Teaching mathematics in disadvantaged contexts: Success as a function of quality resources, quality teaching and quality professional learning

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Introduction

While it is acknowledged that many outside school factors contribute to students from disadvantaged contexts being unsuccessful, quality learning is strongly linked to quality teaching practices (Hattie, 2009). Internationally, education outcomes are a strong determinant of individual and community prosperity. As the level of education qualifications rises, the risk of being in poverty declines sharply and lifetime earnings increase (Lamb & McKenzie, 2001; Zappala, 2003). The four prevalent factors that align with disadvantaged contexts in Australia are: socioeconomic status and remoteness, Indigenity, English language proficiency, and disability (Gonski, Boston, Greiner, Lawrence, Scales, & Tannock, 2011). The more factors a community possesses the more disadvantaged it is considered. In Australia, the numeracy outcomes for students living in disadvantaged contexts are up to two years behind other Australian students, and the gap widens as these students progress through school (Australian Curriculum, a Assessment and Reporting Authority (ACARA), 2009). Thus, though quality learning for disadvantaged students remains an elusive challenge for many educational authorities, a way of addressing these concerns is to assist teachers to provide quality numeracy experiences for these students (Hattie, 2009).

RoleM (Representations, Oral language and Engagement in Mathematics) is a four-year longitudinal study situated in the first four years of schooling in some of the most disadvantaged contexts in Queensland. It is following a cohort of students from their first year of schooling (Foundation) through to the completion of Year 3. It is presently in its fourth year. RoleM aims to develop sequences of targeted numeracy learning experiences that are culturally appropriate, accessible and sustainable for these students. This paper draws on the experiences of one participating school, Dragon school, which has achieved outstanding numeracy gains for their students. Its particular goals are to share the professional learning journey of participating teachers and in particular changes to their teaching practice over a three-year period.

The research questions addressed in this paper are:

1. What are the effects on teachers' teaching practice of more than one year of professional learning in one school situated in a disadvantaged context?
2. How appropriate are the stages of (a) building teachers' confidence, (b) building students' confidence and (c) increasing expectations of their students to individual teachers situated in disadvantaged contexts?
3. How do these stages change for teachers from this school that participated over a three-year period?

Background

Dragon school, a Foundation — Year 7 school, is situated in a low socio-economic area of a large metropolitan city, and consists of students from culturally diverse backgrounds. Its Index of Community Socio-Educational Advantage (ICSEA) is approximately 900, 100 points below the state average. The ICSEA score for each school reflects the occupation and education of parents/carers, the socio-economic characteristics of the areas where students live, the proportion of students from language background other than English, as well as the proportion of Indigenous students enrolled at the school (ACARA, 2013). Dragon school comprises 450 students of whom 14% are Indigenous and 66% come from a language background other than English (ESL). Thus, it meets three of Gonski *et al.*'s (2011) criteria for disadvantage: situated in a low socio-economic status community, a high percentage of Indigenous students, and a very high percentage of ESL students. Australia is a mono-linguist culture where the vast majority of people only speak English, and English is the language used in nearly all school contexts. In addition, all Australian students sit for an annual literacy and numeracy test (NAPLAN). Over the three years of Dragon school's participation in RoleM, their Year 3 NAPLAN numeracy scores changed from 339 (350) to 368 (366) to 380 (360). The figures in brackets are the 'similar school scores' for each year (ACARA, 2013). This paper reports on the professional learning of Dragon school's early years teachers and the changes to their teaching practice in mathematics.

Disadvantaged Australian contexts

Traditionally disadvantaged contexts in Australia have been identified as contexts where there are high levels of unemployment and those that are employed tend to be on low incomes. But living below the poverty line does not necessarily mean that one has low standards of living. "Poverty line measures tend to belie the complexity and scope of disadvantage" (Price-Roberson, 2011, p. 2). Recently, there has been an acknowledgement that these indicators are simplistic and that community disadvantage is denoted by a complex cluster of factors including unemployment, low educational level, and drug

and alcohol abuse (Price-Robertson, 2011). Community disadvantage also is defined by its social and environmental factors such as weak social networks, poor role models, and relative lack of opportunity (Edwards, 2005; Vinson, 2007).

Schools in disadvantaged contexts share four common traits:

- They tend to be situated at the lowest levels of a variety of performance measures (*e.g.*, National and International tests of literacy and numeracy performance);
- They commonly possess poor management (Lupton, 2004);
- They have high staff turnover, and experience difficulties in attracting and retaining high quality teachers (Lyons, Cooksey, Parnell, & Pegg, 2006); and
- The teachers they tend to attract are inexperienced and lack a commitment to teaching in disadvantaged contexts (Heslop, 2011; Mills & Gale, 2010).

Low-income and minority students internationally seem to be disproportionately taught by underqualified teachers (Borman & Kimball, 2013). Thus maximising the mathematical achievement of students and supporting quality mathematical teaching in disadvantaged contexts is complex.

Teaching mathematics in disadvantaged contexts

Studies have shown that very few teachers entering these contexts feel prepared academically, culturally or professionally by their pre-service education to effectively teach disadvantaged students (Lyons *et al.*, 2006; MCEECDYA, 2011; White & Reid, 2008). In addition, due to the population demographics of Australia and the location of disadvantaged communities, many of these teachers feel professionally, socially and geographically isolated. Many are often unable to create highly effective instructional programs (Kent, 2004). Thus, mathematics teaching in disadvantaged contexts is often highly structured and repetitive with a high reliance on worksheets and lowered expectations with regard to student learning (Hewitson, 2007). Teachers in disadvantaged contexts posses few resources or have mentors to assist them to be effective. Yet, Gervasoni *et al.* (2010) assert that providing rich learning environments with specialised instruction for students in disadvantaged contexts is imperative to improving their mathematical learning outcomes. Hence, maximising the mathematical achievement of students in disadvantaged contexts consists of addressing two main dimensions, namely: (a) providing quality mathematics resources that support these students' learning; and (b) assisting teachers in disadvantaged contexts to implement quality instruction.

