in professional learning for teachers is helping them make sense of representations (Feiman-Nemser, 2012). Novices, and we argue also those for whom a teaching approach is new or unfamiliar, may not know what to attend to in a representation (Grossman et al., 2009).

Noticing is concerned with what teachers attend to and how they make sense of their observations (van Es, 2012). Noticing is selective so that what teachers 'see' may stem from their attention to some phenomena and not others (Erickson, 2011). Erickson (2011) argued that helping teachers notice what we intend that they will see requires deliberate reflection in action. With lesson modelling, Casey (2011) emphasised the importance of ensuring that invisible decision-making becomes visible to the observers. For example, when a student makes a novel conjecture, the modeller steers the lesson into a new line of inquiry that reflects the conjecture and then explains this move to the observers. Importantly, Ghousseini and Sleep (2011) argued that simply being given a representation of practice does not automatically lead to teacher learning, without intentional facilitation by expert others.

Learning complex relational practices involves identifying components that are integral to them (Grossman et al., 2009). *Decomposition of practice* involves breaking down and naming the essential elements of practice into discrete components and focusing learners' attention on them. The intention in professional learning is for teachers to recognise the components and then enact them in their own practice (Grossman, 2011). Boerst et al.'s (2011) study exemplified decomposition for teachers learning to develop mathematical discourse; the facilitators described the nature of that work, explained the mathematics discussed, and highlighted the specific interactions between students and teacher.

Approximations of practice involve opportunities to enact practice that has been previously represented and decomposed. In pre-service teacher education, a novice teaches part of a lesson, is observed by a more experienced teacher, and is provided with feedback. Boerst et al. (2011) highlighted the value of such scaffolding to help engage and develop the confidence of pre-service teachers in enacting increasingly complex approximations of practice. This also suggests that a scaffolded model is appropriate for supporting in-service teachers to experiment with new practices in their classrooms.

Grossman et al. (2009) highlighted the interconnected and interdependent nature of representations, decomposition, and approximations for effective learning of complex relational practice. Their conceptualization of learning processes, as with other theorisations of professional learning specific to mathematics education (e.g. Clarke and Hollingsworth's (2002) interconnected model of professional growth) resonate with complementary attention to the learning of the individual and the collective during collaborative participation. The research question for the study was: How did the teachers' observations of modelled lessons create dissonance, as evidenced by their reactions?

Context for the research

The professional learning approach used in this study sought to facilitate teachers' attention to, understanding of, and experimentation with inquiry-oriented approaches for developing students' problem-solving and reasoning. The teacher participants' curriculum context prescribes the development of four student proficiencies—understanding, fluency, reasoning, and problem-solving (ACARA, 2016). These proficiencies require ambitious practices in the mathematics classroom that give students opportunities for problem solving, ownership of their learning, sense making, connecting mathematical ideas, discussion and reflection (Munter, 2014). As Fraivillig (2004) suggested, students are more likely to reason if they have developed their own strategies and justifications for solving problems, which requires thinking for themselves. This thinking takes time and is elicited when students are unable to easily solve tasks (Smith & Stein, 2011). We chose to model lessons using challenging tasks for encouraging problem-solving and thinking time as a first step in facilitating student reasoning (Sullivan et al., 2016).

In the study we drew on key practices for facilitating inquiry-based problem-solving as conceptualised in the US Connected Mathematics project (Lappan et al., 2014) and the Australian Encouraging Persistence Maintaining Challenge project (Sullivan et al., 2016). The key practices include:

- **Launch**: posing the challenging problem; having enabling and extending prompts ready;

- **Explore**: providing opportunity for students to think for themselves and engage in solving task; listening; responding to individual/small-group needs; gathering evidence to draw on for the class discussion;
- **Orchestrating**: drawing on student thinking to orchestrate class discussion.

Given that this was a different lesson structure from the teachers' usual teacher-centred practice, it was considered a beneficial focus for researching teacher learning through modelling new teaching practices. The intent was to support the teachers throughout a planned, scaffolded sequence of lesson modelling, decomposition, and enactment in developing their confidence and intention over time to implement more student-centred practices.

Research design

In this study we employed a multiple case study design for qualitative in-depth exploration (Creswell, 2013) of how 18 participating teachers from four school contexts reacted to and reasoned about modelled practices, and their subsequent collaborative deconstruction and enactment. The unit of analysis for this study is each individual teacher. In this multiple case study, each teacher was studied in their context to research their perceptions and experiences (Stake, 2006). Multiple sources of data were analysed to identify case-based themes (Creswell & Creswell, 2018). We used an interpretive accounts-of-practice methodological approach specific to mathematics education (Simon & Tzur, 1999), originally developed for investigating how experienced teachers can be supported over time to change their mathematics teaching to align with current education principles. A case study design with an accounts-of-practice approach provides descriptions of teacher practice in the researcher's language, and distinguishing between teachers' direct expressions and the researcher's interpretations of them. The approach allows researchers to both facilitate and study teacher professional learning (p. 254). It also resonates with our focus on a practice-based context for studying experienced teacher learning and our intent to be sensitive to anti-deficit framing of teachers. The researcher (first author) was well-equipped to accept the role of modeller in this study given her experience teaching mathematics and coaching teachers, and her familiarity with the relevant research literature.

The educational intervention consisted of a scaffolded and collaborative inquiry that began with two episodes of modelled lessons, focussed on developing students' problem-solving and reasoning in mathematics. These episodes of modelling were followed by one episode of co-planning and co-teaching. The intent was to scaffold the transition from observation of a modelled lesson and learning about new pedagogies to planning for implementation and enactment by teachers in their own classrooms. Co-teaching was another form of a modelled lesson, but this time with the modeller being one of the teachers. The Principal invited teachers to participate in the intervention. The Principal and teachers decided on the selection of classrooms where the modelling took place. This was based on which teachers volunteered. Due to time constraints it was only possible to model in selected classrooms. The modelled lessons were observed by the teacher of that class and the members of the teacher's professional learning team or teachers of similar grade levels who were participating in the study. One participating teacher in each school then self-selected to present a lesson. This was supported by co-planning the lesson with the modeller. The lesson was filmed, and afterwards, the presenting teacher was encouraged to view the footage. A week later, she was interviewed about her reflections of the lesson.

