



# Teacher Narratives about Supporting Children to Read and Write in Mathematics: The Case of Kay

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Received 11 May 2016 • Revised 17 February 2017 • Accepted 24 February 2017

## ABSTRACT

The impact on one teacher of a short professional development project run in a school in a low socio-economic area in a small city in rural Australia is investigated in this case study. The project aimed to support teachers to improve students' writing in mathematics. The teacher's reflections about her work with a small group of Year 3-4-5 students are discussed in relationship to what supported or hindered her to change her practices. Over the two months of the project, the teacher supported the children to comprehend and produce their own word problems. However, the process of deciding how to change what she did to meet the needs of the students was messy because different combinations of factors affected her willingness to try alternative practices. Her narratives, from watching the videos on her lessons and in joint meetings with the other teachers and researchers, indicated that reflecting on what she was doing contributed to her taking more risks in her teaching. This resulted in the students having more opportunities to use their mathematical literacy skills to comprehend and respond to word problems.

**Keywords:** professional development, students' language, mathematics word problems, low socio-economic area, teacher reflection

## PROFESSIONAL DEVELOPMENT AND INCREASING STUDENT ACHIEVEMENT

The scaling up of professional development (PD) is often based on models which expect teacher learning, acquired during the PD, to increase student achievement in a linear fashion (see for example, Carpenter et al., 2004; Higgins & Bonne, 2011). However, as Joubert, Back, De Geest, Hirst, and Sutherland (2010) indicate, the process of teacher learning is messy, due to a combination of factors, that involve interactions between the teacher, the students and the context, including the mathematics being learnt. Generally models of PD do not consider how contextual features affect teacher learning. In this paper, we use a case study to describe how one teacher, Kay, viewed a PD project and its impact on improving students'

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### **State of the literature**

- The relationship between professional development, including on language learning, and improved student learning outcomes is complicated and messy.
- Teachers have an important role in scaffolding students' acquisition of different aspects of the mathematics register.
- For teachers to be able to undertake this scaffolding they need input about mathematics register content and the processes of scaffolding.

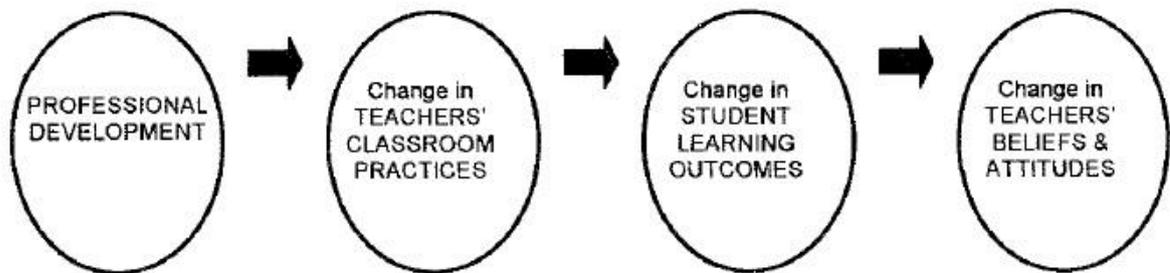
### **Contribution of this paper to the literature**

- The teacher's context of being a non-permanent member of the school staff affected her public comments about her teaching, which then affected her possibilities for receiving suggestions for alternative practices.
- Learning about writing and interpreting word problems requires teachers to recognise that students need to attend to a large number of different aspects simultaneously.
- Teachers need awareness of scaffolding strategies connected to developing students' acquiring aspects of the mathematics register in order to provide activities appropriate for students' needs.

interpretation and production of standard Australian English in the writing and solving of mathematical word problems. Although the students seemed to increase their mathematical understandings through developing their language skills, the teacher's participation in the professional development did not always seem to have a positive effect on changing her practice. Therefore, our focus is not on the students' learning outcomes, but on the teacher's learning and how it was connected to her reflections about what she did. These reflections seemed to provide Kay with deeper understandings of her options and the researchers, who were also the professional development facilitators, with a better understanding of how contexts affected the impact of the PD.

As PD facilitators researching our own practices (Lange & Meaney, 2013), it was important to understand the messiness of the relationship between professional development and teacher change. Although this relationship has been characterised in a range of different ways, evidence for a link to student outcomes remains unclear (Joubert & Sutherland, 2009). Early models, such as Guskey's (2002), see Figure 1, indicate that sustainable change in teachers' beliefs and attitudes occurs after teacher practices have changed, which leads to improvement in student learning.

Other models, such as Clarke and Hollingsworth's (2002), include similar components but allow for different ordering, depending on the teacher. They found that sometimes input from the PD changes teachers' beliefs and attitudes before their classroom practices, something that Guskey (2002) had argued as not being likely. They also commented on the effect of the school environment on teacher learning:



**Figure 1.** Guskey's model of teacher change (Guskey, 2002, p. 383)

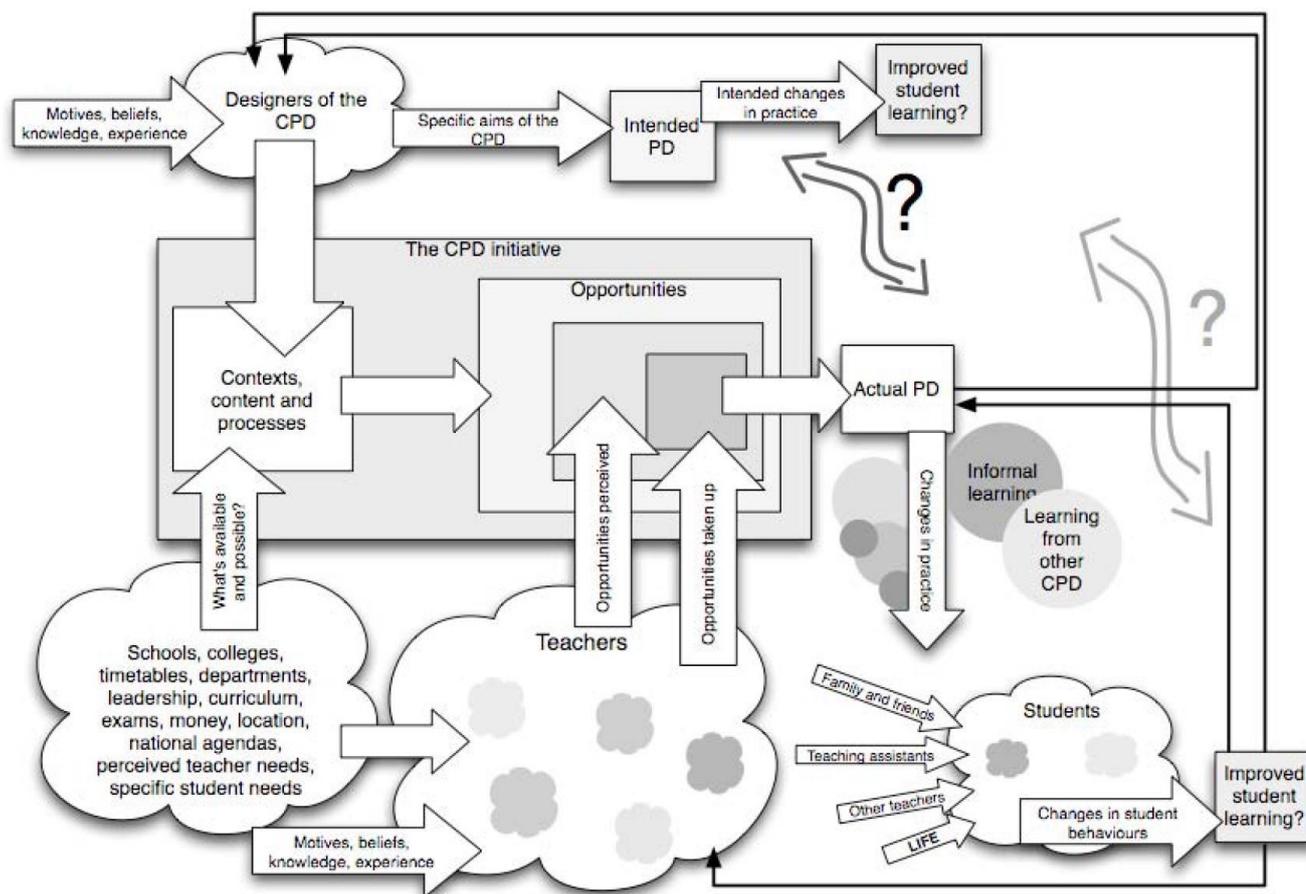
The school context can impinge on a teacher's professional growth at every stage of the professional development process: access to opportunities for professional development; restriction or support for particular types of participation; encouragement or discouragement to experiment with new teaching techniques; and, administrative restrictions or support in the long-term application of new ideas. (p. 962)

