Investigating Teacher Change Through Professional Learning Around the Teaching of Primary Mathematics

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A thesis submitted for the degree of *Doctor of Philosophy* at
Monash University in 2017
Faculty of Education

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Abstract

Nationally and internationally teacher professional learning is deemed to be an important part of any teacher's career. It is recognised and reported upon in international studies such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). The challenge is to identify professional learning that is both effective and sustainable. In Australia, where this research was conducted, professional learning is a requirement for maintaining teacher registration as well as ensuring currency in the profession.

This research reports on a teacher professional learning intervention conducted in mathematics classrooms in a regional primary school. Perhaps unusually, this experience utilised a triad model of professional learning over a period of months conducted with a whole-school teaching staff, including the principal, on-site at a small school. The aim of the research is to identify a teacher professional learning model that can be used as a vehicle for teacher change; and to explore the potential implications of using the selected model to lead change in teacher practice.

The professional learning intervention consisted of: the development and use of a triad model; a series of three week-long intensive professional learning sessions held at the school over a number of months; and the involvement of a mathematics educator, the whole teaching staff, and the principal. This combination of components sought to have teachers observe, discuss and reflect on teaching practice and create opportunity for change in the primary mathematics classroom. The study is design-based research located in a classroom setting, within a wider school context. The data collection for this project is interpretive and consists of both qualitative and quantitative processes.

Teacher change was evident in the intervention data collection, which was analysed using a framework based on Shulman's (1986b) six key elements of pedagogical content knowledge. Two teacher stories provided further evidence of change in teacher practice. Reflections from me, as the researcher and mathematics educator of the triad, indicate further implications for teacher professional learning and possible wider applications for other school situations.

This research in teacher professional learning found three main influences on teacher change through the professional learning intervention. The first is the structure of the intervention itself. In this study, the intervention included the use of triads, utilising elements of collaboration, targeted observation, reflective practices complemented with personal goal setting. The second

influence is the principal and the third influence is the on-going nature of the experience on site at the school.

This research contributes to policy, practice and theory in the field of teacher professional learning specifically in the use of triads. It also contributes to the body of research about teacher change and trust. A number of important insights are identified, including: teacher professional learning is effective when it is personalised; can lead to change in teacher practice when conducted on-site in teachers' own classrooms; it is possible to conduct focused professional learning over a period of time across a whole school; the principal (school leader) has an important role in teacher professional learning.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Date: 11th September 2017

Publications during enrolment

Rogers, P. (2006). Mathematical teacher professional development incorporating an external critical friend. In P. Grootenboer, R. Zevenbergen, & M. Chinnappan (Eds.), *Identities, cultures, and learning spaces* (Proceedings of the 29th annual conference of the Mathematics Education Research Group of Australasia, Canberra), pp. 631–640. Adelaide MERGA.

Rogers, P. (2007). Teacher professional learning in mathematics: An example of a change process. In J. Watson & K. Beswick (Eds.), *Mathematics: Essential research, essential practice* (Proceedings of the 30th annual conference of the Mathematics Education Research Group of Australasia, Hobart), pp. 447– 454. Adelaide: MERGA.

Acknowledgements

To my supervisor Professor Peter Sullivan, what can I say? It has been a journey with many deviations and challenges. I thank you sincerely for your help and support over this journey, particularly over the last year, with all the emotional challenges that it brought for both of us. You are indeed a man of patience, and I have truly enjoyed and valued our discussions, not only about my thesis and research but mathematics education in general. You have been a wise mentor.

This journey began at La Trobe University, and then moved for us both, to Monash University. The length of the study, with my leave to have a baby, move the family interstate a number of times and then finally the experience of divorce, illustrates that study such as this occurs with so many external influences. I believe the research demonstrates its relevance to the field of teacher professional learning both then, now and into the future, and that is the reason I have preserved with the work over the extended period of time.

To my second supervisor Carly Sawatzki, thank you for your willingness to step in and assist me in the last sprint to the line. I appreciate your feedback and advice. I have felt very supported in the last few months. Likewise, Associate Professor Joseph Seyram Agbenyega, thank you for your belief and support in my ability to complete this.

To my workplace and colleagues at the Australian Council for Educational Research, I thank you for your support and genuine interest in my work and the provision of time to get this study complete. This has included advice and support from Jim Spithill and Ron Martin.