Table 1 Overview of schools, participants, and teaching experience

School	Teacher (Pseudonym to match school)	Years of teaching
Raven Primary School (RPS)	Rose	15
	Rachel	6
	Rebecca	5
	Ruth	25+
Swift Parrot Primary School (SPPS)	Sheila (Assistant principal)	31
	Sophie	5
	Sally	14
	Sabrina	30
	Stella	10
	Suri	4
	Sue	14
Magpie Primary School (MPS)	Maude (Assistant principal)	25
	Maggie	0
	Melissa	6
	Molly	36
	Megan	8
	Marita	4
Heron Primary School (HPS)	Heather	30+
	Hannah (Assistant principal)	9
	Holly	4
	Henrietta	30+

The purpose was to ascertain any actions the teachers chose to implement themselves after observing and decomposing earlier modelling by the modeller. The self-selecting teachers were Rose (RPS), Marita (MPS), Hannah (HPS) and Sophie (SPPS) (pseudonyms; see Table 1).

There were four stages in the intervention (see Fig. 1 for an outline of the stages in the intervention); each stage was two hours' duration and included a 60-min modelled lesson and pre- and post-lesson briefings with groups of teachers. Three to seven teachers of lower primary classes (Foundation to Year 3) participated in each school. There was also a 60-min planning meeting prior to co-teaching in Stage 3. The protocols for the pre- and post-lesson briefings are presented in the appendices to provide further detail on the prompts used for establishing norms and facilitating discussion to decompose the intended practices. Four schools were involved in the intervention with one iteration in each school.

Details about the school contexts and participants, data collection, and data analysis are presented in the following three sub-sections.

Phase	Research methods	Sources of data
INITIAL	Teacher survey	– Questionnaire (n = 18) on aspirations for student learning, current student development, ideas for modelling, current teaching challenges, perceptions of effective teaching practices – Questionnaire on lesson requests – mathematical and pedagogical foci
MAIN (~2 months)	**Stage 1** Pre-brief -> Modelled lesson -> Debrief ↓ **Stage 2** Pre-brief -> Modelled lesson -> Debrief ↓ **Stage 3** Co-planning -> Modelled co-taught lesson -> Debrief ↓ **Stage 4** Co-planning -> Pre-brief -> Modelled lesson by volunteer teacher -> Debrief	– Audio recordings of all meetings – Lesson plans for modelled lessons (by researcher and volunteer teachers) – Observation proforma on teacher actions that facilitated student reasoning – Stage 1 Post-debrief proforma – new actions observed; goals for own enactment – Stage 2 Post-debrief proforma – enactment to date; new actions observed; goals for own enactment – Researcher's journal – Videos of modelled lessons by volunteer teachers (n = 4) – Follow-up interviews with volunteer teachers (n = 4) on modelling experiences and reflection on video
FINAL (3 months post-intervention)	Volunteer teacher interviews	– Follow-up audio-recorded interviews with volunteer teachers (n = 4) on any changes to practice
	Teacher survey	– Questionnaires (n = 18) on ideas for modelling, perceptions of effective teaching practices, changes to practice
	School principal interviews	– Audio-recorded interviews on perceived impact of intervention

Fig. 1 Overview of the data collection process

School contexts and participants

Four primary schools from a north-western regional city in the Australian state of Tasmania were invited by the Department of Education regional director to participate in the study. Students from the four schools evidenced educational disadvantage with below-national-average ICSEA[2] scores and below-benchmark test results in the national assessment program (NAPLAN). Between four and seven primary teachers (Foundation to Year 3 (5 to 9-year-olds) from each school—a total of 18—with a wide range of teaching experience, agreed to participate. The schools differed in pre-existing cultures of teacher collaboration; Swift Parrot and Magpie Primary Schools had regular team planning and Raven and Heron Primary Schools had none at all.

Data collection

Data collection occurred over a five-month period and included pre- and post-intervention surveys, modelled lesson request forms from participating teachers, audio recorded pre- and post-lesson briefings, observation of teaching practice proformas, and exit

[2] Index of Community Socio-Educational Advantage; see https://www.myschool.edu.au/.

interviews with four teachers and four principals. An overview of the phases of data collection and sources of data is presented in Fig. 1.

The discussion of findings in this article draws on multiple sources of data, particularly: audio recordings of meetings in which the teachers responded to the modeller's decomposing practice from the modelled lessons; post-observation surveys and observation proformas; and interview transcripts in which the four teachers who self-selected to enact new practices in stage four reflected on their experiences during and after the study.