When PD projects are scaled up, concerns about the impact of different factors on outcomes have been raised. For example, Coburn (2003) called for a reconceptualization of scaling up that:

... emphasizes the spread of norms, beliefs, and pedagogical principles both between and within classrooms, schools, and districts. And it includes an additional outcome—the shift in ownership—that may prove key to schools' and districts' abilities to sustain and spread the reform over time. (p. 8)

She saw it as essential that ownership did not reside with PD facilitators or other external bodies but with districts, schools and teachers.

In trying to capture some of the contextual factors that affect the outcomes of PD, Joubert et al. (2010) produced a complex model based on socio-cultural understandings about learning, in which they identified a range of factors that could affect the outcomes for both students and teachers (see Figure 2). In this model, they indicated that the planned PD is based on the motivations, beliefs, knowledge and experiences of the designers, but would also take into consideration contextual features that could affect its implementation. The designers would also identify the specific aims of the PD, related to the intended changes in practices and improved students learning, which were to be the outcomes of the PD. Teachers would then identify, from their motives, beliefs, knowledge and experiences, opportunities within the PD that they would want to adopt. The actual PD would arise from the interactions and contribute to changes in practices, which would affect students' learning, depending on previous and ongoing interaction between the students and others. Although already complicated, Joubert et al. (2010) stated:



**Figure 2.** Joubert et al. (2010, p. 1163) model showing the relationship between Continuing Professional Development (CPD) and improved student learning

As with many analytical frameworks, this representation could be seen as ‘too neat’, yet the data is messy and complex. Further, it is a static diagram which cannot represent the ways in which the nature of the CPD may be dynamic and changing in response to feedback from teachers and their changing needs over time. (p. 1763)

Discussions of different models showing the relationship between PD, teacher learning and consequent student achievement suggests that the interaction of contextual features affects the outcomes from the PD and this complexity is difficult to incorporate into a static model. This is because the relationship between components changes as the PD progresses, making it difficult to predict what should be in focus at any particular moment.

As a result of these concerns, Coburn (2003) highlighted the need for “new research designs better suited to capture this more complex vision” (p. 8). To do this, we suggest that there is a need for better understanding of the complicated relationship between professional

development and student outcomes. This is particularly important if differences in student achievement, correlated to certain demographics, are to be overcome (Flores, 2007).

As professional development facilitators, we considered that it was important not just to understand the teachers' background and needs, but also the context in which they worked and how these interacted. To do this, we conducted a case study of three teachers to investigate what affected individual teachers to make changes to their teaching, so that they could support students' writing in mathematics with the intention of improving their results. This paper examines the case of Kay through analysing her narratives about her involvement.

### **PD on Language in the Learning of Mathematics**

The focus of the professional development was about language in mathematics, particularly about writing in mathematics. As Joubert et al. (2010) indicated in their framework, the choice of focus came predominantly from two sources: our previous research experiences on language in mathematics education (see Meaney, 2006; Meaney, Trinick, & Fairhall, 2012); and the school leadership and the teachers who identified literacy issues as contributing to students' poor test results. Similar to Jorgensen's (2015) point, there was general agreement that there is a need for teachers "to be aware of the language demands of mathematics if they are able to successfully transition speakers whose home language is different from school mathematics instruction into successful learning of mathematics" (p. 314). In this school, the students were transitioning from non-standard dialect into learning to use standard Australian English in learning mathematics. For many teachers, attending to language issues is often not part of their professional awareness and even when they recognise that there is a need to attend to it, they are uncertain how to do it. For example, Jackson and Gibbons (2014) noted that classroom practices which supported students' reasoning and justifying skills "are complex to support and develop, for both teachers and students" (p. 3). The school and teachers in our project identified language issues as being important and welcomed the possibility of gaining input on this.

In summarising research on what is needed for students to develop deep understandings of mathematics, Jackson and Gibbons (2014) identified that "students need regular opportunities to justify, prove, and debate the accuracy of solutions and to compare solutions in an effort to identify mathematical connections between them" (p. 3). For this to happen, students need skills and fluency for discussing mathematical ideas and this usually requires a teacher to support them to gain these. If this support is not provided, then students may struggle to learn mathematics. Prediger and Krägeloh (2016) stated, "large scale studies show that many multilingual students and monolingual underprivileged students experience substantial language barriers resulting in limited school success and in particular achievement in mathematics" (p. 89).

Barriers can occur because of differences between the students' everyday communicative language and the standard academic language needed to participate in discussions about abstract mathematical ideas (Mushin, Gardner, & Munro, 2013). They also may arise from societal expectations about the potential of these students to learn mathematics, particularly

in regard to how fluency in the language of instruction may affect their learning (Svensson, Meaney, & Norén, 2014). Regardless of the reasons for the barriers, there is evidence that better understanding of the role that language plays can lead to improved student achievement in mathematics (Jorgensen, 2015). For example, one of Jorgensen's findings was that careful scaffolding by teachers and assistant teachers of the language requirements for working with mathematics contributed to the sustained provision of student learning opportunities.

*Teaching and learning the mathematics register*

The language used to work with mathematics has been labelled, the mathematics register (Meaney, 2005). Halliday (1978) stated:

We can refer to a 'mathematics register', in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language that is: not mathematics itself), and that a language must express if it is being used for mathematical purposes. (p. 195)

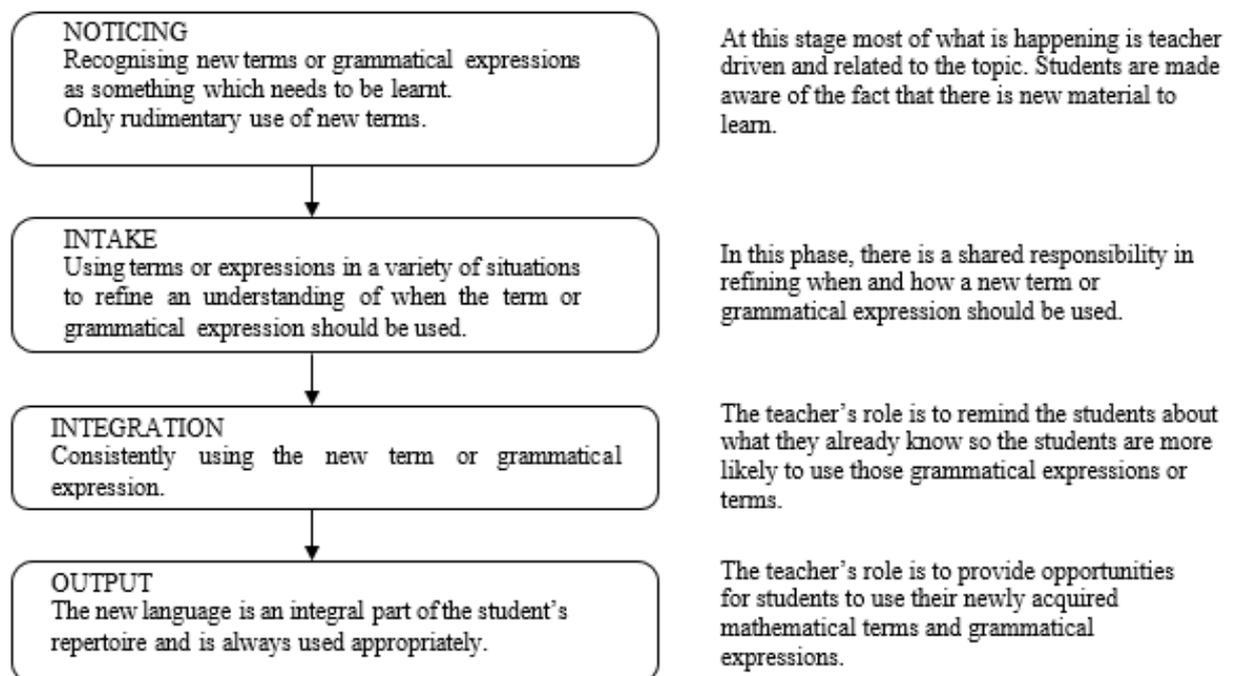
Mathematical vocabulary is only a small part of the mathematical register, with grammatical structures being more important as they provide students with the logical structures needed to express the relationship between mathematical ideas (Meaney et al., 2012). Logical structures are important in interpreting typical mathematical learning tasks, such as word problems, and in producing acceptable responses. One way of supporting students to understand the structure of word problems is to have them write their own as this can raise issues, to do with interpreting word problems. For example, in a study of 509 Year 6 and 7 students' posing of mathematical problems, Silver and Cai (1996) found that 20 percent of the responses were statements rather than questions. In their analysis, 40 percent of students generated less than 20 percent of the mathematical questions. This suggests that many children have difficulty with the aspect of the mathematics register to do with structuring mathematical problems, which is likely to result in students struggling with interpreting word problems.

