# A Teacher Pair Approach to Adopting Effective Numeracy Teaching Practice

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While the notion of numeracy as the capacity to make use of mathematics within contexts associated with personal and public life, as distinct from basis mathematical competence, is broadly accepted, forms of professional teacher learning that lead to the effective teaching of numeracy are still the subject of ongoing research. This paper reports on a small scale study which aimed to investigate the potential for pairs of teachers, working with two tertiary mathematics educators, to improve the quality of their teaching of numeracy through reflection on each other's teaching practice. While viewing their teacher pair's lesson via video each teacher identified aspects of the lesson that they could use to improve their own teaching.

The notion of numeracy as the capacity to make use of mathematics within contexts associated with personal and public life, as distinct from basic mathematical competence, has been recognised since at least the time of the *Crowther Report* (e.g., Ministry of Education, 1959) with subsequent reports and influential literature (see for example, Cockcroft, 1982; Steen, 2001) emphasising the importance of numeracy as a focus of schooling. More recently, the OECD Program for International Student Assessment (PISA) has sought to ascertain the standards, among 57 participating countries, of knowledge and skills across the domains of reading, scientific and mathematical literacy that are necessary for full participation in society. PISA's Assessment Framework – Mathematics, Reading, Science and Problem Solving Knowledge and Skills (2003) provides the following definition for mathematical literacy.

> Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (p. 24)

In Australia the issue of numeracy has been the subject of much discussion and research resulting in the following broadly accepted definition.

> To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life. (Australian Association of Mathematics Teachers Inc., 1997 p. 15)

The importance of developing the numeracy capacities of young people to accommodate the demands of their current and future lives has also been identified in policy documents such as the *National Numeracy Review* (Human Capital Working Group Council of Australian Governments, 2008) and in the recently released draft curriculum documents for Mathematics, Science, English and History (ACARA, 2010).

While understandings of what is meant by numeracy have converged over time, what constitutes effective numeracy teaching and what forms of teacher professional learning best promote effective classroom practice are still developing fields of study. A large study that included over 2000 students and 90 teachers in the United Kingdom found that highly effective teachers of numeracy tended to engage in mathematics specific professional development on a regular basis over an extended period of time (Askew, Brown, Rhodes,

L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia.* Fremantle: MERGA.

Johnson, & Wiliam, 1997). These teachers perceived that ongoing professional leaning was critical to their continued development as teachers of numeracy. It was also observed that highly effective teachers were able to assist other teachers to become more effective. Using Askew et al's (1997) study as a starting point, Muir (2008) developed a synthesis of the literature related to effective teaching in numeracy, identifying commonalities across studies and learning contexts. While Muir (2008) concedes that the studies that form the basis of the synthesis operated from varying definitions of numeracy and of what constitutes effective teaching, she identifies the following principles of practice as being central to effective teaching of numeracy: making connections; challenging all pupils; teaching for conceptual understanding; facilitating purposeful discussion; maintaining a focus on mathematics; and possessing and instilling positive attitudes towards mathematics.

While the identification of these principles is helpful in describing teaching actions that lead to effective numeracy teaching, the principles do not in themselves describe how effective teachers of numeracy acquire these ways of working.

In a study which investigated effective pedagogies for the teaching of numeracy in Tasmanian schools, Beswick, Swabey and Andrew (2008) found that the majority of teachers in their study used pedagogies that contributed to supportive classroom environments. However, they also observed a disconnection between the aims of the mathematics curriculum and teachers' actions in relation to numeracy specific pedagogical approaches. These studies highlight the need for ongoing research into improving numeracy teaching, particularly in light of the state and national curriculum priorities.

This paper reports on a small scale study which aimed to investigate the potential for pairs of teachers, working with two tertiary mathematics educators, to improve the quality of their teaching in numeracy through reflection on each other's teaching practice. The processes used to facilitate pairwise reflection will be described and implications of its use in professional learning of effective approaches to teaching numeracy will be discussed.

## Theoretical Background

In order to theorise the changes in teaching practice that took place in this study we draw on Millett and Bibby's (2004) model of teacher change within the context of curriculum reform. Millett and Bibby's (2004) model illustrates the local context of curriculum reform and, in so doing, suggests that the role played by a teacher's professional learning community is vital to effective reform. Their model (Figure 1) represents the role of the teacher as central to the implementation of curriculum reform and so a teacher's "personal agency beliefs" and "beliefs about self-efficacy…and academic self esteem" (p. 5) play a part in determining the success or otherwise of the implementation process. Here we are reminded of the cyclical nature of teacher efficacy. With every new task teachers can go through a cycle that begins with a state of *unconscious incompetence* where a teacher is unaware of the limitations of their knowledge, to a state of *conscious incompetence* where a teacher becomes aware of their limitations in respect to a specific aspect of their teaching. A teacher can move from a state of *conscious incompetence t*o a state of *conscious competence* following positive efficacy feedback before entering a state of *unconscious competence* where they have no need to dwell on their competency level (Schratz, 2006). Surrounding the teacher is the *situation*, a specific school culture that impacts on the teacher's capacity to change. Finally, the teacher and the situation are located within a wider context that includes influences such as: policy developed by governments and various authorities; professionals external to education; the

private or commercial sector; and the general public or those who are outside the school but are none-the-less interested in education such as parents and the media.