Data analysis

The interpretive accounts-of-practice methodological approach (Simon & Tzur, 1999) was used in the data analysis. It involved generating "accounts of practice" (p. 253), defined as "explaining the teacher's perspective from the researchers' perspectives" (p. 254). Explicit reflexive attention was given to distinguishing between teachers' own expressions (verbal, written, gestural) and actions, and researcher interpretations of them. Data were drawn from conversations and observations during meetings and lessons, interviews, and also written artefacts such as observation proformas and surveys. Written responses, such as from the teacher observation proformas and surveys, were read and coded line by line to form categories (Creswell, 2013). The initial analysis involved inductive coding for exploring any themes related to teacher professional learning that emerged from the data (Guba & Lincoln, 1989). For example, we coded for features that the teachers noticed in relation to the modeller's teaching actions specifically related to facilitating students' problem-solving and reasoning. It was hoped that the teachers might 'see', for example, how beginning the lesson with a challenging problem for the students to solve by thinking for themselves could facilitate worthwhile student reasoning. However, we found that many of the teachers in the four schools reacted with a sense of conflict when they discussed seeing their students struggling to explain their own thinking. They seemed initially confronted about the practices, different from their usual teaching practice of starting a lesson by explaining how to solve a task and then getting students to practise the teachers' strategy. We then sought to analyse other examples of teachers being confronted about or reacting to practices they had observed. One key category was "Challenging Teacher Assumptions" (see Appendix 3). That category was comprised of several themes that were analysed with a dissonance lens: teaching as telling; student difficulties in explaining their thinking; fear of student-generated responses to tasks; student struggle with tasks where the solution is not known; expectation of student achievement; confronting ideas about catering for diversity; and perceived disengagement of some students.

The initial coding was re-visited, discussed (among the authors and another doctoral supervisor), and revised (Creswell & Creswell, 2018). For example, the first three themes (student difficulties in explaining their thinking, fear of student generated responses to tasks and student struggle with tasks where the solution is not known) were collapsed into "Recognising their teaching as telling when their students struggled with challenge" (see Appendix 3). Audio recordings of meetings and interview transcripts, from each of the four interventions were also analysed and drawn on in revising the coding categories. Significant statements and utterances from interviews, conversations, and vignettes from the observations were documented to provide insights into the participants' perspectives on the modelled lessons, experiences, and responses throughout and after the intervention (Simon & Tzur, 1999). Units of data were mostly spoken or written sentences or phrases.

From these, clusters of meanings from each school context were formulated into emergent themes.

Next, cross-case analysis was conducted to see which themes had commonalities in the data across the 18 participants in the study. The professional learning facilitator (first author) initially coded the data, and the research team (both authors) examined the data for emergent themes both within and across the four cases (Miles & Huberman, 1994). Case study methodology enabled us to analyse the diverse experiences of individual teachers as they engaged with the intervention, and we sought to illuminate their perspectives (Simon & Tzur, 1999). Our reporting aims to elaborate the complexity and connectedness of the elements of the modelling process.

From the analysis, five categories and thirteen themes emerged; these are outlined in the coding framework in Appendix 3. In this article, to address the research question, we focus on three key themes related to teachers experiencing dissonance and having their assumptions about teaching challenged.

Findings

To address the research question on how the teachers' observations of the modelled lessons created dissonance as evidenced by their reactions, we discuss three themes that emerged from analysis of the teachers' own expressions and researchers' interpretations. These interpretations were based on of conversations in meetings, teacher actions, and artefacts.

Recognising their 'teaching as telling' when their students struggled with challenge

Eight teachers (across all four school contexts) reflected on their use of teacher-centred practices, after observing their own students' struggles to articulate their mathematical reasoning. Their comments during post modelled lesson debriefs in response to the modeller's (first author) prompt "what did you notice about student's reasoning in that lesson?" related to their usual approach of beginning a lesson by explaining to students—'teaching as telling'. It appeared that observing their students in a lesson beginning with students solving a challenging problem on their own highlighted the contrast to their own practice:

> The children didn't have the language to explain. We would have explained things to the nth degree where perhaps it's better not to. I wasn't even aware of it until I saw it happening. (Rebecca, RPS, Debrief, Stage 1)
> Students found it really hard to explain their reasoning. For example, Sally knew the correct answers but could not explain… Seeing a problem seemed quite overwhelming for them. (Stella, SPPS, Debrief, Stage 2).
> Some kids found it difficult to explain . . . I noticed that they need more practice on this kind of pedagogy because a lot of the stuff I do in the class is very linear, for example, 'This is the process, this is how you solve the problem, this is what I'm wanting you to do'. (Rachel, RPS, Debrief, Stage 1)

We were surprised by the teachers' frankness in grappling with the issue of their students' perceived struggles. Their comments were suggestive of noticing that their students were not used to explaining their reasoning. Rebecca highlighted explicitly that seeing it happen brought it to her attention; she was unaware of the impact of her 'teaching as telling' practice until she saw her own students struggling. It was surprising to us that these eight

teachers, rather than attributing their students' difficulties to student capability or lack of effort—attributes outside of their locus of control—reflected on their own teaching practices as perhaps impeding their students' capacity to reason.

In later decomposition of the modelled practices, nine of the teachers across the four school contexts expressed a personal sense of discomfort when comparing the observed inquiry-oriented teaching practices with their own, for example,

> It feels a bit like the rug has been pulled out from under my feet… I had a way of working and a way of choosing tasks, but now it's turned my head around and I'm really thinking about why it is I am choosing them. (Heather, HPS, Pre-brief, Stage 3)

> We are coming from a model where we teach kids how to do things and then [we] let them practise those skills and revise them, it's been a bit hard to think [we're] giving them the challenge before [we've] taught them how to do it and what if nobody in the group knows how to do it, where do you go? (Sabrina, SPPS, Debrief, Stage 3)

We noticed the teachers seemed to feel confronted about their own approaches to teaching, which they realised were considerably different to the modelled approaches. Another source of dissonance seemed to relate to concern about responding effectively to student struggles or to student-generated responses to tasks, if they were to start a lesson with a challenging task:

> I am used to lessons where I know where I am going, but in this approach, it is more about the response from the children, so it could go anywhere and I'm not confident to know where to take it or what response to give. (Ruth, RPS, Debrief, Stage 2)

> What to say to kids when they are confused? What to do with kids when they are really stuck? (Stella, SPPS, Survey, Stage 3)

From our perspective, it seemed this discomfort stemmed from the teachers' self-perceived lack of confidence in knowing what to do or say if students came up with a solution to a problem that they had not anticipated beforehand.