The PD program was based on previous work, where improvements in students' ability to explain and justify their mathematical understandings had occurred (Meaney et al., 2012). In that work, we had used the Mathematics Register Acquisition model (MRA) to raise teachers' awareness of the kind of scaffolding that students needed at different points when learning new aspects of the mathematics register. In each of the four steps, the contributions of both the teachers and the students to the learning is described (see Figure 3). The MRA model illustrates how students should gain increasing control over their production of new aspects of the mathematics register. As discussed in Meaney (2006), the MRA model uses understandings from second language acquisition to consider how teachers' scaffold students' learning of different aspects of the mathematics register. In Meaney et al. (2012), a large number of recorded lessons from a range of classes, across 11 school years, were analysed to identify the strategies used in teaching oral and written mathematical language. It was found that the teachers' strategies did not differ with the students' age but changed as a new topic was introduced and consolidated. This research also found that although teachers provided a range of scaffolding strategies connected to the first two stages of the

MRA model, they did not provide as many opportunities for students to take control of their language use, as required in the final two stages. This awareness provided the opportunity to work with the teachers to develop strategies that supported the students to work more with the last two stages of the MRA model.

For the PD with Kay, we designed it so that it combined a focus on writing in mathematics with an awareness of how to scaffold students' learning of the mathematics register. We considered that this had the best possibilities for supporting teachers to change their practices so that students had increased opportunities to work mathematically.

In this paper, we examine Kay's involvement in the PD. Her focus came to be on children's posing and responding to word problems. As noted in a later section, Kay's students seemed to increase their understanding of the structure of word problems as well as how to present their ideas orally to their classmates. However, this change in student outcomes does not indicate that Kay's involvement in the PD was straightforward. Our analysis describes how aspects of the messiness around her acceptance of input and her adoption of new practices, at different times supported or hindered their implementation and thus the possibilities for students to learn mathematics.



**Figure 3.** Mathematics Register Acquisition model (adapted from Meaney, 2006)

## METHODOLOGY

The research on Kay is a case study, in that the events discussed are bounded by Kay's involvement in the professional development, both temporally and physically (Cohen, Manion, & Morrison, 2000). Hitchcock and Hughes (1995) identified the defining features of a case study as:

- It is concerned with a rich and vivid description of events relevant to the case.
- It provides a chronological narrative of events relevant to the case.
- It blends a description of events with the analysis of them.
- It focuses on individual actors or groups of actors, and seeks to understand their perceptions of events.
- It highlights specific events that are relevant to the case.
- The researcher is integrally involved in the case.
- An attempt is made to portray the richness of the case in writing up the report. (p. 317)

In the next sub-sections, we show how this project incorporated these features into the design of the study.

### **The Data**

In order to gain the rich description of Kay's involvement in the PD, we collected data in a range of ways. These included: the initial and final interviews of Kay (about half an hour each); initial and final group interview of her students (about 20 mins each); video recordings of four lessons (between 30 minutes to an hour for each lesson); audio recordings of Kay and Tamsin's discussion of the lessons made while watching the video recordings the following day (about an hour to an hour and a half for each meeting); and audio recordings of the five weekly meetings between the teachers and researchers (about an hour and half for each meeting). As well, student work samples were collected.

### **Data Analysis**

The data was analysed in two ways. The first identified whether the students' use of the mathematical register had improved, by comparing how the students used language to describe their mathematical work in the first and fourth videoed lesson. The differences in topic and tasks did not allow for a systematic analysis of language differences, so the results are discussed in very broad terms and from Kay's perspective. Guskey's (2002) model suggests that teachers' attitudes and beliefs change only after they have identified improvements in students' learning outcomes. Therefore, it was important to identify whether Kay saw improvements in her students' learning outcomes and how this seemed to affect her attitudes and beliefs about language learning in mathematics education. In a case study, it is important to gain the main actor's perspective on events.

In case studies, it is important to identify key events. Hence, the second analysis determined what seemed to affect Kay's possibilities for changing her practices. It consisted of first identifying factors that appeared continuously over time in Kay's narratives and which seemed to influence her reflections on the tasks that she trialled in her lessons.

In doing these analyses, we were inspired by narrative enquiry, a methodology that has been much used in teacher education (Clandinin, Pushor, & Orr, 2007). As Connelly and Clandinin (2006) stated "narrative inquiry, the study of experience as story, then, is first and foremost a way of thinking about experience" (p. 375). In particular, we have used Clandinin et al.'s (2007) three commonplaces in regard to narrative inquiry research: temporality, sociality and place. Temporality recognises that events never just happen but that participants' future, present and past affect the events, which should be considered to be in transition. Across the PD, both previous and future events were described differently by participants at different times. We, therefore, identified when Kay seemed to tell different stories about the same event and what influence those differences. Sociality includes "environment, surrounding factors and forces, people and otherwise, that form each individual's context" (p. 23), including the relationships between participants and researchers. In case studies, it is important for researchers to acknowledge their own participation. As the PD facilitators, acknowledging our role in wanting to find out what was occurring was important. However, it was also important to see how Kay made use of her professional relationships in the narratives that she told. The commonplace of place was about the importance of where the PD was occurring. The context is described in the next section. In our analysis, we looked for how Kay discussed different aspects of the situation in which she was working. By iteratively enquiring into the data across these three commonplaces, we were able to identify the contextual features that affected Kay's possibilities for adopting different aspects of the PD.

### **The Context**

The school where Kay worked was in a regional centre of New South Wales and serviced a low socio-economic population. It had a high Indigenous population as well as children from defence service families, which contributed to a turnover of up to sixty percent of students during the year. The students' poor academic results in national tests meant that the school received funding for teachers to attend PD. However, within a context of ongoing political discussion about what to do with schools that failed to show improvements, a non-negotiable result of the professional development was that national test results had to improve (see Lange & Meaney, 2013). The school funded the teachers' release time to participate in the professional development project that we offered. Our university at the time funded us to conduct a research project to identify the aspects of the PD, which supported or hindered the teachers to change their practices. The project began in September and finished in November 2009.

Unlike the other two teachers in the project who were full-time, permanent staff members, Kay was employed on a part-time, casual basis, from funding given to the school because of their poor test results. This use of short-term funding was common in Australia and so Kay's experiences provide insights into a group of teachers who carried the responsibility for

improving test results, but whose work is under-researched. In the interview before the project began, Kay described that as a casual teacher she was not usually considered eligible for PD as the permanent staff's needs had priority. She felt able to volunteer for our project when few other teachers wanted to participate.