I would like to thank Pam Firth (Detail Devil Editing Services), who provided a professional copyediting service according to the guidelines laid out in the university-endorsed, national *Guidelines for Editing Research Theses* (Institute of Professional Editors, 2010).

To a number of my friends, Annita Allman I thank you for your willingness to listen and discuss my work with interest. Karen Felstead, this is a journey we have shared together, professionally and as friends, and it is your turn next. Cathy Adamson, I could not have done the last few months without your family's support and friendship.

No-one truly knows how challenging and difficult this has been except three people: my children; Veronica, Daisy and Cooper. You have been with me the whole journey of this study, and this last year you have really stepped up and supported your mum. You have been patient and understanding when I have been doing 'study'. I truly couldn't have done this without you. I hope you

appreciate and understand the value of learning and perseverance. I have loved the conversations with each of you about my project and I hope I have shown you that we are indeed a formidable team.

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AAMT	Australian Association of Mathematics Teachers
ABS	Australian Bureau of Statistics
ACARA	Australian Curriculum, Assessment and Reporting Authority
AGQTP	Australian Government Quality Teacher Programme
AITSL	Australian Institute of Teaching and School Leadership
DEECD	Department of Education and Early Childhood Development
DEEWR	Department of Education, Employment and Workplace Relations
DEST	Australian Government Department of Education, Science and Training
MSP	maths science partnerships
NRC	National Research Council
PCK	pedagogical content knowledge
PISA	Programme for International Student Assessment
PST	Preservice Teacher
TALIS	Teaching and Learning International Survey
TIMSS	Trends in International Mathematics and Science Study
UN	United Nations
VIT	Victorian Institute of Teaching

CHAPTER 1: INTRODUCTION

The introductory chapter is divided into five sections. The first two sections explore my background experience, my passion for teacher professional learning, and my journey to the study. The third section discusses the importance of teacher professional learning in Australia and introduces the Australian Government Quality Teacher Programme (AGQTP) in which the study is situated. I then present the research aims and questions. Finally, I summarise the main points of the chapter.

1.1 The Importance of Professional Learning to the Researcher

My passion is teacher professional learning as a vehicle for change in teacher practice. I began my career as a secondary mathematics and science teacher, teaching in a range of classrooms. I was a professional learning 'junkie', attending conferences, workshops, and training to expand my own understanding about the art of teaching and learning. I quickly started to feel that often the professional learning I was attending was not meeting my needs; it was not engaging and in many cases, it was irrelevant to my environment, my classroom, and my students. While the professional learning looked good on paper, it did not have the depth that allowed me to develop my own practice.

I moved away from classroom teaching to roles in teacher professional organisations, in which I was then conducting the professional learning myself. In many cases, I devised, wrote, and presented the different professional learning programmes. Teachers would attend and engage, but often I felt they were looking for the 'quick fix', and deeper discussions about practice were not being held. I began to question whether this style of professional learning was really 'making a difference'. I asked, 'Were teachers returning to their classrooms and making changes, or were the experiences and materials something that sat on a shelf?'

In an attempt to 'make a difference', I moved into tertiary education and began working with preservice teachers (PSTs). I hoped that I could change PSTs' perceptions about the teaching of mathematics leading to a change in the way mathematics was being taught in schools, at both primary and secondary levels. PSTs engaged with the classes and the learning of ideas and practices they may not have been familiar with, and this seemed to be reflected in their assessments. However, when viewing these PSTs on placement, their practice of teaching mathematics was not any different to what I had experienced in schools 20 years earlier, so it seemed they were not implementing what they were learning. I began to deeply consider how to have teachers think about their practice and possibly make change. I felt that observing each other and also reflecting on their own teaching practice was a natural place to begin. This led to my consideration of research in this area.

1.2 The Impetus for the Research

Two things happened that were pivotal prior to my research beginning. The first was a marking experience and the second was a discussion.

During my time as a sessional academic, I completed some marking of a secondary mathematics assessment for a research study. I was shocked. At that time, I had not taught in a secondary classroom for more than 10 years. I could not believe that the presentation and content of the assessment had not changed from when I was teaching in schools. In my roles and work, I had been involved in many innovative programmes and delivered these as professional learning, but it appeared that teaching and learning in secondary mathematics classes may not have changed. Contexts of questions were still the same, the presentation of questions were still the same, and the general ‘feel’ of the assessment was the same, even with significant moves to technology. I again experienced this when I was viewing PSTs on placement. I began asking, how can student results change or improve if teaching practice does not change?