In response to the teachers' reactions at SPPS, the modeller emailed an article (Smith & Stein, 2009) to the teachers with the intent of supporting them to deepen their understanding of the practices she was modelling. It seems that the article prompted Sabrina to notice the modeller circulating and paying attention to the students' thinking and solution strategies as they worked on a task during the modelling in Stage 3: "[The modeller] roves and has one-on-one conversations with the students. She asks them to explain their reasoning. [By doing that], she can see how the whole class is going and whether to move on or not" (Sabrina, SPPS). We were heartened by Sabrina's comment, it seemed to indicate she reflected "in action" (Erickson, 2011) on the reading she was provided with, which supported her to make sense of her observation.

Grappling with issues of ability grouping when surprised by some students' progress

The teachers in all four school contexts overwhelmingly requested that the modelled lessons address differentiation, yet all 18 teachers seemed confronted by the practice of posing the one rich mathematical problem to the whole class, with adjustments by way of enabling and extending prompts (Sullivan et al., 2009). (Their usual practice was using ability groupings with different tasks for each group.) The intention of the modelled approach was

to ensure that all students were part of the class learning community—to enable learning through social interaction and whole-class discussions, which are critical for developing mathematical reasoning (Smith & Stein, 2011). The teachers expressed noticeable dissonance during the modelled lesson debriefs. They reported that they would usually start lessons with explicit teaching and might give a difficult task later but only to those students they perceived to be 'ready':

> The fundamental difference with what you did was that you did not teach in ability-based groups. It is a whole swing for me to think differently. (Ruth, RPS, Debrief, Stage 1)

> How do you work with 25 kids all at different levels, all working on the same problem and have conversations with all of them during the lesson? (Rose, RPS, Debrief, Stage, 2)

> I would have just taken a group that was ready for the idea and others would have been doing other concepts. (Henrietta, HPS, Debrief, Stage 2)

Rebecca and Sally seemed to puzzle over whether they could maintain their current practice of ability grouping and explicit teacher instruction but use more challenging tasks. They questioned the efficacy of the modelled approach in their survey responses:

> Yes, we are catering for a diverse range of learners, but are we giving them the explicit teaching needed for the level they are at? . . . The enabling questions allow them to enter the learning, but do they need more explicit instructions, more teacher focus time? Could this work with ability groupings to allow a more personalised approach? (Rebecca, RPS, Survey Stage 2)

> Are there teacher groups involved in lessons like these? (Sally, SPPS, Survey, Stage 3)

Four teachers expressed uncertainty that their lower-achieving students would be able to think for themselves to solve a challenging task, for example:

> What will we do with students who are unable or unwilling to attempt the enabling prompt? (Molly, MPS, Survey, Stage 3).

> How many times [do you] revisit a concept to make sure [the low attainers] have 'got it' before moving on? (Holly, HPS, Survey, Stage3)

Similarly, two teachers reacted negatively to seeing their students grappling with a challenging task, even when provided with an enabling prompt:

> [The low attaining students] would be the ones I would gravitate towards first. The enabling prompts were too hard for them. They weren't even in the zone of the room. (Maggie, MPS, Debrief, Stage 3)

> The enabling prompts are not low enough and if you say, 'Think of lower ones' because this is a new [approach to teaching], we haven't got a bank of ideas that we can tap into on the spur of the moment. (Ruth, RPS, Debrief, Stage 3)

Ruth intimated that she would not have sufficient knowledge to adjust an enabling prompt in the moment if a student could not proceed with the given prompt. This is skilful pedagogical work requiring unpacking of the concept being taught to enable a student to grasp the idea without reducing the mathematical demands of the task (Sullivan et al., 2009).

This prompted the modeller to support the teachers to consider before a lesson how the prompts could be adjusted in different ways to meet specific student learning needs later in the lesson.

In contrast, whilst a handful of teachers expressed uncertainty about using enabling prompts, we were heartened by 12 teachers who expressed surprise at seeing their lower-achieving students engaging positively with challenging tasks. For example, the following excerpt is from a post-lesson conversation at MPS regarding the modeller's pedagogical decision of selecting students to present their thinking and the subsequent teacher noticing of the students' learning:

> As soon as Rick [student pseudonym] shared his idea [of using a number line] there were quite a few that went back and [used] that number line that Rick had explained. The children learned, that they could use an idea that the [other students] had explained. (Melissa, MPS)

> That little girl at the end, she used that number line in a different way by breaking it into 5s . . . That's how they learn . . . from listening to [and understanding] what the other students say. Some of them listened to Rick, they used that notion of 10… Another student said, "I did it the same way as Jo . . . That's what we want to see". (Modeller)

> I noticed that Rick could get the answer really quickly, but he struggled to explain his thinking and it took him a while. (Maude)
> So, then we have to re-voice because it was really important thinking for all students to hear. (Modeller)

This extract shows that the modeller articulated the purposes of both re-voicing and having students explain their thinking as a way of making her focus (on choosing student explanations) more explicit and noticeable to the teachers. The modeller found decomposing in detail those pedagogical actions that seemed unfamiliar to the practising teachers was important in her attempts to support their making sense of them. It seems that this student response and other unexpected responses created dissonance for several teachers, which prompted them to question their own expectations of students and current teaching practices:

> I'm thinking maybe I'm under pitching way too often. Maybe I'm not setting [expectations] high enough. This has got me thinking about changing my beliefs. (Marita, MPS, Debrief, Stage 1)

> Initially I thought my goodness, my children would not be able to do this … they surprised me… The children were very much getting the concept at the end and wanted to continue working, even when they heard the bell, which was surprising. (Stella, SPPS, Debrief, Stage 1)

> I have held back on my modelled explicit teaching and allowed the children to have more thinking time. [I saw] the children thriving on the challenge. (Megan, MPS, Survey, stage 4)

> I saw student understanding and reasoning with difficult problem-solving tasks. I recognised what they were capable of. (Suri, SPPS, Survey, Stage 4)

By observing all their students in the class working on the same problem with variations, four teachers also seemed to become aware of catering for students who need more challenge:

> You could extend those that got the concept but then go back to those others who were struggling. It is normally so hard to work with low ones when you're working by yourself (Melissa, MPS, Debrief, Stage 2).