Kay worked with a group of six children who were withdrawn from a multi-Year 3/4/5 class because they were identified as likely to do poorly on national tests. In her initial interview, she described her aim as altering the children's attitude from not enjoying mathematics, by tailoring her teaching to match their learning needs. She felt able to do this because she was not restricted by the syllabus for the school, which required teachers to teach topics according to a pre-determined schedule. Nevertheless, she considered important the long-term needs of the students, which included being able to use mathematics in high school and to function in society. From her perspective, the students needed short, hands-on lessons to match their attention span, and which were relevant to their lives. In a discussion during one of the PD meetings, she described how the Indigenous students, who were the majority of students in her group, particularly needed hands-on lessons.

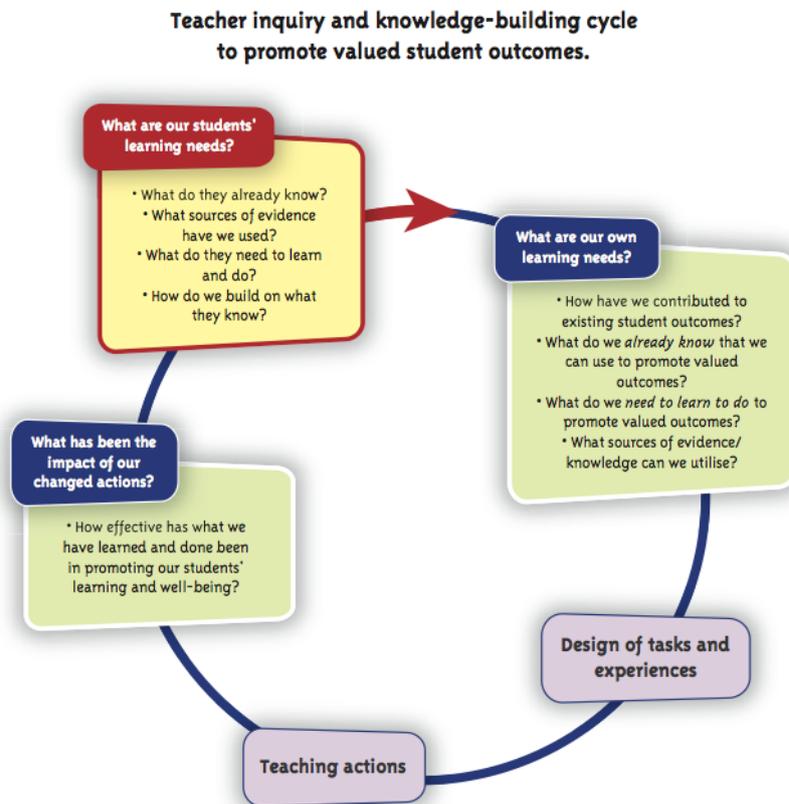
She considered that teachers at the school would view working on writing in mathematics as difficult because of the children's literacy problems. She considered that it was possible to do this if the children heard mathematical language, as a first step to writing it.

In the initial interview, the children in the group verified the importance of language issues in mathematics by stating that in high school they would get hard stuff and the teacher would not read the question for them - "you've got to learn how to read yourself, and you have to figure it out yourself" (Student focus group interview, 15/09/2009). Thus, it seemed that the teacher and the students were in agreement that language issues were important in mathematics learning.

### **The PD**

The three teachers participating in the PD were all working with different ages of children and taught different topics. Focusing on writing provided opportunities to discuss common aspects, but individualise the writing tasks to the different classes. To support the tailoring of the PD, we introduced Timperley, Wilson, Barrar, and Fung (2007) teacher inquiry and knowledge building cycle, shown in Figure 4 in the first group meeting. We anticipated that this would enable us to "build on what teachers already know, taking into account the voice of the teacher" (Joubert & Sutherland, 2009, p. 28). Using such a model also appeared to be in alignment with conducting a case study as it contributed to the teachers providing input about their perception of events (Hitchcock & Hughes, 1995).

After the teachers had agreed to participate, the teachers were provided with a copy of Meaney (2006) in which the MRA model was described. At the initial meeting, we discussed what quality writing in mathematics might be, which included making students aware of how to combine sentences with diagrams in order to explain their thinking through writing, while also considering different audiences for their writing. This discussion was followed by a discussion of the MRA model and the reading that the teachers had been given. Tamsin described the importance of the MRA model as "a meta language for teachers to be able to talk about what people were doing" (10 September 2009).



**Figure 4.** Teacher inquiry and knowledge building cycle from Timperley et al. (2007).

In order to support teacher reflections on their practices as required by the teacher inquiry model (Timperley et al., 2007), we video recorded a lesson from each teacher for four weeks and Tamsin discussed the lessons with each teacher individually on the following day. This approach had been viewed by the teachers in earlier research projects as being valuable in supporting their learning, as it involved them having to reflect deeply on their own teaching (Meaney et al., 2012). In the weekly group meetings, the teachers were expected to discuss, but not show, their lesson as we considered that showing their videos to other teachers may have been too confronting (Meaney et al., 2012; van Es, Tunney, Goldsmith, & Seago, 2014). Certainly, the requirement to be filmed reduced the interest of teachers in the school to participate in the PD.

In the weekly group meetings, the teachers had to describe what had happened that week, particularly in the recorded lesson. This supported them to discuss the steps in the teacher inquiry and knowledge building cycle (Timperley et al., 2007). The teachers discussed what they had done, not just in terms of whether the students had improved their writing in mathematics and how, but in regard to what they, the teachers, wanted to develop in future lessons. These discussions allowed us, as PD facilitators, as well as the other teachers to offer

suggestions about possible alternative teaching practices and to discuss the purposes for writing in the learning of mathematical ideas. It was during the group meeting, after the third set of filming, that Tamsin suggested having students write problems as a way of helping them understand the structure of word problems and, thus, be able to respond more appropriately to them. This suggestion had arisen from Kay's frustration with her students answering word problems.

### **Success of What Kind?**

The first analysis was to determine if the students' mathematical writing was considered by Kay to have improved over the PD project. Identifying how Kay saw the relationship between what the students could do and the activities that she had implemented on the first and last filming days was part of the teacher inquiry model. This analysis contributed to understanding whether Kay considered that changing her teaching practices was effective in supporting students' learning.

In the first videoed lesson, Kay asked the students to provide a title to a mathematical game about rounding numbers to the nearest ten that they had played and describe the rules for it. Kay's idea was to model writing by writing the students' ideas on a flip-board. Although Kay felt that the children enjoyed playing the game, providing a title was difficult. In the joint meeting following the lesson, she said "they really struggled on, even the title, like, well what will we call it. So, we eventually got that" (17 September 2009). However, in her comments from the day following the video recording (15 September 2009), she acknowledged that the students seemed unaware of the needs of an audience who knew nothing about the game. In the video of the lesson, Kay channelled the children into providing a title that included "rounding", which was the mathematical skill that they had practiced. However, it is not clear if Kay, in stating the students "got that", meant that they did eventually offer what she felt was necessary in the title or that the students actually realised what an audience would need in order for the game title to make sense to them.

In the joint meeting, when she discussed what she would focus on the following week, she told a story about where the group had been when she first began to work with them, how far they had developed and what she wanted them to develop next:

I said something like write a sentence about the picture or something, they wouldn't even pick up their pens. ... We don't know how to spell it ... and basically flatly refused. So, I've got them to the stage where they will give me some sort of written stuff, and I'm sort of wanting to move on to giving them something to work on and going away and thinking what are the different ways I can present that? ... Produce that by themselves, like the maths, working mathematically, and then writing. Rather than just relying on the teacher all the time. Because they've got the ideas, haven't they? The ideas are there. It's just getting the confidence to write about it. (17 September 2009)

Kay's perceptions of the students' struggle with producing an appropriate title is placed in a chronological narrative of events (Hitchcock & Hughes, 1995), in which she described the students as gradually taking on more responsibility for their writing. Although it may be

somewhat naïve to consider that all that the students needed was more confidence, Kay's acknowledgement that students should be able to write mathematics independently was in alignment with the MRA model (Meaney, 2006).