Drawing on Spillane's (1999) earlier work, Millett and Bibby note that the impetus for curriculum reform often comes from a wider context beyond the school environment that stimulates a "zone of enactment" (p.4) in which the teacher will respond positively or negatively to this external challenge. Critical to a teacher's response within their *zone of enactment* is the type of support found within a teacher's professional learning community in which sharing and critical interrogation of their practice takes place. Positive support within the community includes "rich deliberations" that, when "grounded in practice and supported by resources, curriculum change [is] more likely to be operationalised" (p. 4).

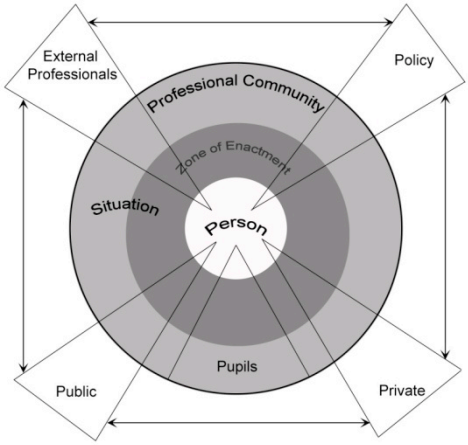


*Figure 1.* Theoretical model for analysing the context of curriculum reform. (Millett & Bibby, 2004, p.3)

The influence of a teacher's personal and professional identity on curriculum reform is also supported elsewhere in the literature where efficacy issues in respect to mathematics teaching in primary schools are identified as critical factors (Ball & Bass, 2003; Ma, 1999).

The importance of time, talk, expertise, and motivation in providing the sources of support necessary for positive self-efficacy has been identified by Millett, Brown and Askew (2004). It seemed that time, talk, and expertise complement internal motivation, resulting in "deep change" (p. 245). They also noted that external expertise was deemed to be essential to support teachers' learning with respect to new content knowledge and content specific pedagogical knowledge. More recent research (Heirdsfield, Lamb, & Spry, 2010) found that another factor critical to developing the motivation that leads to deep change is length of time. This study reports that the two teacher participants needed two years of ongoing assistance from the external expert to provide the necessary expertise for them to develop a sense of agency.

## Method

### *Participants and Procedure*

The data reported in this paper is drawn from interactions with and between one pair of Year 7 teachers who participated in a study that involved eight teachers, four each from Years 5 and 7 from one primary school located in the inner suburbs of Brisbane, Queensland and two university-based researchers. The study was conducted over a six

month period in the second half of the 2009 school year. A case study approach (Stake, 2005) was used to document the actions and interactions of these two teachers as they worked together to enhance each other's numeracy teaching practice. The selection of the school was opportune (Burns, 2000) as the leadership of the school invited the researchers to work with staff on a research project that aimed to enhance numeracy teaching practice within the school due to recent disappointing results on NAPLAN tests. All teachers in Years 5 and 7 (two of the years in which NAPLAN testing takes place) were strongly encouraged by the school leadership team to participate in the project.

Two teachers are the focus of this paper. Julie is an experienced teacher with more than 20 years experience who has worked at the school for six years. Stephanie has five years classroom experience with the last two years working at Hillside. Selection of the teachers reported on in this paper was purposive as their cases were chosen for the capacity to illuminate rather than for representativeness (Stake, 2005). In particular, the cases reported in in this paper were selected because of the way these teachers influenced each other's *zones of enactment*.

Data collection methods included classroom observations and field notes, audio and video recording of individual teacher interviews, and audio recording of a pair-wise stimulated recall interview (Meade & McMeniman, 1992) based around a video recording of one teacher's lesson.

This project was designed to provide *time*, through the provision of funded teacher release for teachers to *talk* and reflect on the difficulties identified by the Department of Education Training and the Arts (DETA) in the 2008 NAPLAN testing and Hillside's results in order to *plan* action that would lead to improved student outcomes. *Expert* input came from the researchers working with the teachers in the project. The sharing of expertise in a collaborative and supportive environment was designed to promote *motivation* within this professional learning community. In order to enable this process the project was enacted in four phases.