Over time, we noticed the teachers seemed to envisage more positively the possibilities of catering for all students through variations to the one rich task. The modeller's role seemed paramount in providing teachers with questions to provoke their inquiry about mathematics teaching and learning, such as "What did you notice about student learning in that lesson?" From our perspective, this seemed to lead to collaborative conversations about student learning and critical reflection on teaching practices. An example dialogue after the enactment of the Stage 3 co-taught lesson at MPS illustrates this:

> I'm wondering whether meaning was lost in the enabling prompt? I don't know if it was the wording of it? Just wondering if you think it may have been more effective if you used the same context as the main problem? (Megan, MPS)

> Yeah, do you think we needed to have it exactly worded the same?" (Marita, MPS)

Similarly, in another conversation, Marita stated,

> I don't think I would put the lower group in that "zone of confusion". I am still inclined to rein it back a little. (Marita, MPS)

> Putting low attainers in with those highfliers would just give them the experience. They might see what the highfliers are doing. They might not understand it but they will have the opportunity. (Maude, MPS)

These excerpts highlight what seemed to us to be the teachers' increased empowerment and sense of agency in asking such questions and proposing improvements. In the process of decomposing the new practices together with the modeller, the teachers' dissonance seemed to stimulate worthwhile pedagogical reasoning, as described by Loughran et al. (2016). Evidence of this shift in the teachers' reasoning about student-centred practices occurred in Stage 4 after their own enactment of a lesson:

> Previously I would have started the introduction of a task by explaining and modelling and modelling again … but now I find it is fine to introduce the task and let the students think for themselves... I saw that some kids really did rise to the challenge and achieve success on tasks that I thought were too hard… Rather than hold those high-fliers back as I had previously been doing, they could extend their thinking… In my planning, each week I've got a challenging open-ended maths task with extending and enabling prompts. (Marita, MPS, Exit Interview)

> I used to teach in levelled groups. We never got together… I normally would have whole–small–whole…There would be the whole group and there would be small groups. I would be working with a group and the others would be doing games or activities, but I was not there asking questions or probing thinking because I was working with a different group. (Rose, RPS, Exit interview)

> Initially I thought the lessons may have been too difficult, but now I think more about catering for the top end… I learned that it's okay to challenge all the kids (Sophie, SPPS, Exit Interview)

Overall, 15 teachers expressed a shift in their reflective awareness of alternative approaches to ability grouping for differentiating student learning. It appeared that observing new student-centred approaches multiple times and the subsequent collaborative discussion of them with the modeller, supported the teachers to critique their usual practice and develop pedagogical reasoning.

Making shifts in their interpretations of student actions when seeing authentic (not 'perfect') modelling

Evidence emerged in two schools that some teachers had evaluated the modelled lessons negatively. The teachers initially expressed their negative comments in the debriefs.

> A huge concern is that while you've got kids that are engaged…sitting there listening … and actually having a go, the others aren't [getting it]. They are off task…they are not thinking about learning, they have no meta-cognition. (Marita, MPS, Debrief, Stage 1)

> I got distracted when I stepped back and thought, that one needs more talking to, that one has no idea, that one hasn't got pen to paper yet. (Rose, RPS, Debrief, Stage 2)

In contrast, another teacher Rebecca (RPS) challenged Rose's interpretation and said that she thought those students were not so much disengaged as "trying to get their heads around the thinking". It seemed to her that the students were grappling with the unfamiliarity of the new ways of working, including thinking for themselves. Nonetheless, the modeller decided to make a disclaimer at HPS in the pre-brief that modelling is not intended to be "perfect" across all aspects of classroom management and requested that the teachers refrain from evaluating those aspects of the lesson. At that school, Hannah commented favourably about the disclaimer and subsequently those teachers did not critique classroom management.

The Assistant Principal (AP) at SPPS mentioned that the collaborative post-lesson discussion was powerful in supporting the teachers to understand why students who appeared to not be doing much might actually be thinking rather than off-task: "Making mathematics a group activity is a powerful technique—and that allowing discussion of concepts/thinking is to be encouraged rather than feared as an indicator of time off task". (Sheila, SPPS, Exit Survey).

In this study, two modelled lessons were spaced two weeks apart followed by co-teaching and then enactment (spaced a further two weeks apart). We surmise the short spacing of four episodes of modelling and co-teaching, involving pre- and post-lesson briefings for decomposition, and also enactment, may have been a catalyst for the teachers' shift in perspective. It may also have enabled a relationship of trust between researcher and teachers to grow, leading to a positive rapport and less evaluative stance.

Two principals and two APs reported their view that teacher learning resulted from seeing the researcher persevere, rephrase questions, give thinking time, and modify the planned lesson 'on the fly' in response to students' unanticipated reactions:

> The second lesson showed them [the teachers] that if you persevere and rephrase your questions and give the children time to think it through then eventually they will get there. I think that for those people who are not that keen on this approach they saw that you don't give up, you keep going, you give time, you challenge, you let the kids stew . . . a little bit in that zone of confusion. (Sheila, SPPS, Debrief, Stage 2)

> They [teachers] liked to see you work hard . . . it wasn't a process that was a breeze for you . . . you did have to adjust and modify as you were teaching and have different parts that didn't go quite right and then how you adjusted. (Principal, SPPS, Exit Interview)

These comments indicated to us that the teachers valued the experience of observing the modeller adjusting and modifying their teaching in the moment, revealing the complexity of teaching with student-centred teaching practices. For example, in the following excerpt, Hannah from HPS asked the modeller a question about why she halted demonstrating a number sentence during the summary phase of the Stage three co-taught lesson, which was focused on the concept of comparison in a composite Foundation/Year one class.