This need for the students to become independent writers of mathematics who were not reliant of the teacher for input was also present in Kay's discussion of the final videoed lesson, but in this case she could use the lesson itself to indicate that the students had become more independent writers. Figure 5 shows the problems that the children wrote and how the other pair of students worked out their solution to it. In the final joint meeting, Kay stated:

So we did a 'writing your own problem' which is what you've [Tamsin] been talking about, so I thought that's a really good idea so we'll have a whack at that now and see how it goes ... we were really, really happy with the result, like they followed the format of what to do next and they wrote the algorithm.

Yeah we [Kay and Tamsin] were just blown away basically both of us ... it went much better than I thought it would ... they came back and shared again and they had to explain how they actually got the answer - how did I write the algorithm, how did I write the answer and actually present the picture and the work. (30 October 2009)

From Kay's perspective, the activity of having the students write their own problem, which had been suggested by Tamsin in the previous joint meeting, was a success. She could see that they had used the model she had provided for constructing and solving their own problems. This kind of problem posing is known as "presolution posing" in that a stimulus, in this case the numbers, is provided to the students who then pose a problem based on that stimulus (Silver & Cai, 1996). The students were able to present first the problem and then the solution to each other, where they explained some of their reasoning about what they did. Although these students did not reach the level of reasoning and justifying advocated by Jackson and Gibbons (2014), which would contribute to them gaining deep mathematical understandings, from Kay's perspective the students were more willing to use language to

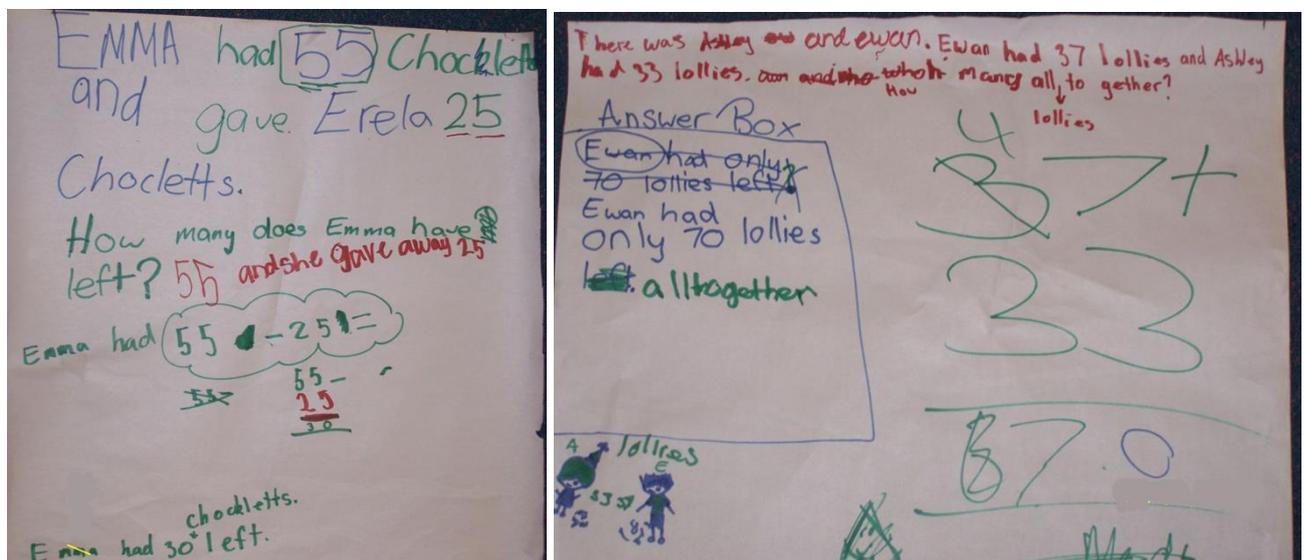


Figure 5. The problems and solutions of the two pairs of students

discuss mathematical.

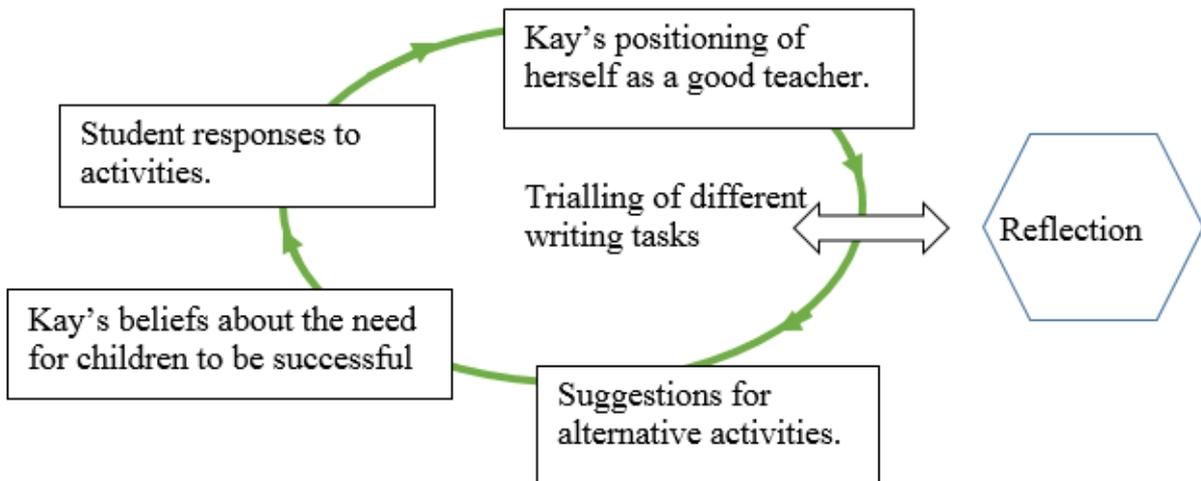
Nevertheless, the question needs to be asked whether the increase in student achievement was because the students had gained skills that they did not have already or because the teacher had changed her practices, which allowed the students to show what they could do. As is discussed in the next sections, it was likely a combination of these that produced the student performance in the fourth lesson.

Clandinin et al.'s (2007) commonplaces of temporality, sociality and place can be seen in Kay's stories about the two videoed lessons. Temporality was important in that it helped Kay to place her work with these students in an ongoing project. She related her teaching practices both to past experiences with these students and to future ones that she would like them to have. This can be seen specifically in the story from the first videoed lesson, but is also implicitly present when she referred to the suggestion for having the students pose their own problems as arising from a previous group meeting. Sociality was also important because Kay's relationship with the students is at the heart of her stories. In describing both the first and fourth videoed lesson, she situated the students as knowledgeable. Timperley et al.'s (2007) model (Figure 4) clearly indicates that knowing what students can do needs to be the basis for further teaching. Although perhaps naïve in her evaluation that the students just needed more confidence, she did adjust the activities she provided based on her reflections on previous experiences with this group of students. Kay's story about the students' success with the problem posing indicates that the relationship with us, as the PD facilitators, helped her identify alternative teaching approaches. Place also influenced the stories in that they were situated within a school environment, where there were certain expectations of teachers and students. As is discussed in the next section, identifying how Kay wove these commonplaces into her stories provided insights into the factors that affected her possibilities for changing her teaching to increase the students' mathematics results.

### **Factors Affecting Kay Changing Her Teaching Practices**

In our second analysis, we identified four factors that interacted together to support or hinder Kay's possibilities for changing her practices. These were: Kay's beliefs about the need for children to be successful; the suggestions offered for alternative actions by the professional development facilitators; the responses of the students to the activities; and Kay's situating of herself as a good teacher. Describing the four components provides an analytical simplification of the messiness of being in a PD project, while still contributing to seeing the process as complex.