Quality mathematical resources

Underpinning the development of the RoleM mathematical resources to be used in disadvantaged contexts was a recognition that:

- Students' learn in a variety of ways;

- Classrooms have students who are at different stages in their learning of mathematics;
- Student engagement is closely associated with student learning;
- Classrooms in disadvantaged contexts are often poorly resourced;
- Teachers often have pre-conceived beliefs that these students are incapable of engaging in the main-stream curriculum; and
- Teachers are professionals with an understanding of what works and what does not work in their classroom contexts.

The principles of equitable teaching drove the creation of RoleM resources. This required ensuring that the resources are: conceptually orientated, open-ended to cater for the differential that exists in students' ability, of high cognitive demand, and are culturally appropriate (Boaler & Staples, 2008). The RoleM learning activities also encapsulated:

Learning pathways — providing a gradual progression along a learning path, with the teacher first modelling what is required, followed by students of similar ability working in groups and finally students working on an individual basis;

Integrated experiences — Involving listening, reading, writing, recording, manipulating, physically moving, and speaking about the concepts to enhance students' transference of skills;

Multi-representations — Using and linking concepts to a variety of mathematical representations including number lines, charts, concrete, and symbolic;

Language building — Encouraging students to move between home language, mathematical language, and Standard Australian English (SAE) as they communicate their mathematical learning;

Engaging and focussed — Ensuring that the materials were visually stimulating in conjunction with specifically focussed on the mathematical concept under consideration; and

Making connections — Linking resources to other mathematical concepts and to with students home and community environment.

(Frigo & Simpson, 2001; Jackson & Cobb, 2010; Warren *et al.*, 2009).

The following provides two explicit examples of how the RoleM resources captured these principles. Given that many students', in Dragon school, first language was not Australian Standard English and many were not engaged with learning mathematics, the two examples chosen relate to *Language Building* and *Engaging and Focussed*. Both examples are drawn from the Foundation learning activity relating to Subitising[1]. Foundation is the first year of formal schooling in Australia. *Language building* comprised four main components; (a) listing the mathematical vocabulary to use when implementing the task;

(b) an open ended question that encourages mathematical communication; (c) a word problem that required translating language; and (d) a multiple-choice question reflecting the type of communication commonly used in both National and International testing regimes (see Figure 1).

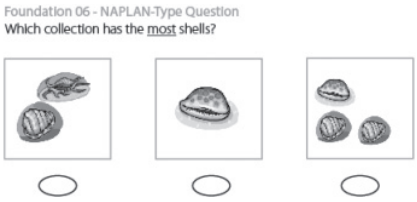
Mathematical language Six, Seven, Eight, Nine, Ten, is the same as, one more, one less, between, two more, two less, group, part, whole, and total.	*Open-ended task* Find all the cards that are more than five but less than ten. Tell me what the numbers would be? How many cards are there? What are the different ways you can work out the number of dots?
Word problem I had three stamps in front of me and Sarah gave me four more stamps. How many stamps do I have altogether? How did you work out your answer?	*Multiple choice question* 

Figure 1 — *Language Building* components of the Subitising learning experience

Engaging and focussed was exhibited in the concrete materials and representations that accompanied the learning activities. They were also conceptually relevant to the participating students. For example, in the context of Dragon school, two types of insects are of major concern. The first is the poisonous red back spider and the second is fire ants that are noted for their bite. Thus, subitising cards were created to reflect this context. The game they played was *swatting*[2] the spider or ant. Students worked in small groups and each was supplied with a *fly swatter*. Numbers were called and the first person to swat the insect 'won' that insect. At the end of the game, the person who had the most insects was declared the winner and handed the 'golden fly swatter'. Some of the cards used in the game are illustrated in figure 2.

Figure 2 — Red back spider and fire ant subitising cards

The RoleM resources consisted of purposively developed learning activities, concrete materials, digital materials and assessment tools. These were given to participating teachers three times throughout each year. The teachers were also supported by the RoleM website which aimed to support them to differentiate learning for their particular context.

Quality instruction

The quality of instruction is as imperative to enhancing student learning as is access to quality resources. Effective teachers know what to teach, and how to structure and organise this in the context of their particular students and circumstances (Askew, 2008). High quality lessons are structured and implemented in a way that enhances students' understanding of concepts and engages them in the learning (Weiss & Pasley, 2004). As Hattie (2003) shared, the most effective primary focus for improving students' learning involves augmenting students' affective and academic domains. Thus, high quality lessons are more likely to enhance students' understanding of concepts and engage them in the learning. These lessons also need to be situated in a context that invites students to interact purposively with the content, cater for the level of the learner, and tap into multiple pathways of development (Weiss & Pasely, 2004). Lampert *et al.* (2010) refer to these types of experiences as *ambitious teaching*. From their perspectives ambitious teaching incorporates three main dimensions: first, it supports students to solve cognitively demanding tasks; second, it orchestrates whole class discussions where students build on others' contributions to support their understanding of key ideas; and finally, it encourages students effectively to communicate their mathematical reasoning by using and making connections between multiple representations (Cobb & Jackson, 2011). One concern expressed in the literature with regard to these dimensions is the notion of equity (Boaler & Staples, 2008), and the social norms such a vision requires. Thus, it is suggested that teachers in socially disadvantaged contexts may need to make some accommodation in order for all students to participate. These include rephrasing and revoicing students' reasoning that may be expressed in informal and non-mathematical language, ensuring students are recognised as mathematically competent, and negotiating how to participate in all phases of the lesson (Jackson & Cobb, 2010).