> I found it really interesting when you [started to] put up that [number sentence] and then you stopped and I could see you thinking but I was just wondering if you could explain. (Hannah, HPS)

> I thought to myself, this isn't going to work . . . because the way the number sentence is recorded needs to match the semantics of the problem. So, $8 - 5 = 3$ wasn't correct . . . [I was trying to represent that Xavier saw eight zucchinis and Toula saw three; Xavier saw 5 more]. (Modeller)

> You actually needed the answer to be 5. (Henrietta, HPS)
> The difference is 5. (Holly, HPS)
> Older children use subtraction to record difference . . . We must be careful how we use the language. I was conscious of that and that half the kids are preps; it's early in the year . . . I didn't want to confuse them. You can use terminology like difference but recording that [as a number sentence] is difficult. (Modeller)

In this situation, the modeller had stopped herself from making an error of judgement, and Hannah had noticed it. It is not clear if the other teachers had also observed this change in direction, but they did have the opportunity to reflect on it and comment when it was raised afterwards. Higgins and Parsons (2009) highlighted that by providing commentary on the teaching practices they modelled, teacher attention was drawn to the underlying mathematical principles of their actions. In our study the modeller (first author) found that commentary was best situated in post-lesson discussions to promote lesson flow for the students' and her sake, and to enable her to decompose her teaching decisions in detail.

Four teachers reported that they valued the opportunities to talk about the uncertainties in their thinking regarding the teaching they observed. Maggie (MPS) said, "Gathering together and reflecting on why choices were made was crucial." It seemed that the 'messy' but authentic elements of the researcher's modelling and the later decomposition of her actions created possibilities for the teachers to uncover and make sense of underlying complexity and expertise required for student-centred teaching practices.

Discussion

In this study, we investigated the experiences and perceptions of 18 primary teachers in observing ambitious practices modelled in their classrooms and decomposing those practices. We applied Grossman et al. (2009) cross-disciplinary framework to the professional learning of in-service teachers as they grappled with practices different from their own. We drew on dissonance theory as a lens for making sense of the teachers' experience of discomfort, reflection, and apparent resolution (Thompson & Zeuli, 1999).

We found that dissonance was stimulated (Harmon-Jones & Mills, 2019) when the teachers observed their own students' responses to the modelling of ambitious practices, particularly their struggles in verbalising their thinking. In the literature, students' limited capacity to explain reasoning has been associated with teaching that is focused on demonstration and skill practice (Hiebert & Grouws, 2006; Sleep, 2012). Rather than attributing their students' difficulty to student lack of capability—as found in other studies (e.g. Cobb et al., 2018; Wilkie, 2019)—several teachers connected it to their own 'teaching as telling': that their teacher-centred approaches may have interfered with their students' development of critical reasoning. The teachers' comments relate to Munter's (2014) theorised progression of teachers' visions of their roles in teaching from level 0—teacher as motivator; level 1—teacher as deliverer of knowledge; level 2—teacher as monitor; level 3—teacher as facilitator; to level 4—guiding the mathematics in meaningful ways. It seems their observation of teaching for guiding the mathematics in meaningful ways (Munter, 2014) prompted the teachers to grapple with their own views of teaching.

Wilson et al. (2014) described eight possible attributions, of which problematic teaching practice is one. Bragg and Vale (2014) found that teachers, having observed modelled lessons, attributed students' limited reasoning to student lack of capability. It is encouraging but unclear as to why the teachers in this present study responded differently. It is possible that they held growth rather than fixed mindsets (Dweck, 2010) and were open to changing their practice. It is also possible that the prompt given in the pre-brief to observe *teacher actions that facilitated student reasoning*, which explicitly connected practice and student response led the teachers to reflect on if or how their practice elicited student reasoning. This suggests that the focus for the observation i.e. what to attend to in the representation (Grossman et al., 2009), may have supported the teachers in prompting them to compare the observed practice with their own practice.

Cobb et al. (2018) in their large-scale longitudinal study found that teachers who doubted their students' capabilities tended to *decrease* the cognitive demand of challenging tasks rather than *adjust* their practice to support students to participate in rigorous mathematical activity. It appears that some teachers attribute student difficulties to the use of high-level tasks and 'pull the task down' rather than 'lift students up' (Smith & Stein, 2011). The teachers' discomfort seemed a catalyst for change (Golombek & Doran, 2014) and motivation to participate in an opportunity to learn new student-centred practices (Cobb et al., 1990). It appeared that providing a specific focus for these teachers' observations, i.e. what to attend to specifically in the representation of practice (Grossman et al., 2009), as well as in-depth decomposition with the modeller explaining her thinking, may have stimulated them to critique their own practice with a similar focus. It also seemed

that providing a professional reading associated with the focus of the modelling was an important tool to enable teachers to make sense of the new ideas (Clarke & Hollingsworth, 2002).

Another source of the teachers' dissonance, that seemed to emerge from comparing new practices with their own, was their apprehension about how to respond to students' own strategies for solving problems (Fraivillig, 2004). The knowledge required to respond to students' thinking in the moment is difficult to acquire because it requires knowledge of mathematics content that intersects with a student's developmental level of understanding (Hill et al., 2008). This implies that opportunities for teachers to learn a comprehensive range of student responses and strategies beforehand seems critical for them to be willing to try out teaching practices that foster student reasoning and problem-solving.