All four factors can be linked to aspects of Joubert et al.'s (2010) model (Figure 2) which deal with the teachers' motives, beliefs, knowledge and experiences. Clandinin et al.'s (2007) commonplace of sociality can be seen in all four factors as they are related to the sociality of the environment in which Kay was operating, her relationships to students, her colleagues and us as PD facilitators, who tried to enlarge the possibilities Kay saw for action. However, Joubert et al.'s (2010) model does not show the dynamic nature of how participating in the PD and trialling new tasks was affected by the context in which Kay worked. Although Putnam and Borko (2000) suggested that the context of the classroom contributes to teachers



**Figure 6.** Reflection connected to trialling of different writing tasks through 4 factors

developing views about what they can do and these views are resistant to reflection and, therefore, also to change, we considered that the factors that affected Kay's reflections were connected to the trialling of the different writing tasks and thus connected to changes in her practices. Figure 6, although still a static representation, is an attempt to represent the dynamic nature of the relationships, connected to Kay's actions of reflecting and trialling of different writing tasks. In the next sections, we describe each of these factors using data from Kay's narratives, before providing a description of how the factors blended together in the second lesson.

*Kay's beliefs about the need for children to be successful*

Teacher beliefs were a component of all of the models discussed in the earlier section (Clarke & Hollingsworth, 2002; Guskey, 2002; Joubert et al., 2010). In these models, changing teacher beliefs were connected to changing teacher practices. In contrast, from the initial to final interviews, Kay reiterated a consistent set of beliefs about ensuring that children were successful. From her perspective, the students mostly hated mathematics because they were not good at it and her role was to change their view, by ensuring that they were successful. In the initial interview, as well as mentioning the children's literacy problems, she stated:

Most of the children I'm teaching are finding difficulty with mathematics, so their attitude generally is that they don't enjoy it and that they don't want to actually do any of it at all, they find it very difficult, they find it boring, they find that they can't keep up in the classrooms, so that a lot of the time they may become behaviour problems because they're struggling with it all, I don't think that they understand

that if I do that now that will help me later on in my life, I don't think they see it as relevant to their life ...

In the small groups the children are within reason of about the same ability, so if I can aim it at that and I think they have that sense of okay it's not so bad I can actually do some of this stuff. (Initial interview)

From Jackson and Gibbons' (2014) perspective, these comments include a mixture of both productive and unproductive views of learning mathematics. On the one hand, Kay positioned herself as the person who could affect students' learning. On the other hand, the students are ascribed an attitude which situated them as being responsible when they did not learn.

The need to have her students succeed contributed to Kay trialling out what Jackson and Gibbons (2014) would consider productive and unproductive instructional actions. An example of Kay's productive instructional actions was when she suggested, while watching the video of the final lesson, that the students needed to have control of mathematising the problem. She stated "I wanted them to be able to get to the algorithm and use what they've been taught in solving the problem without the teacher, which they did and I was really happy with that". This was in alignment with our promotion of the MRA model to support teachers to gradually remove their input, so the students could take control of their writing in mathematics and, therefore, their learning (Meaney, 2006).

Nonetheless, the need for children to experience success also led Kay to adopt unproductive instructional actions. As Jackson and Gibbons (2014) noted, teacher actions such as these tended to reduce the cognitive demands of the task. For example, in the first lesson when Kay was trying to have the students come up with a suitable title for the rounding game, she ended up sounding out the start of words she was expecting, such as "rounding", so that all the children had to do was to provide the final part of the word to be successful. By adopting this strategy, she seemed to focus her teaching on the first phase of the MRA model, Noticing, by highlighting for the students the importance of the term "rounding". If the children had been able to use this term appropriately in the title for the game as requested by Kay, they would either be acting in phase 3 or 4 of the MRA model. By instituting the phase 1 activity of having the children fill in the name, following her heavy prompts, Kay may have divorced the meaning of rounding, experienced in the game, from the term being used to describe it.

The need for the children to succeed also lured Kay into trying to produce a set of procedures for students to follow so they could be successful. For example, in discussing the video of the third lesson, Kay stated:

What I'm trying to do with them is keep them in a structured way so that when they get out of the classroom they can carry that across, they've got to know: first thing; second thing; what do I do next?; where do I go next?; where do I write it?; what order do I do all that in. (27 October, 2009)

Although the intention was to have the children be in control of the process, this approach often did not support the children's mathematical writing because the children did not

understand the purpose of each step. As described in a later section, engagement in PD on writing in mathematics resulted in her rethinking the appropriateness of having the students follow a lock-step series of procedures.

### *Suggestions offered by PD facilitators*

Timperley et al.'s (2007) teacher inquiry model (see Figure) requires that the teachers clarify their own learning needs. Therefore, in the first joint meeting before filming began, all the teachers were asked to do this. Kay considered her involvement to be "more about developing my teaching style rather than what I actually want the kids to gain from this" (First joint meeting, 10 September, 2009). However, as she began to reflect on her lessons and share her understandings in the joint meetings, she started to describe her aims for the students. For example, she stated in the third joint meeting that her aim for the students was to write responses to word problems using complete sentences:

The other thing I've been trying to get them to do is actually answer the question, like write a sentence about the answer ... they just wrote the question again, like when I said, write the answer. (1 October 2009)

Once she described her goals for the students' mathematical writing, it was possible for us as PD facilitators to offer suggestions for how she could support the students, both in the sessions discussing individual lessons and in the group meetings. These suggestions, such as having the students write their own word problems, were open-ended and required the teachers to determine for themselves how to implement them. They also provided opportunities for Kay to offer different kinds of scaffolding, in alignment with the four phases of the MRA model. At the end of the project, Kay commented that the PD was not just about listening to suggestions from the facilitators but being expected to implement them.

I think this PD is more hands on. It forces you into looking at okay what sort of lesson am I going to do, how am I going to structure that, how am I going to plan for it, how am I going to critique it and what am I going to do with that information after, whereas the normal PD is just go and watch and then you may or may not get to actually put any of those things into your actual classroom or to share it. (Final interview)

Kay took our suggestions and also ones gained from listening to the reflections of the other teachers in the group meeting and incorporated them into her planning. This is in alignment with her original aim about improving her teaching style (September 10 2009), which was raised again as a concern when watching the first video (September 17 2009), but moved on to considering explicitly the opportunities that she could make available for students' writing. In so doing, she followed the steps of Timperley et al.'s (2007) model (Figure 4) by basing her planning on what she considered the students needed in order to improve their writing in mathematics. She was able to use her reflections, on past and present events to do with the students' mathematics writing, to consider how and why she adopted new teaching practices to support students to gain more control over their use of different aspects of the

mathematics register. Her reflections seemed to contribute to her perceiving what was offered in the PD as something that she could and should try with her students (Joubert et al., 2010).

### *The responses of the students to the activities*

Kay's relationship with her students also affected the environment in which she operated and these were evident in the narratives that she told about being in the PD. In Guskey's (2002) model (Figure 1) but also in Joubert et al.'s (2010) (Figure 2) model, changes in student outcomes led to changes in teacher attitudes and beliefs. In contrast in Kay's case, it was often what she perceived that the students could not do which caused her to think about her teaching practices. For example, in watching the third lesson with Tamsin, Kay commented on the students' difficulties with interpreting numbers, which she considered to be a language issue:

Those students need the same language and repetition from the teacher, so they understand what you're asking, 3 tens, what is it really and they didn't know. We went back and we built it, there it is. What is it really? (27 October 2009)

In discussing the student's actions, she often described what she considered to be alternative actions that the students should be able to do. In this case, Kay decided to provide intake activities, phase 2 of the MRA model, about interpreting the place value of different numerals. Sometimes, as a result of seeing how the students responded to a lesson, she made changes while teaching:

When I actually planned the lesson, this whole bit in it was not planned. I hadn't actually thought of doing it as a small group first, then as I was teaching I thought, hang on a minute, they hadn't actually been asked to do this before. I don't want to whack them into it and see what happens. Let's do a group example first, so that sort of happened as I was teaching. (3 November 2009)

Her reflection on the students' previous experiences combined with what she saw happening in the lesson made her adapt her teaching to better fit what she felt were the students' learning needs. In this example, the adaptation was in alignment with the third phase of the MRA model (Meaney, 2006) (Figure 3), in that the students were expected to know how to write mathematical problems, but by modelling it as a whole group activity first, she could remind them of the features that they should be paying attention to. However, as noted in the previous section, when the students were unsuccessful Kay's aim of ensuring that they were successful led her to adapt her teaching so that it restricted the students' possible behaviours, without necessarily providing them with a clear understanding of why it helped their writing in mathematics.