Additionally, expert teachers have deep representations about teaching and learning. They have knowledge that is more integrated and are flexible in its use in the classroom. Expert teachers also take ownership of their lessons, changing and adding to them as needs may emerge and goals change (Borko & Livingston, 1989). Professional Development (PD) that supports teachers' professional learning is a powerful influence in assisting teachers to become experts (Hattie, 2003). Hence, professional learning is seen as a key to improving disadvantaged students' educational outcomes. Thus, a strategy that is seen as the most important agenda schools can adopt to raise students' achievement is high quality professional learning for teachers (Hattie, 2009).

Quality professional learning

Limited professional learning occurs in one-off professional development events. Professional learning is dependent on the interactions that occur between the learner, the context, and what is learned (Gravani, 2007; Jarvis & Parker, 2005, Murrell, 2001). Thus, it happens over a long time, and is a contextualized holistic experience (Vygostky, 1978). Integral to continued professional learning is the notion of the Zone of Proximal Devel-

opment (ZPD) (Vygotsky, 1978). ZPD is defined as an individual's potential capacity for development through the assistance of a more knowing person (Vygotsky, 1978). The significance of ZPD is that it determines the lower and upper bounds of the zone within which PD instruction and teacher learning should be directed. In the lower bounds, formal PD sessions provide important information that teachers need to know about mathematical content, changes in the curriculum, innovative teaching strategies, and using resources effectively. However, instruction is only efficacious when it goes beyond the notion of simply assisting a person to acquire a particular set of skills or knowledge. Such instruction enables learners to extend themselves through active engagement, exploration and investigation of teaching and learning concepts and activities. In the upper bounds of the ZPD, the *more knowing person*, or *expert*, provides support for teachers through mentoring and scaffolding as these teachers are guided towards competent and accomplished practices (Brockbank & McGill, 2006). A purported result of such a model is that the learner is better placed to independently implement innovative pedagogical practices across all curriculum areas after the 'expert' has withdrawn.

The nature and quality of a teacher's reflection influences the depth and scope of learning as much as that of the learner's capability (Phillips, 2008; Wells, 1999). Thus, when extensive teacher reflection is combined with action, students' experiences are transformed into learning (Schön, 1983). Teacher reflection serves both an instrumental and a critical function (van Manen, 1977). The former encourages teachers to reflect on teaching and learning problems that arise in their classrooms, and formulate practical plans that may solve the problem. Reflection as a critical function provides cognitive and affective insights that can challenge assumptions teachers hold about such things as: the nature of teaching and themselves as teacher, and their students' ability as learners in mathematics (van Manen, 1977). As Dewey stated, genuine thinking only occurs "when there is a tendency to doubt" (as cited in Garrison, 2006, p. 3). With ongoing support, teachers and 'experts' become co-constructors of knowledge moving within and beyond each others' ZPD.

The RoleM Professional Learning model

The RoleM Professional Learning model is a socio-constructivist model based on the theories of Vygotsky (1978) and was built on the Transformative Teaching in the Early Years Model (TTEYM). TTEYM drew from both traditional and job-embedded professional development models to inform teaching practice in the early years (see Warren, 2009). Five principles drawn from the literature also underpin the model: teachers' professional learning is more evident when continuing PD includes a focus on classroom practicalities (*e.g.*, Porter, Garet, Desimone, Birman, & Yoon, 2000); PD emphasising general teachers' knowledge and teaching competencies known to improve student learning, requires teachers to reconsider their current practices (*e.g.*, Timperley, 2008); PD more meaningful to teachers when it is situated within the context of their workplace (Webster-Wright, 2009); the most significant changes in teacher beliefs and attitudes occur when teachers have multiple opportunities to absorb new information, put it into prac-

tices and observe improved student learning outcomes (*e.g.*, Darling-Hammond, 1997); and, resourcing has an impact on a teacher's capacity to effectively teach mathematics (*e.g.*, Clements, 2004). We argue that Professional Development days are components of professional learning. For effective professional learning to occur teachers, together with experts, need to trial ideas in their classroom contexts and reflect on the student learning that has occurred.

The RoleM Professional Learning model (RPL) involves teachers in self-reflection as they trial approaches and resources in their classrooms to improve the quality of their teaching practice. It is based on the view that teachers have the ability to improve their practice by trialling *proven* effective learning experiences, and through continuous cycles of on-the-job reflections and discussions with experts from the field (Castle & Aichele, 1994). Figure 3 presents the key components together with the key focuses of the professional learning model.

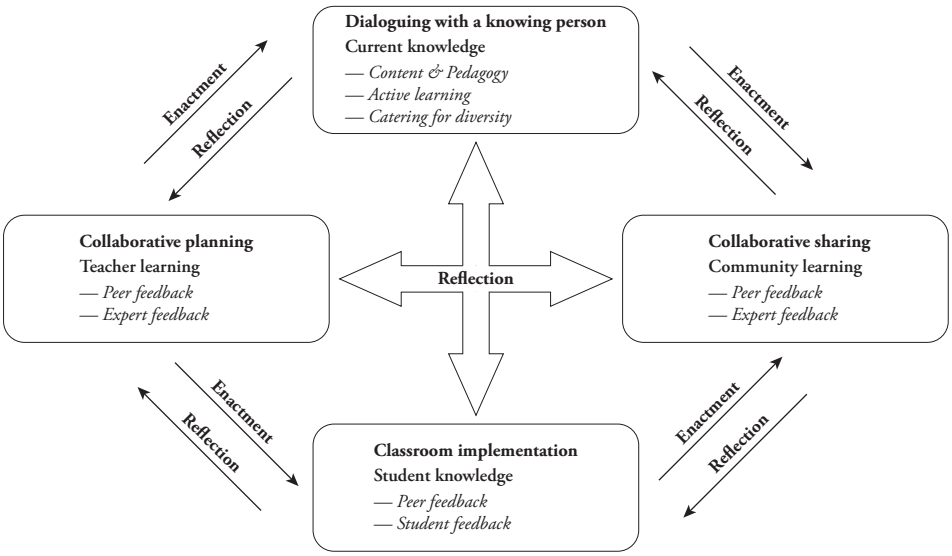


Figure 3 — The RoleM Professional Learning model

The cycle begins with a professional development day (Dialoguing with experts) where activities are presented, modelled, and discussed with a particular focus on implementation in the classroom context. Teachers return to the classroom and begin to trial ideas. Approximately three weeks after the PD day, experts visit teachers' classrooms and work collaboratively with them to address identified issues (Collaborative Sharing — follow up visits). Teachers then continue to implement the activities in their classrooms. Finally, teachers and experts work together to plan the next phase in students' learning (Collaborative Planning), and the cycle begins again. Throughout the model there are reflections between each stage (PD day, collaborative sharing, classroom implementation, collaborative planning stages) and across all stages (depicted in the centre of the figure).