In this study the teachers also evidenced dissonance when comparing their usual practice of grouping by ability with the modelled practice of posing one challenging task to all students in a class, with adjustments by way of enabling and extending prompts (Sullivan et al., 2016). Many teachers initially questioned the efficacy of the new practice, expressing concern about their students' ability to cope. Their concern resonates with a study by Clarke and Clarke (2008) that found teachers held low expectations of their lower-achieving students. They later, however, expressed surprise as they observed their lower-achieving students persist with and respond successfully to the challenging tasks. Cobb et al. (1990) maintained that challenging teachers' current practice by using a new practice that engages effectively with their students can stimulate the possibility of change. The teachers' surprise at their students' success with the new approach seemed to evoke conflict with their existing teaching approaches and provoked them to reflect on their expectations of students and critique their ability-grouping practices.

Chapman (2012) highlighted the influence of teachers' views and attitudes on their willingness to learn new practices: that they play a facilitating or inhibiting role. She suggested that if teachers hold conflicting views or perceive barriers in implementing new practices, their professional learning will be hampered. Cobb et al. (2018) also highlighted that teachers who hold productive views of students' mathematical capabilities are more likely to develop ambitious and equitable teaching practices. In our study, we found that teachers' dissonance was not resolved by 'writing off' the new practices, because they were confronted with their students' evident success. We suggest that classroom experimentation on its own (without modelling) or seeing other students' success on a video clip may be insufficient for some teachers to provoke this reflective awareness, i.e. that both modelling and evidence of their own students' success are needed in combination.

In this study, we found that teachers' attitudes towards the modeller also played a role in their willingness to consider new practices. It seemed that multiple opportunities to observe authentic (rather than 'perfect') modelling and interact with the researcher 'won over' some initially critical teachers. Some had initially focussed on negatively evaluating classroom management in the modelled lessons, commenting that they noticed some students to be 'off task'. We found that encouraging teachers to focus instead on actions that promote student reasoning in a lesson enable a modeller to then decompose those practices for teachers (Grossman et al., 2009) and support them more effectively to reflect critically on their own practices. By the last stage of the intervention, the teachers seemed to have shifted their pedagogical commitments (Erickson, 2011) and no longer evaluated

classroom management aspects in the modelled lessons. It appeared that they began to consider alternative interpretations of student behaviours. For example, those students who had not immediately put 'pen to paper' may have been thinking about the mathematics in the task, rather than disengaged.

Several teachers reported that they valued seeing the modeller's challenges, dilemmas, and adjustments to support student learning. Loughran (2006) argued that pre-service teachers can learn to recognise, react, and respond to teachable moments by having their attention drawn to instances where teaching is adjusted in response to the unanticipated. We found this equally applied to in-service teachers. The teachers' noticing and questioning prompted the modeller to explain adjustments to her teaching, which seemed to support them to more clearly understand the thoughts and actions underpinning the pedagogical approach. This is consistent with Loughran and Berry (2005) who argued it is important for teacher educators to unpack teaching practice to pre-service teachers so that the association between knowledge and action is made more visible and accessible. The bi-directional conversations seemed to support the teachers to develop an understanding of pedagogical decision-making from the modelled lesson: interaction considered an advantage specific to real-time modelling (Clarke et al., 2013; Grierson & Gallagher, 2009; Higgins & Parsons, 2011).

Our study found evidence that for some perhaps 'change-resistant' teachers, authentic modelling and explicit decomposition of practice (Grossman et al., 2009) with the modeller may decrease the likelihood of their 'writing off' new practices as unsuitable for their context—a risk we suggest is inherent with using video clips exemplars of best practice for professional learning.

Lefstein and Snell (2014) also argued that when practice is perfect, the complexity of teaching is not easily noticed. Furthermore, "A pervasive best practice mentality shuts down possibilities for critical discussion of the complexities of teaching" (p. 3). In accordance with what others have previously argued (e.g. Casey, 2011; Feimen-Nemser, 2012), we believe that opportunities to make unanticipated pedagogical decision making visible to observing teachers is critical to teachers' development of pedagogical reasoning (Loughran et al., 2016). This confirms that those who model new practices have an important role in ensuring that the thinking, judgements, or decisions associated with unanticipated teaching moves are made explicit to observing teachers so that they can be discussed, interrogated, and understood. Nevertheless, this finding also necessitates a prior disclaimer being made to the teachers that the modelled lessons are not intended to be 'perfect', but rather an approach that supports teachers to understand the how and why of practice (Loughran et al., 2016). This might discourage the teachers from evaluating classroom management, and focus their attention, as intended, on teacher actions to facilitate student reasoning and problem-solving.

This study employed a gradual scaffolded process of moving from modelling to co-teaching to enactment with several opportunities for teachers to learn together in pre- and post-lesson briefings facilitated by the modeller. We found that many teachers shifted from being wary or passive to engaged and talkative participants in the discussions. It seems that ongoing conversations about the complexities of the modelling, the new teaching practices, and student responses to the tasks increased the teachers' confidence to participate in

knowledge-building discussions (Lave & Wenger, 1991) and experiment with enacting new practices (Grossman et al., 2009).