*Phase 1*: This first phase of the project involved the researchers introducing the participating teachers to the topic of teaching numeracy by discussing the current research literature in this area. The teachers then reflected on their school's NAPLAN results in light of a review conducted by DETA which analysed student responses. Teachers also examined the most recent NAPLAN assessments for both Years 5 and 7 in order to gain a sense of the type of tasks to which students were required to respond.

*Phase 2*: Teachers worked collaboratively to vision and then plan a series of lessons that were taught within a life-related context.

*Phase 3*: Teachers delivered their planned lessons with one lesson in the series for each teacher being video recorded. The lesson chosen was negotiated between the researchers and the teacher. Following each videoed lesson a semi-structured interview was conducted with the teacher.

Phase 4: This final phase involved a discussion of teachers' video recorded lessons. Commentary was provided by the teacher who taught the lesson on intended lesson outcomes and justification of enacted approaches as both teachers and the researchers viewed the video together. This was followed by a discussion between the teaching pair and the researchers which provided opportunity for a critique of the lesson.

Audio and video recordings from each of the phases were transcribed and then examined, in conjunction with other data, for evidence of changes or perturbations to a teacher's *zone of enactment*. Patterns of behaviour were identified initially through observation during the introductory phase of the project. Ongoing changes in behaviour

were identified through classroom observation and triangulated via post lesson semi-structured interviews. New understandings and changes to practice were confirmed during final discussion by re-examining transcripts at all phases of the project. The results from this study are now reported.

## Results and Analysis

### *Phase 1: Introduction and Preparation*

The researchers began the introductory session by outlining current research based understandings of best practice in teaching numeracy. After this presentation teachers were asked to review the 2009 NAPLAN numeracy tests for both Years 5 and 7 in order to identify the types of tasks to which students were required to respond. The purpose of this activity was to challenge teachers to reflect on their own teaching practice in the light of the demands placed on their students during the national testing regime. From this activity teachers noted that many questions were embedded in a context and that a number of tasks required students to engage in higher order thinking and problem solving. After some discussion the teachers decided the best way to assist their students on these tests, and also help them develop into numerate citizens, was to include additional open ended or investigatory activities which were embedded in life related contexts.

To support this direction the researchers outlined the data gathering procedures that would be used to assist them to reflect on their won practice. The prospect of being video recorded was of no concern to Julie. She held positive self-efficacy beliefs about her teaching ability and outlined how in a previous school her lessons were regularly video recorded and used as exemplars for pre-service teachers. In contrast, Stephanie was very reluctant to be video recorded. She believed that Julie was a better teacher and was worried that she was more likely to produce a lesson that would demonstrate what not to do. This indicated that Stephanie held low self-efficacy beliefs about her potential to produce a lesson comparable in quality with that of Julie even though neither teacher had previously made extensive use of investigatory and context driven approaches to teaching numeracy.

According to Millett and Bibby (2004) the teachers' *zone of enactment* is the area for potential and possibility. In this study Julie demonstrates both personal and professional self efficacy characteristics that have the potential to promote motivation, providing her with the capacity to engage in curriculum reform. For Stephanie, the new task of developing and delivering lessons on numeracy had pushed her into a state of *conscious incompetence* (Schratz, 2006) where considerable discomfort was experience. Consequently, the decision was made, by mutual consent between Stephanie and the research team, not to video her lesson although Stephanie did agree to have her lesson audio recorded. At this stage it appeared that Stephanie was less likely to engage in curriculum reform.

### *Phase 2: Planning*

Both teachers reported discussing their intended lesson approaches on a regular basis. These discussions proved to be a source of positive self-efficacy feedback for both teachers. They described how they both adapted their planned lessons following these discussions to provide purposeful open-ended investigations that would be of interest to their students while challenging their mathematical thinking. These two teachers are clearly changing the *situation* in which they work by stimulating each other's *zones of*

*enactment* through vicarious experiences. In particular, it can be argued that Julie's positive self-efficacy also gave her the confidence to support Stephanie in pushing the boundaries of her own *zone of enactment*. This in turn empowered Stephanie to make a contribution to Julie's intended lesson approaches reinforcing Julie's motivation and actions, extending her *zone of enactment*.

### *Phase 3: The Lessons*

Julie began her lesson by displaying six packs of different brands of toilet paper asking an open ended question by saying that she didn't know which pack was the best buy and needed her students' help to make a decision. Her students immediately became involved suggesting that she just compare the prices. In response, Julie asked them to provide her with information listed on the packs as she recorded it on the board. It didn't take long before a student realised that the pack contained different numbers of sheets per roll which led to calculations on price per sheet. Some students then noticed that the size of each sheet was different which lead them to calculating the area per pack and a follow-up comparison of price. The student then noted that some rolls were one-ply, others two-ply and still others three-ply. New calculations were conducted. Once these aspects of mathematical calculations were completed, Julie asked, "Well what is the best toilet paper for me to buy?" There was division in the classroom and some students claimed other aspects, such as comfort, needed to be considered. One student called out, "How much do you have to spend on toilet paper?" This lesson ended with Julie introducing the topic of budgeting.