The literature delineates a number of measurable outcomes that are commonly utilised to determine the effectiveness of professional learning. These outcomes fall into three broad categories. The first pertains to the teachers' affective domain (Guskey, 2003). This is hinged on the premise that if teachers enjoy the professional development session they are more likely to implement the ideas and activities in their classrooms (Salpeter, 2003). The second is associated with measurable gains in students' achievement (Kent, 2004). This is underpinned by the notion that the implementation of the ideas presented at the professional development will result in greater learning outcomes for students. Hence for professional learning to be considered, effective positive changes in students' outcomes should occur. Finally, effective professional learning is seen as resulting in changed teacher behaviour, especially in terms of their classroom practice. This is related to the finding that teachers' classroom practices and students' background have a similar effect on students' learning outcomes (Wenglinsky, 2002). All of these have implications for how professional learning occurs and the support that makes it happen.

Based on the teacher data of the first year of RoleM Professional Learning involving 30 teachers and 90 interview transcripts (Warren & Quine, 2013) we argue that teachers' professional learning occurs in three stages, with each building on the previous stage, and each having different focuses. These stages with their accompanying focuses are:

- *Building teachers' confidence (BTC)*: developing their knowledge of the language of mathematics, developing an understanding of how to effectively use *proven* mathematics learning experiences;
- *Building students' confidence (BSC)*: gaining more general mathematics pedagogical knowledge, gaining a deeper understanding of how to differentiate learning;
- *Increasing expectations for their students (IES)*: gaining a deeper understanding of mathematical content knowledge, gaining a deeper understanding of pedagogical knowledge.

Research Design

Sequence of events

The RoleM Professional Learning model (RPL) was implemented three times each year, constituting three cycles of the model. Hence the learning activities for each Year level were split into three components. At the commencement of each year, a pre-test was conducted with all participating students. These tests were developed and administered by especially trained members of the RoleM team. Each cycle commenced with a Professional Development day (Dialoguing with a knowing person). At these days members of the RoleM team distributed the RoleM resources applicable to the focus of the learning activities for that component. Together with teachers, the team discussed the learning activities, and the accompanying content and pedagogical knowledge required for their successful implementation. Three weeks after each PD day, members of the RoleM team visited each

classroom (Collaborative sharing — follow up visit (FV)). The focus of these visits was to model in the classroom the activities that teachers were experiencing difficulties with, and to ascertain what aspects of the resources and materials were successful and what needed to be adjusted. These visits were responsive to the needs of the participating teachers, and included addressing particular learning difficulties students were experiencing. Three weeks after each visit, interviews were conducted with participating teachers. This sequence of events occurred three times each year. At the completion of each year members of the RoleM team conducted a post-test with all participating students to determine overall mathematics improvement for the year. The particular focus of this paper is on the teachers and their teaching of mathematics.

Participants

For the purpose of this article, the data is drawn from the first three years of the project (2010–2012). In all, 12 teachers from Dragon school participated in RPL over this period. Of these 12 teachers, four participated over a two-year period (Teacher D, E, H and I). For example, Teacher D (Year 1 teacher) participated in the 2010 PD (three sessions) and FV (three visits), and in the 2011 PD (three sessions) and FV (three visits). The sample comprised both beginning teachers and experienced teachers. Table 1 presents the participating teachers' year level, their teaching experience, and the RPL they participated in.

Table 1 — Teacher Experience, Year level, and RoleM Professional Learning conducted over three years

Teacher	Experience	Year level	Focus of RPL
A	6 years	Foundation	2010 (Foundation)
B	7 years	Foundation	2010 (Foundation)
C	3 years	Foundation	2010 (Foundation)
D	1 year	Year 1	2010 (Foundation) & 2011 (Year 1)
E	7 years	Year 1	2010 (Foundation) & 2011 (Year 1)
F	1 year	Year 1	2011 (Year 1)
G	1 year	Year 2	2011 (Year 1)
H	3 years	Year 2	2011 (Year 1) & 2012 (Year 2)
I	18 years	Year 2	2011 (Year 1) & 2012 (Year 2)
J	2 years	Year 2	2012 (Year 2)
K	25 years	Year 3	2012 (Year 2)
L	8 years	Year 3	2012 (Year 2)

As can be seen from the above table, the sequence for the RPL was 2010 (Foundation year), 2011 (Year 1) and 2012 (Year 2).

Instrument development and data analysis

Participating teachers were interviewed three times each year. The duration of each interview was approximately 30 minutes and was conducted via telephone by the same researcher. This researcher did not conduct the professional development or follow up visit. All interviews were audio-recorded and transcribed for analysis. Given that the data analysed for this paper are from the self-reporting data gathered from participating teachers' interviews, its validity relies on the interviewees being 'good' informants. All participants willingly participated in the interviews, and were aware that only de-identified data, that is removal of information that would directly link data to a particular individual, would be shared with members of the RoleM team. There were four themes that were explored through the interview: Professional learning, teaching mathematics, teacher confidence, and perception of student learning. The questions asked were broad questions, such as, *What do you consider to be the greatest difficulty for you to overcome in relation to teaching mathematics?* In this type of interview, validity and reliability depend on conveying the same meaning across the interviews (Denzin, 1989). Thus, where required, the words used in the questions were changed to ensure consistency in meaning. In addition, probing proved an invaluable tool to ensure reliability of data (Hutchinson & Skodol-Wilson, 1992).