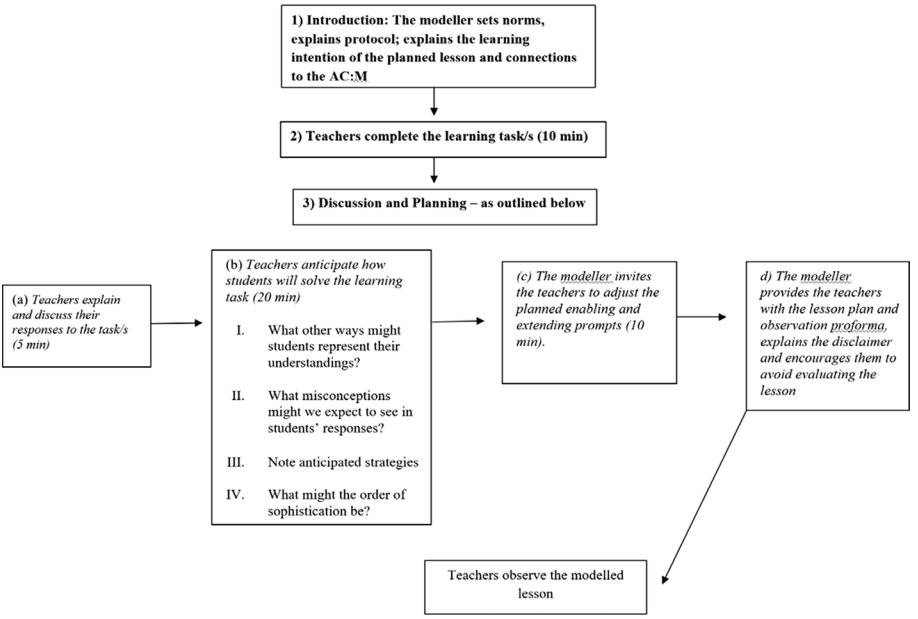
Conclusion

Our study's findings contribute to the literature on professional learning by highlighting that modelling and decomposing ambitious practices in teachers' own classrooms, thus demonstrating their own students' success in problem-solving and reasoning, may evoke the necessary dissonance, reflection and resolution (Thompson & Zeuli, 1999) for some teachers to develop more productive views of students' capabilities and new visions of teaching for themselves (Cobb et al., 2018). They provide evidence that modelling such practices associated with developing students' mathematical proficiency in teachers' own classrooms may confront teacher assumptions about traditional approaches to teaching and learning mathematics. This creates psychological discomfort and stimulates dissonance that can result in shifts in practice. It seems the teachers' surprise at their students' engagement in the challenging learning experiences conflicted with their existing views of teaching and impelled them to reflect on and set goals for improving their practice. Further research on modelling to support teachers in learning to conduct student-centred mathematical discourse in classrooms would be worthwhile.

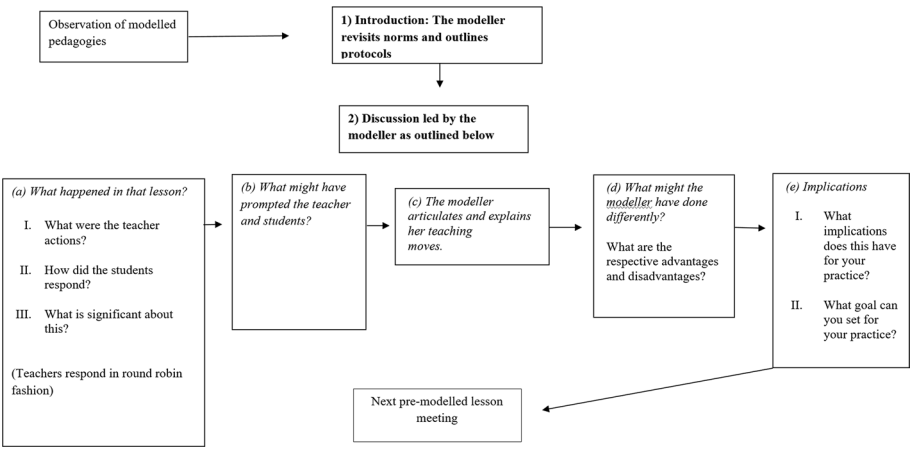
From our perspective and in agreement with Grossman et al. (2009), the interdependent and interconnected nature of observing and decomposing practices seemed to prompt the teachers to shift their visions of teaching from conventional to more interactive approaches for teaching and learning mathematics. This implies that opportunities for modelling and decomposing practices in a sequenced and structured school-based intervention can be a productive form of professional learning for teachers.

The broader study also involved investigating the teachers' own enactment of the practices they had observed and decomposed with the modeller, but longer-term research would be useful to investigate the sustainability of the teachers' changes to their practice over a longer time period. Further longitudinal research on changes to teacher practice through a scaffolded process of modelling, particularly for change-resistant teachers, and at other levels of schooling, would be worthwhile. Future research on the design of the scaffolded process would also be of value in terms of its sustainability and feasibility in a range of school contexts.

Appendix 1: Pre-modelled-lesson briefing protocol



Appendix 2: Post-modelled-lesson briefing protocol (adapted from Lefstein et al., 2017)



Appendix 3: Coding framework

Categories and themes from RPS, SPPS, MPS, and HPS.

Categories	Themes	RPS	MPS	HPS	SPPS
(1) Challenging teacher assumptions	Recognising their 'teaching as telling' when their students struggled with challenge	✓	✓	✓	✓
	Grappling with issues of ability grouping	✓	✓	✓	✓
	Making shifts in their interpretations of student actions	✓	✓	–	✓
(2) Teacher learning from observing	Noticing particular teaching practices	✓	✓	✓	✓
(3) Teacher learning from deconstructing teaching practices	Choosing cognitively complex tasks	✓	✓	✓	–
	Building mathematical knowledge for teaching	✓	✓	✓	✓
	Trialling an observed lesson	✓	✓	✓	✓
	Building trust and learning from each other	✓	–	✓	–
(4) Teacher learning from enactment	Shifting towards student centred approaches to teaching	✓	✓	✓	✓
(5) Stakeholder reactions to the intervention	Seeing, deconstructing, and enacting new practices	✓	✓	✓	✓
	Engaging students	✓	✓	✓	✓
	Differentiating the experience for teachers	✓	–	–	✓
	Accountability	✓	✓	✓	✓

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