### *Kay's situating herself as a good teacher in discussions*

The final factor that appeared consistently in Kay's narratives about the PD was her need to situate herself as a good teacher. In the narratives that she told, this provided information on the temporality, sociality and place commonplaces in which she operated. Needing to see

herself as a good teacher seemed to affect her willingness to evaluate her changes to teaching practices as required by the Timperley et al.'s (2007) model (Figure 4) and instead led her to blaming the students for their lack of learning. As identified in Joubert et al.'s (2010) (Figure 2) model, contextual aspects of the situation were likely to influence teachers' motivation as well as their attitudes and beliefs. The contextual features, such as her situation as a casual teacher, seemed to result in Kay being unwilling to show her uncertainty which affected how she adapted her teaching and evaluated new practices.

In the discussions about the videoed lessons and in the group meetings, Kay rationalised her decisions about adopting new activities so that she appeared as a good teacher. This rationalisation could be seen in how Kay changed from noting that she had asked the children the wrong question in the commentary on the first lesson, to describing the same situation in the joint meeting as an activity, which brought out a lot of language in the children. Her shifting of the narrative over time indicated how temporality provided opportunities to describe what had happened to different audiences at different points in time. This seemed to be because she did not have the same possibility for displaying her uncertainty as the other teachers in the PD. Kay's uncertainty is in contrast to other research in which teachers gained confidence to change their teaching by discussing it in collaborative groups (Horn & Little, 2009) and with such reflection leading to growth (Day, 1999; Pitsoe & Maila, 2013). For example, Hardy and Rönnermann (2011) advocated professional development that included:

A broader conception of education, involving robust, collaborative inquiry amongst teachers into their work, not only results in much more sustained and substantive student learning, but also leads to improved outcomes on more standardised measures of student assessment. (p. 464)

It may be that Kay's situation as a casual teacher, employed specifically to ensure that low-achieving students improved their mathematics achievement, meant that she felt unable to discuss her struggles with teaching writing in mathematics. The other two teachers were permanent staff who at times admitted that their videoed lessons were not successful and that they were responsible for what occurred (see for example Lange & Meaney, 2012). Kay may have felt that if she showed too often what she could not do, it could affect whether her contract was renewed, which would have serious implications for her financial situation. This uncertainty seemed to result in her not being able to take advantage of the support that a network of teachers has been documented as providing (Coburn, Russell, Kaufman, & Stein, 2012).

However, one outcome of not being able to discuss problematic aspects of her teaching was that she was restricted to blaming the students. For example, in the third joint meeting, Kay said:

I'm trying to get them to be able to answer me verbally and written, you know, and really they struggle and need to do it verbally, you know, I'm almost like, there's the answer, look at the bottom of the algorithm you've just got to write it, you know (laughing) but they still don't know that's where the answer is. ... I think they're starting to get it but ... (1 October 2009)

In the initial interview, Kay had distanced herself from the other teachers at the school who felt that the children's literacy problems made it inappropriate to teach writing in mathematics. Yet, when she failed to see the students being successful, she ended up blaming them. This blaming of students restricted Kay's possibilities for reflecting on her own teaching practices. In the example above, she did not recognise that the students needed to be scaffolded into identifying how the answer to the algorithm was also the answer to the word problem, a phase one activity on the MRA model, but instead seemed to expect them to be fluent in interpreting what they had in relationship to the answer to the word problem, phase 4 in the MRA model. Without having the possibility to reflect on the mismatch between her expectations and the level of support on the MRA model that the students' responses indicated they needed, it was more difficult for Kay to provide appropriate activities for the students.

Kay often situated Tamsin into her narratives as an independent evaluator of what she had done well. This can be seen in her description of the students' success in writing, solving and presenting problems in the fourth lesson that was provided earlier. The relationship between Kay and us, as the PD facilitators, was delicate. The professional relationship between teachers and facilitators is complicated by personal relationships as well as societal ones (Meaney, 2004). In order to work with teachers, it is necessary for facilitators to develop trusting relationships, which can only be based on good personal relationships. However in an insecure working environment, Kay used her developing personal relationship to show that an external evaluator supported her teaching approach. It is unlikely that Kay was conscious of situating herself as a good teacher and using us in the process. So although this seemed to affect her possibilities for reflecting on her own teaching, it was difficult to make her aware of how this was affecting her interactions with the children.

### **Reflection and Teacher Change**

Kay's narratives illustrate the messiness of the relationship between PD and improving student outcomes that Joubert et al. (2010) described. Kay's reflections on the students engaging in the tasks she implemented were affected by the factors, outlined in the previous sections, sometimes in isolation and sometimes together. Day (1993) suggested that teacher reflection is often limited to planning or evaluating the actions that occur in a lesson. However as indicated previously, it seemed that Kay could reflect more broadly about what she wanted to achieve. In this section, we look at Kay's reflection in regard to the second lesson in which the children did not read and respond appropriately to word problems. The difficulties with the lesson provided Kay with much to reflect on. However, not all of this reflection contributed to her changing her practices or to improved student outcomes.

In the joint meeting after the second videoed lesson, Kay described what had happened:

What do you do when you're trying to solve a problem, because I've been doing lots of lead up into dissecting the problem, how do you read it, how do you get the numbers out of it, so we did that first, and actually did like a flow chart, I guess, on the board. We're going to read it twice, we're going to look at the numbers, we're going to look at the question, we're going to look at, what does the question want us

to do, what are we going to do, we're going to draw it, we're going to write an algorithm. ... Then we split off into groups and the problems were probably harder, well, they were harder than I'd been doing before with them. Because I've been wanting to keep it really simple, so they could learn process, rather than be challenged by the maths of it, and so this was the first time they'd done something that was challenging and the first time that they'd worked in small groups by themselves, with just a partner. So a lot happened in a very short period of time and it showed me a lot about where the kids are at, and what parts of the process that they understand and what they had trouble with. And I think the main thing which was just emphasised again today, is that they don't understand the question, they can't decode the question, they can read the question, but then they can't, they don't know what it is that they want you to do. So they had all sorts of problems in different ways and the groups, one group just couldn't do it at all, one group went pretty well, and the other group got off on a tangent, and just couldn't get back to the original story. (1 October 2009)

In this description, Kay situates herself as a good teacher by describing how this lesson fitted her focus. When it did not go to plan, she blamed the children for not being able to complete the activities. In this quote, Kay's reflection stayed at the level of identifying who was to blame for why the lesson was not a success. Her reflections on the unproductive instructional techniques (Jackson & Gibbons, 2014) she had used were not shared with us, as facilitators, or the other teachers. She fell back on the normalising discourse around the children having literacy problems (Horn & Little, 2009). She did not seem to gain support from being part of a teacher network.

In the video of the lesson, the children followed the steps in the list, but seemed unsure why they did them. For example, one step was for them to find the numbers in the problem. The pair of students described by Kay as those who "got off on a tangent" worked on the following problem:

Miss Butcher has chickens at home. If the chickens laid 2 eggs per day for a week, and Miss Butcher saved them up, how many eggs would she have?

Following Kay's list of steps, this pair of children identified the "2". The next step was to draw a picture, so the children drew some chickens. At this point Kay sat with them and went over the problem, repeating that the chickens laid two eggs on Monday, two eggs of Tuesday etc. The children asked how many chickens there were and eventually Kay stated that there were only two chickens, so they laid one egg each, every day. Kay then reminded them that the next step was to write an algorithm. When Kay moved to another group, the children counted the chickens that they had drawn and wrote a number sentence where they added the 12 chickens to the 2 eggs. Consequently, the answer that they arrived at was 14. When Kay realised what the children had done, she spent time trying to get them to see that their interpretation of the steps was wrong. In the discussion of the lesson with Tamsin, Kay stated:

Done some work on key words like: how many altogether? What's the difference between? How many were left? The most common ones that you see. They still

haven't got it, I've done some of but I know they haven't got it yet. (29 September 2009)

In this comment, Kay situated the students as having possibilities for learning by adding "yet" to her description. The productive view (Jackson & Gibbons, 2014) that students could be successful, one of the factors that influenced her reflection, gave Kay possibilities to considering different ways to move the students forward. In this case, the reflection allowed her to think about alternative actions.