The systematic approach of the constant comparative method was used to analyse the interview data. This form of analysis focuses on generating theory, thus a grounded methodological approach was used to analyse the data. To manage these documents a coding system was utilised to determine how to examine, cluster, and integrate themes (Creswell, 2008). The coding procedure was flexible and adopted three approaches: open coding, selective coding and axial coding. Selective coding was employed to examine the interrelationships between the codes to determine theories (Creswell, 2008). Three key themes emerged from the data. These were: gains that they had made (a) from the RoleM professional learning, (b) in their teaching practice of mathematics, and (c) in their knowledge of mathematics. References made by teachers with regard to students' learning and their confidence in teaching mathematics tended to fall under these three themes. Hence, the following section presents the analysis of the data organised under these themes.

Results

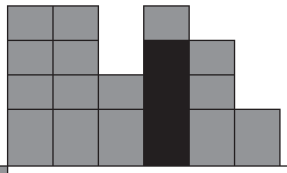
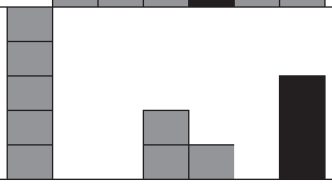
Teacher participants

The next sections present the analysis of the data relating to each theme together with the sub-themes that emerged from the interviews. The data are presented in the order in which the themes emerged in the interviews. Each teacher's interview data are also coded according to whether it was their first or second year in RPL. In the second row of tables 2, 4 and 6, the first, second and third interviews are represented as 1, 2, and 3. The column graphs represent the frequency of teachers who referred to that particular sub-theme in their interview.

Theme 1 — Teachers' gains from the RoleM professional learning

Six key sub-themes were identified by teachers with regard to what they gained from their participation in the professional development days and follow up visits. Table 2 summarises these themes, together with representative quotes for each. The themes are presented in the order of most agreement to least agreement.

Table 2 — Frequency of teacher agreement with the sub-themes for gains from PD and FV

Sub-theme	2010 1	2	3	2011 1	2	3	2012 1	2	3
Increased understanding of how to teach mathematics *Through watching and participating in the demonstrations at the PD, I became aware of the different ways that I could teach mathematics with a hands-on approach.*									
Demonstrations by experts and resources provided *I love the RoleM resources and it was very helpful seeing the experts use them. It was so nice to have resources ready for us to use in our classrooms.*									
Enhanced own learning of mathematics *I thought I knew about place value until I did the PD and found there was more to be learnt. It has enhanced my own understanding of mathematics.*									
Increased understanding of how students learn mathematics *I never realised some of misconceptions that students can have and seeing how to address some of them now has helped immensely.*									
Increased confidence to teach mathematics *Being a new teacher, my confidence in teaching mathematics was low but since doing the PD, I am now much more confident.*									
Sharing with colleagues beyond the PD *I have brought RoleM back to our school and have been sharing the resources and the information gained with other teachers.*									

Note: The column graphs represent the frequency of teachers who referred to that particular sub-theme in their interview; ▒ represents teachers participating in their first year of RPL; and ■ teachers participating in their second year of RPL

There are clear shifts in the themes in the table, with the 2010 participants primarily focusing on the first two subthemes, and the other two years including examples of how RoleM PD days and follow up visits had enhanced their own learning of mathematics, and increased their understanding of how students learn mathematics. In addition, only one teacher reported that she had shared the resources and information gained with other teachers at their school. The shifts are easier to see when we compare the sub-themes that emerged for each interview across the years; these are presented in table 3.

Table 3 — Comparison of the sub-themes that emerged from each interview in relation to PD gains across the three years

Interview 1 Theme Movements				
2010	Demonstrations and resources			
2011	Demonstrations and resources	**How to teach mathematics**	**How students learn mathematics**	
2012	Demonstrations and resources	How to teach mathematics	How students learn mathematics	**Mathematical concepts**
Interview 2 Theme Movements				
2010	How to teach mathematics	Confidence in teaching mathematics		
2011	How to teach mathematics	Confidence in teaching mathematics	**Mathematical concepts**	
2012				Mathematical concepts
Interview 3 Theme Movements				
2010	How to teach mathematics	Confidence in teaching mathematics		
2011	How to teach mathematics	Confidence in teaching mathematics	**Mathematical concepts**	
2012	Mathematical concepts	**How students learn mathematics**	**Sharing with others**	

Note: The bolded components indicate the introduction of a new sub-theme.

As the RPL progressed across the three years at Dragon school, the gains teachers made from the PD sessions and FV widened and deepened. For example, examining the first interview for each year: in 2010 teachers' gains were purely in the areas of the superficial aspects of the PD, the resources and demonstration of the activities; in 2011 their gains included understandings of classroom practice (an increased awareness of how to teach mathematics, and support student learning); and, in 2012 their gains included an increased understanding of mathematical concepts. Thus they moved from superficial aspects, to pedagogical aspects to finally purported changes in their content knowledge. We conjecture that their starting point for their engagement in RPL progressively moved

over the three years, and this movement reflected their increased 'buy into' their perceived effectiveness of the program. This shift occurred across the three interviews for the three years. In fact, it was not until Interview 3 of 2012 that teachers shared (a) they had gained an increased understanding of how students learn (4 out of 5), and (b) a willingness to share what they themselves had learned with their peers who were not involved in RoleM (1 out of 5).