Stephanie's lesson began with a list of questions posted on the whiteboard and a newspaper article which selected students read to the class. This article was critical of the Brisbane City Council for increasing parking meters to inner city residential areas from 2900 to 9100, netting an extra $16 million a year. The article went on to detail that these extra parking meters would be implemented over three phases. Stephanie directed her students to a list of questions on the whiteboard with the first question requiring the calculation of the increase in parking meters. The next question required the calculation of revenue raised per meter and then the money raised per phase of implementation. As these calculations were conducted the students were very surprised by the large amounts of money per meter. As these students had recently completed study on the responsibilities of the Brisbane City Council they began suggesting further increases to parking meters to fund local swimming pools and libraries. Although this activity was set in a life-related context the closed approach limited the potential for student generated follow-up investigations resulting in the task being constrained to one lesson.

### *Phase 4: Reflection, Discussion and Feedback*

This phase of the study involved the teacher pair and the researchers viewing Julie's video recorded lesson and listening to the audio tape of Stephanie's lesson. Prior to Julie's lesson being shown she explained to Stephanie and the researchers her objectives for the lesson and reflected on how she believed she had achieved her objectives. She felt that her students had enjoyed the lesson as indicated by requests for "more like that". At this point it became evident that the role played by the researchers had been instrumental in supporting Julie to experiment with a new teaching approach. After the initial interaction with the researchers, Julie had become convinced that her students would benefit if she made changes to her teaching practice. Julie's positive self-efficacy had enabled her to enact these changes. The proficiency of her performance and positive feedback from the

students and her learning community, which included Stephanie and the two researches, had changed the *situation* re-enforcing the changes she had made to her *zone of enactment*.

As Stephanie observed with focussed attention the video of Julie's lesson she made comments such at, "that's so clever", "look how those kids are eating out of your hand." When the video was stopped, Stephanie highlighted the points that were important for her. She explained, "Right from the beginning you gave the direction of the lesson over to the kids. You gave them the problem and the toilet paper rolls ... They could have given you the information in any order [a sense of fear of the unknown was evident here] ... I need to let go a bit [realisation of new learning] ... It is so engaging, just look at these kids [positive feedback]."

This pattern of discussion persisted throughout Stephanie's discussion of Julie's lesson. In particular, she noted the open-ended nature of Julie's task and its potential to lead into a range of mathematics topics compared to her own closed, one lesson approach. Also noteworthy was the fact that Stephanie chose not to criticise Julie's lesson in any way and referred only to positive aspects of the lesson that Stephanie thought she should marry with her own practice. In this way, Stephanie did not introduce any issues which might deintensify the momentum for curriculum reform Julie had gained within her *zone of enactment*. In addition, as Stephanie focused on the positive aspects of the lesson which she believed were achievable within her own practice, she reinforced the direction she had taken within her *zone of enactment*.

Interestingly, when Julie had the opportunity to critique the audio presentation of Stephanie's lesson, she adopted the same approach of only commenting on positive aspects of the lesson which Julie thought she could adopt in the future. This had the effect of positively influencing Stephanie's self-efficacy as she received positive feedback on her approach pushing her *zone of enactment* in the direction of the desired curriculum reform.

This session concluded with both teachers stating they would introduce further lessons of the type they had tried during the project and that they believed their students had engaged in learning in a way that they had not noticed when working with mathematics through traditional approaches.

## Conclusion

The positive feedback provided by both teachers on each others' attempts to implement curriculum reform was a very important influence on the self-efficacy of Julie and Stephanie. In this *situation* the rich interactions that were grounded in practice resulted in the teachers pushing the boundaries of their respective *zones of enactment*. These changes only took place because the project had provided the teachers with time to talk and the provision of expertise from outside the school, once the researchers were accepted into the teachers' learning community. The opportunity to view each others' classroom practice, facilitated via video recording, was also a critical factor in positively influencing each teacher's *zone of enactment*. This method has implications for approaches to teachers' professional learning as the difficulties of viewing another teacher's classroom within the context of the business of a school day means that, in general, teachers practice remains personal, private and not open to any form of critical interrogation. While the findings of this study are encouraging, further research is necessary to establish whether the approach adopted in this study leads to long term changes in practice. This is especially so given the short term nature of the intervention which challenges advice from the literature on the length of time require to effect permanent change to practice (e.g., Heirdsfield, Lamb, & Spry, 2010). In addition, the effects of negative feedback on teachers' zones of enactment

must also be documented in order to understand self-efficacy feedback cycles that inhibit rather than promote curriculum reform (Schratz, 2006).

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