In the two days between discussing the video with Tamsin and the joint meeting with the other teachers and researchers, Kay had the children redo the problem with the chickens, focussing on different representations and their connections to the meaning of the word problem. The solutions were brought to the joint meeting (see Figure 7) and allowed Kay to talk about the difficulties she was facing, while also showing that her students had ultimately been successful. She could then receive suggestions for alternative practices, while still appearing to be a good teacher. It gave her a small space to take on the "experimentation, risk taking, and reflection required to transform practice" (Putnam & Borko, 2000, p. 10). Reflection on the lesson combined with the wish to be seen as successful led to Kay trying out new tasks with the students. Reflection on the outcomes of these tasks provided her with an opportunity to discuss both the difficulties with the original lesson and the success of the following lesson.

The focus of the professional development was on writing in mathematics. The complexity that Kay encountered when trying to support her students through modelling and scaffolding how to interpret and produce word problems made her reflect more generally

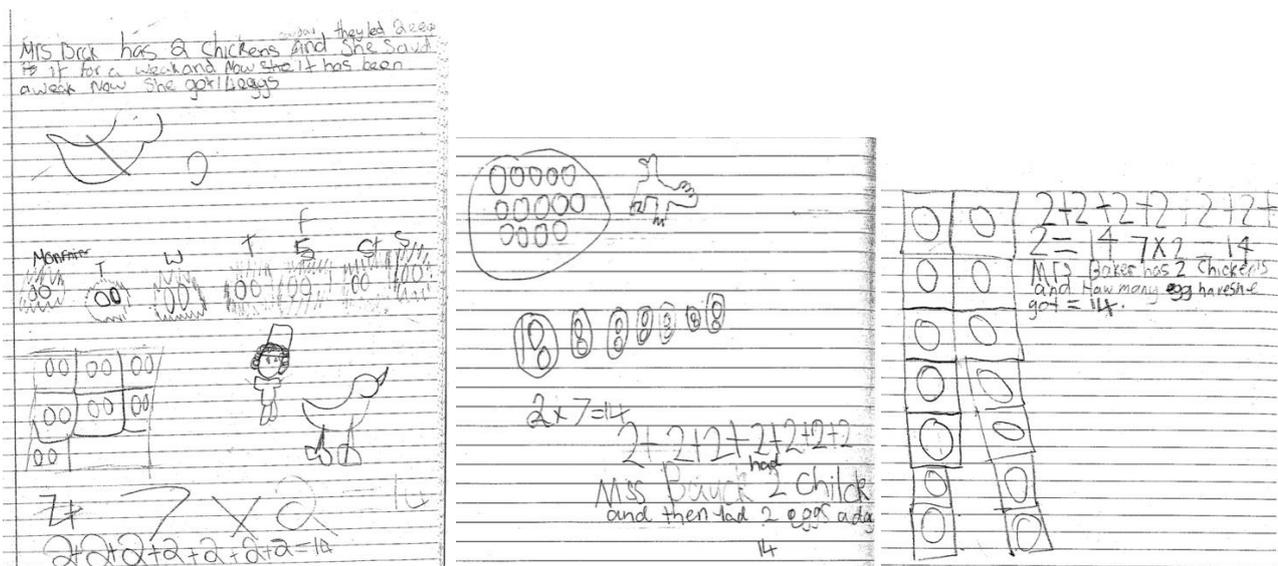


Figure 7. Children's solutions to the chicken problems

about mathematics and language learning.

As I work with this group more, it's sort of like Pandora's box, just as you think of what I need to teach them, then that leads into other things they don't know and in order to teach them that and there's another. It's like unpacking a suitcase. (29 September 2009)

Thus the reflection that Kay engaged in about the trialling of the tasks was complicated. Her assumptions about the different aspects of writing and interpreting word problems were tested regularly as she found that the students had not noticed the importance of some term or expression and therefore were unable to use them meaningfully to make sense of what they were doing. This often forced her to reconsider what aspects of the word problems she should work on with the students.

The four factors operated together to affect what she reflected on and the outcomes of the reflection. Sometimes the reflection made her focus on specific incidents, where her need to be seen as a good teacher clashed with her aim for the students to be successful. If the aim for the students to be successful was at the fore, then suggestions from the PD were considered in regard to how the previous lesson could be improved. On the other hand, if the need to be seen as a good teacher could not be achieved easily when discussing the results of an activity, then the students tended to be blamed and it was difficult for alternative practices to be suggested by us, as the facilitators, or to be adopted by her into the new lessons. However, Kay's reflection would sometimes give her a broader understanding about the teaching/learning of how to write and interpret word problems. When this happened the factors seemed to align in a positive manner. This then provided her with opportunities to take more risks with her teaching and not always expect students to experience immediate success.

## CONCLUSION

In this case study, we investigated how one teacher, Kay, perceived her participation in a short PD programme. From Kay's narratives, it was possible to see how she reflected on the trialling of different tasks through the four factors of: her beliefs about the need for children to be successful; the suggestions offered for alternative actions by the professional development facilitators; the responses of the students to the activities; and her positioning of herself as a good teacher. As the PD facilitators, an understanding of Kay's reflections gave insights into why some of our suggestions were not adopted in regard to providing students with better opportunities to improve their writing and interpreting of mathematical problems.

Recognising the role of language in mathematics learning requires knowledge about how children learn to listen, speak, read and write mathematics (Meaney, 2006; Meaney et al., 2012). Although many of the teachers at this school considered that the students' poor literacy results meant that asking them to write in mathematics was not possible, Kay's work with the students suggests that both mathematics and literacy understanding can be improved when students engage in tasks that are meaningful for them. Kay found that accepting the complexity of "unpacking the suitcase" required her to deal with more than

one aspect of the students' learning at a time. Assuming that students had fluency in regard to one aspect of interpreting and writing word problems led Kay to become aware that students struggled with at least one other aspect that was important for solving word problems. Dealing with this complexity made her to some degree re-think what was involved in the teaching and learning of word problems.

From our perspective as PD facilitators, the research indicated that it might have been useful both to Kay and the other teachers in the project, if examples of difficulties were discussed in relationship to mismatches with the MRA model. For example, the circumstances in which Kay assumed the students were fluent when in fact they did not show they had even noticed essential aspects could have provided Kay with possibilities for re-structuring the activities during the lesson. This may have provided her with increased reflection possibilities.

Taking a broader perspective, there will always be teachers, like Kay, who because of a range of factors interacting together, may not produce the improvement in student results that large scale professional development often promises. Kay's status as a casual teacher who relied on being able to show that the students were increasing their possibilities for improved test results affected how she could interact with others. Yet, in countries such as Australia, funding specifically provided to improve students test results, generally goes to employing teachers on short-term contracts. Such teachers have reduced opportunities to indicate openly that they struggle with aspects of their teaching. In Kay's case, the complexity of the language issues connected to mathematical learning did seem to support deep reflection, even if she rarely discussed all aspects of that reflection in the group. The outcomes of this deeper reflection led to her trialling a variety of activities and reflecting on what was helpful about them for supporting students' learning.

This small study describes some interesting results, especially about how teachers who are often given the responsibility to raise students' test scores but who are not permanent staff need to situate themselves as good teachers. As was the case with Kay, this may make it difficult for teachers to take on PD suggestions about how to support students' mathematical learning. Further research could contribute to identifying how using models such as MRA can provide discussion starters for reflection on why students are only sometimes successful with learning how to use mathematical language. Although the MRA was the foundation for this PD project, it was not used explicitly to discuss why activities were successful or not. Further work should consider how this model could be used to raise discussions above individual experiences to reflect at a meta level about students learning of mathematical language.

#### ACKNOWLEDGEMENT

Funding for this project was provided by Charles Sturt University. Marianne Thurling provided valuable assistance in the implementation of the project and in the initial analysis of the data.

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