Table 4 — Frequency of teacher agreement with the sub-themes for their practice of teaching mathematics

Sub-theme	2010			2011			2012		
	1	2	3	1	2	3	1	2	3
Delivery of mathematics to students My instructional strategies have improved and I am also able to differentiate activities for my students' needs. My planning and sequencing for mathematics has improved.									
More hands-on activities *I now use less [fewer] worksheets when teaching mathematics. My students are really engaged when using the hands-on materials.*									
Required higher expectations from students *At the beginning of the year, I didn't think my students would be able to cope with the maths, but I now have higher expectations of them.*									
Increased time teaching mathematics *The time I spend with my mathematics lessons have increased substantially.*									
Group rotations *I never used to do group rotations, it was too hard, now can I successfully do this with my students.*									
Reflective practice *As a teacher, I am now more reflective and think about how I can improve my mathematics teaching.*									

Note: The column graphs represent the frequency of teachers who referred to that particular sub-theme in their interview; ▒ represents teachers participating in their first year of RPL; and ■ teachers participating in their second year of RPL

Theme 2 — Teachers' gains in their teaching practice of mathematics

During each year of RPL, how these teachers taught mathematics also changed. Table 4 presents the 6 sub-themes relating to this theme together with representative quotes and the frequency of agreement with each sub-theme.

The most common sub-theme that emerged from the interviews was improvement in their delivery of mathematics followed by the use of more hands-on activities and requiring higher expectations from their students. Table 5 presents the sub-themes that emerged from each interview across the three years.

Table 5 — Comparison of the sub-themes that emerged from each interview in relation to teaching practice across the three years

Interview 1 Moved From					
2010	Delivery of mathematics to students				
2011	**More hands--on activities**				
2012	Delivery of mathematics to students	More hands-on activities	**Reflective practice**		
Interview 2 Moved From					
2010					
2011	Delivery of mathematics to students	More hands-on activities	**Higher expectations from students**	**Time teaching mathematics**	**Group rotations**
2012	Delivery of mathematics to students	More hands-on activities	Group rotations		
Interview 3 Moved From					
2010	Delivery of mathematics to students				
2011	Delivery of mathematics to students	**Required higher expectations from students**			
2012	Delivery of mathematics to students	Required higher expectations from students	**Time teaching mathematics**		

Note: The bolded components indicate the introduction of a new sub-theme.

In 2010, teachers had little to say about how their practice changed across the whole year. They certainly were not referring to students' learning in their interviews. Participating teachers from 2011 and 2012 were much more explicit with regard to how their practice had changed, and towards the end of each year began to discuss how they were

now setting higher expectations for their students. In 2012 the level of agreement to this theme had increased to 4 out of 5 teachers discussing how their expectations for their students had increased. Even though two teachers in their first interview mentioned reflective practice in 2011, it should be noted that these teachers had participated in RPL for two consecutive years.

Theme 3 — Teachers' gains in their knowledge of mathematics

Table 6 presents the sub-themes highlighted by teachers with regards to gains they made in their understanding of mathematics, in particular the content knowledge of mathematics, in their classroom over the three years of the implementation of the RoleM Professional Learning model.

Table 6 — Frequency of teacher agreement with the sub-themes for knowledge of mathematics

	2010			2011			2012		
Sub-theme	1	2	3	1	2	3	1	2	3
Increased understanding of the mathematical content and what the students should be learning *I now understand the content that needs to be taught to students.*									
Increased understanding of mathematical language *I didn't understand how important Mathematical language was for student learning and understanding of mathematical concepts. Since focusing on it in class, the students are now really using well.*									
Deepened understanding of mathematics *I now have a deeper understanding of mathematics. I now understand how concepts relate to each other.*									

Note: The column graphs represent the frequency of teachers who referred to that particular sub-theme in their interview; ▒ represents teachers participating in their first year of RPL; and ■ teachers participating in their second year of RPL

The gains in knowledge were mainly in the dimensions of understanding the mathematical content and understanding mathematical language. With regard to the gains they made in the knowledge of mathematics, the data exhibited similar trends as delineated to the gains they made from PD and FV. That is, their gains widened and deepened. Their starting points became more complex at the start of each year, and this complexity was sustained throughout each year. Table 7 presents the subthemes that emerged from each interview across the three years.

Table 7 — Comparison of the sub-themes that emerged from each interview in relation to knowledge of mathematics across the three years

Interview 1 Moved From			
2010			
2011	**Deepened understanding**		
2012		**Mathematical language**	**Mathematical content knowledge**
Interview 2 Moved From			
2010	Mathematical language		
2011	**Deepened understanding**	**Mathematical content knowledge**	
2012	Deepened understanding	Mathematical language	Mathematical content knowledge
Interview 3 Moved From			
2010	Mathematical language	Mathematical content knowledge	
2011	Mathematical language	Mathematical content knowledge	
2012			

Note: The bolded components indicate the introduction of a new sub-theme.

The 2010 cohort did not appear to engage with the mathematical content until the second interview, and then they progressed from mathematical language (Interview 2) to mathematical content knowledge (Interview 3). By contrast, the 2012 cohort began the year with a focus on mathematical language and mathematical content knowledge, and sustained this throughout the year.

Trends across the three tables show an overall movement from a focus on theme 1, to theme 2 to theme 3 over the three years of the RPL. In 2010 the percentage of teachers who identified various sub-themes in their interviews were: Theme 1 (46%), Theme 2 (15%) and Theme 3 (38%) with two thirds of comments for Theme 3 being in the area of mathematical language and none pertaining to deepened understanding of mathematics. In 2013 the percentage of teachers who identified various sub-themes in their interviews were: Theme 1 (29%), Theme 2 (47%) and Theme 3 (23%) with the comments for Theme 3 being spread over the three sub-themes (Deepened understanding, mathematical content knowledge and mathematical language). They had moved from talking about the PD days and follow up visits and what they gained from these, to focusing more on their own classroom practice and sharing their gains in their own knowledge about mathematics.

Discussion and Conclusion

Effects of professional learning on teaching practices

The effects of the RoleM Professional Learning model are efficacious for supporting teachers' professional learning and supporting their teaching practices. Teachers identified that there were particular factors that influenced their professional learning. Initially in the early stages of the RPL model, after teachers participated in the first PD, they identified that their gains were mainly around themes relating to the superficial dimensions of RoleM. Teachers' gains were predominately about the resources provided by the project and observed demonstrations from experts. While quality resources and demonstrations are an important component of professional learning, these alone will not improve students' learning outcomes nor result in quality teaching practices, that is teachers who augment students' affective and academic domains (Hattie, 2003) and exhibit *ambitious teaching* (Lampert *et al.*, 2010). Often superficial gains are the types of gains that occur when teachers attend on off professional development days (Boyle, Lamprianou, & Bolye, 2005). Conversely, participating in year-long professional development gives teachers the opportunity to develop a better understanding in terms of their own pedagogical knowledge and content knowledge of mathematics. Both of these dimensions are deemed important to improving teachers' teaching practices (Askew, 2008). The results of RPL showed that once teachers developed a deeper understanding of mathematics and the ways of teaching mathematics, it impacted on their expectations for their students' learning. They were more capable of structuring their teaching practices to suit the context of their students (Weiss & Parsley, 2004). Understanding where all students are *at* in their learning is a key dimension of highly effective instructional programs (Kent, 2004). Therefore, it is the intertwined relationship of quality resources and quality professional learning that results in quality improvements in the learning outcomes for students from disadvantaged contexts. But this quality professional learning is not instantaneous and requires ongoing long-term support from experts in the field.

Stages of teacher change in practice during the professional learning

While participating in the RPL model we conjecture that teachers transition through five stages of professional learning as they move towards becoming expert teachers. We also contend that expert teachers exhibit effective teaching practices, and thus these stages are aligned with changes not only in how they view their students but also changes in how they teach. As teachers move through the stages they deepen their understanding, change their practice, and finally recognise how these changes impact on students' learning. The initial stage focuses on gaining teachers' interest in the RoleM professional learning model. This was achieved by the provision of quality resources, quality activities that teachers could immediately use in their classrooms, in conjunction with experts demonstrating how to implement these activities using hands-on resources. These aspects are particularly crucial for gaining the interest of teachers working in disadvantaged

contexts, contexts where there is high staff turnover and minimal expertise to call on for help (Lyons *et al.*, 2006).

The second stage involves heightening teachers' engagement, an important stage for teachers to experience. This stage commenced with teachers independently trialling the activities and resources in their classroom environment. As they trialled the activities they observed their students becoming more engaged in the mathematics, with a resultant shift in how these teachers delivered mathematics to their students. Thus, the third stage is changes in teachers' pedagogical knowledge. Experts modeling the activities in their classroom had a substantial impact on this dimension. This gave teachers the opportunity to draw on the experts' experiences and re-engage with the resources/activities they were experiencing difficulty with in their classroom context. As Dewey stated, genuine thinking only occurs "when there is a tendency to doubt" (as cited in Garrison, 2006, p. 3). With ongoing support, teachers and *experts* become co-constructors of knowledge moving within and beyond each others' ZPD. During this stage there was a marked shift away from using worksheets in mathematics to providing more engaging activities, and differentiating the activities to cater for the diverse range of students. Catering for the diversity that commonly exists in disadvantaged contexts resulted in teachers beginning to observe *all* their students' learning. For many this was a revelation, as often teachers working in disadvantaged contexts hold a belief that these students are not capable of achieving (Hewiston, 2007).

Stage four links to changes in teachers' content knowledge. As teachers gained a deeper understanding of the mathematics, they applied this to both the high-achieving students and students at risk in their everyday teaching. Teachers were able to easily adapt learning activities to cater for students on an individual basis during lessons, and began to exhibit the traits of expert teachers; teachers who have knowledge that is more integrated and are flexible in its use in the classroom (Borko & Livingston, 1989). During this stage teachers also shared their experiences, both successes and failures, with others. Importantly, this stage resulted in a more reflective practitioner.

The final stage was teachers holding higher expectations for students. At this stage teachers had begun to identify that they have an influence over their students' learning. During this stage, the influences that often are equated with students not achieving (*e.g.*, external school factors, absenteeism, behaviour, language) were no longer an excuse for students not making gains. Expert teachers also take ownership of their lessons, changing and adding to them as needs may emerge and goals change (Borko & Livingston, 1989). Expert teachers set high expectations for students from disadvantaged contexts and know what to teach, and how to structure and organise this in the context of their particular students and circumstances (Askew, 2008). However, teachers must move through the previous stages before this occurs. Figure 4 displays a proposed professional learning trajectory with the stages teachers/progress through, as they become experts in teaching mathematics in disadvantaged contexts.

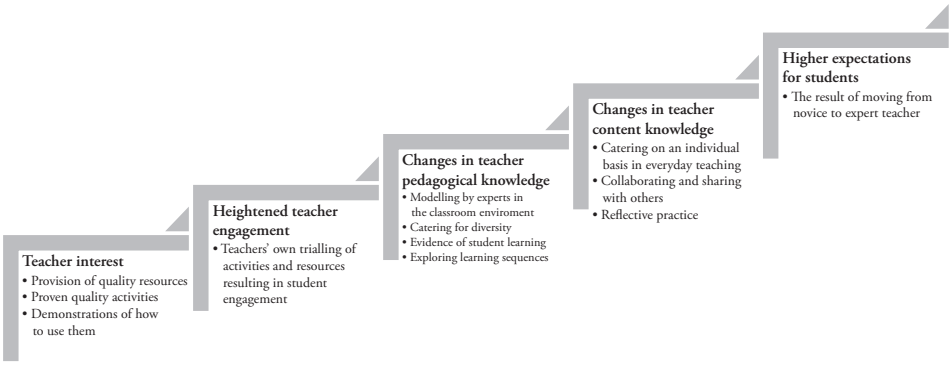


Figure 4 — Conjectured RoleM professional learning trajectory for the formation of expert teachers teaching in disadvantaged contexts

This trajectory aligns with the stages identified in our previous research with regard to teachers effectively teaching in disadvantaged contexts (Warren & Quine, 2013), namely, first building teachers' confidence (teacher interest and heightened teacher engagement), second building students' confidence (changes in teachers' pedagogical knowledge), and finally increasing expectations for students (changes in teachers' content knowledge and higher expectations for students). The results of their students' learning also suggests that teachers' teaching practices became more effective in these disadvantaged contexts as they moved through the stages. The stimulus for these changed practices were: first, providing quality resources specifically developed for engaging students in disadvantaged contexts together with demonstrations on how to use them; second, teachers trialling the resources in their own classroom; third, experts modelling how to use the quality resources in the teachers' classroom, fourth, teachers reflecting on the modelling and the pedagogical and content knowledge embedded in the quality resources; and, finally teachers restructuring their practices to cater for the higher expectations they now hold for their students.

The benefits of a three year focus on professional learning in mathematics

There are major benefits to providing support for teachers' professional learning in one particular subject area over a three year period, especially if it is planned and focused. This is best evidenced by the conjectured trajectory as delineated in figure 4. In the initial year of professional learning many teachers begin to see the changes in students' learning. In the first six months teachers are coming to terms with their own understandings of mathematics and effective pedagogy. Towards the end of this year they begin to see the positive effect these changes have on the students' learning. But more importantly, in the second year, the starting point for new participating teachers on the professional learning trajectory is further advanced than the previous year's cohort. There are two proposed reasons for this. First, while it is these teachers' first year participating in RPL, their student cohort had already experienced RoleM in the previous year. Thus, as students enter

their classrooms, these students have already engaged with learning mathematics and experienced prior success, something that is quite rare in disadvantaged contexts. Second, the teachers from the first year of RPL have shared the success they have had in their own classroom with their peers. As a consequence, the new cohort of teachers buys into the professional learning faster. They already believe that the program is worthwhile. It is in the third year that these changes and positive outcomes are entrenched. Thus, while one year's focus on teachers' professional learning of mathematics begins to shift in teachers' mathematical teaching, the shift is greater (and more sustainable) in schools that have participated for longer periods. Fundamental to these gains is the provision of quality resources and quality conversations with experts in the field.

Implications for the professional learning of teachers working in disadvantaged contexts

The results from this research have implications for professional learning for teachers teaching mathematics in disadvantaged contexts. If the effective teachers' primary focus is on student learning in terms of their affective domain and academic achievement (Hattie, 2003), the professional learning needs to occur in disadvantaged contexts over an extended period, as it was only in the second year of participation that student learning became a primary focus for these teachers. In addition, it was only after a three-year period that teachers saw themselves as capable of structuring and organising the learning to cater for their particular students and circumstances, the hallmarks of effective teachers (Hattie, 2003). From this, the five principles underpinning the RoleM professional learning model (teacher knowledge to improve students' learning; professional development situated in the context; providing multiple opportunities to change teacher beliefs and attitudes; resourcing for effective teaching) translates to building teacher confidence, building student confidence and increasing expectations for students' learning. In disadvantaged contexts where teachers are consistently moving in and out, an approach of focusing on a new subject area in each progressive year is ineffective. It results in a constant process of *reinventing* the wheel and constantly starting at the beginning of the professional learning trajectory. We conjecture a more effective approach is an ongoing focus on the key subjects areas of literacy and mathematics, the two areas that are known to lead to future employment and future educational opportunities (Lamb & McKenzie, 2001; Zappala, 2003), and this is accompanied with quality resources and quality professional learning.

Notes

[1] Subitisation relies upon the recognition of difference using perceptual or spatiotemporal cues — cues that are not numerical. Fundamental to this theory is the notion of subitising, the ability to quantify something without really counting (either internally or externally). Instead, things are quantified by looking, allowing the number of objects in a small collection to be determined rapidly.

[2] Swatting is to hit something with a sharp blow or with a flat object, such as a fly swat.

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Abstract. Students from disadvantaged contexts in Australia continue to be 1 to 2 years behind other students in both International and National measures for numeracy. The results of research clearly indicate that quality teachers make a difference. This study focuses on the impact that a model of professional learning, the RoleM Professional Learning model (RPL) had on one school over a three-year period. The participating teachers (n = 12) taught in the first three years of school (Foundation to Year 2, 4.5 – 8 year old). To ascertain the effectiveness of RPL, the teachers were interviewed three times a year. The results indicate that quality teaching is related to the provision of quality resources and quality professional learning. As teachers move towards exhibiting the characteristics of expert teachers they progress

through five stages and it takes at least two years for this progression to occur. Fundamental to these gains is the collaboration with experts.

Keywords: Disadvantaged contexts; early years mathematics; professional learning; teacher change; teaching practice.

Resumo. Na Austrália, os alunos provenientes de meios socialmente desfavorecidos continuam a revelar um atraso de um ou dois anos relativamente aos colegas oriundos de outros meios no que se refere a testes de numeracia, tanto nacionais como internacionais. Os resultados da investigação indicam claramente que a qualidade dos professores faz a diferença. Este estudo foca-se no impacto de um modelo de aprendizagem profissional, o modelo RoleM (RPL), numa escola, ao longo de três anos. Os professores participantes (n = 12) lecionavam os primeiros três anos de escolaridade (desde a Educação Pré-escolar ao segundo ano; alunos de 4/5 a 8 anos de idade). Para avaliar a eficácia do RPL, os professores foram entrevistados três vezes por ano. Os resultados indicam que um ensino de qualidade se relaciona com a disponibilização de recursos de qualidade e com uma aprendizagem profissional igualmente de qualidade. À medida que os professores evoluem no sentido de manifestarem características de professores peritos, torna-se evidente que eles progridem segundo cinco estádios. Além disso, são precisos pelo menos dois anos para que esta progressão possa ocorrer. A colaboração com especialistas revela-se fundamental para que estes ganhos possam existir.

Palavras-chave: Meios socialmente desfavorecidos; matemática nos primeiros anos; aprendizagem profissional; mudança; prática de ensino.

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