The second thing that happened was a discussion I had with a principal at a school in late 2005. The principal was looking for a consultant to work with the school on an AGTQP they were applying for in 2006. The principal wanted professional learning that would focus on teacher change, and mathematics was the focus area. Rather than a consultant, it became apparent the school needed a mathematics educator, someone with mathematics education experience rather than a pure mathematics background. During the discussion, it became clear this professional learning would be conducted on-site in the teachers’ own classrooms. The discussion concentrated around teachers as the learners in their own classrooms with their students.

I jumped at the chance to be involved for two reasons. The first was the project; although broad and the actual structure was not fully defined, it was about teacher professional learning and wanting to change teachers’ practice, something I was passionate about. The professional learning was to be set on-site and in teachers’ classrooms. This was something I had not been involved in before. It was for the second reason that I jumped at the opportunity, as there were so many new possible learning experiences for me as well as the teachers. These included working with a rural school, working with the whole staff of a school, working closely with a principal, and working with a school over an extended period. These different aspects guided the reading and design of the study. While it is acknowledged that the research in the school took place in 2006, it is still deemed relevant, as I have used the current contexts such as the Australian Curriculum, Australian Institute for Teaching and School Leadership [AITSL] Standards and Victorian Institute of Teaching [VIT] requirements to contextualise the research to demonstrate its current relevance.

The next two sections present the context of the research both nationally and at the school level to provide a broader context for the study. The first of these looks at the national context.

1.3 The Context of the Research: Nationally

In Australia, where the research was conducted, teacher professional learning has never been more important. Teachers are held accountable through many mechanisms, including students' results via national assessments, evidence of student improvement, and parent feedback. There has been a move to a national curriculum with the development of the Australian Curriculum, of which mathematics is one of the domain areas. The development of the Australian Curriculum is

> guided by the Melbourne Declaration on Educational Goals for Young Australians . . . [which] emphasises the importance of knowledge, understanding and skills of learning areas, general capabilities and cross-curriculum priorities as the basis for a curriculum designed to support 21st century learning. (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2015, para. 1)

The development of the Australian Curriculum has been accompanied with the development of Australian Professional Standards for Teachers.

It is stated in the Australian Professional Standards for Teachers (Australian Institute for Teaching and School Leadership [AITSL], 2015a) that these standards 'guide professional learning, practice and engagement, facilitate(s) the improvement of teacher quality and contribute(s) positively to the public standing of the profession' (AITSL, 2015a, para. 1). The key elements of quality teaching are described in the standards, and they articulate what teachers are expected to know and be able to do at the four career stages: graduate, proficient, highly accomplished, and lead. Table 1.1 shows the three domains of teaching and the seven standards. It can be seen that Standard 6 relates directly to professional learning.

Table 1.1: *AITSL Domains of Teaching and the Teaching Professional Standards (AITSL, 2015a)*

Domains of teaching	**Standards**
Professional Knowledge	1. Know students and how they learn. 2. Know the content and how to teach it.
Professional Practice	3. Plan for and implement effective teaching and learning. 4. Create and maintain supportive and safe learning environments. 5. Assess, provide feedback and report on student learning.
Professional Engagement	6. Engage in professional learning. 7. Engage professionally with colleagues, parents/ carers and the community.

Professional learning is an essential element of teacher registration and in Victoria, where the research took place. The Victorian Institute of Teaching (VIT) states to successfully renew teacher registration each year; it is a requirement to have 'completed at least 20 hours of professional development activity that references the Australian Professional Standards for Teachers' (VIT, 2015a, para. 3). Hence, the need for teachers to review, critique, and to continually improve their practice is seen as important, at both the national level and as a component of registration. Supporting the Australian Professional Standards for Teachers, an Australian Charter for the Professional Learning of Teachers and School Leaders (AITSL, 2012b has also been developed.

The Australian Charter for the Professional Learning of Teachers and School Leaders provides information about professional learning for schools. It emphasises the importance of professional learning of all teachers and leaders as an ongoing activity throughout people's careers.

It provides detail about characteristics of effective professional learning and the importance of developing a professional learning culture. The Australian Curriculum, the Australian Professional Standards for Teachers, and the Australian Charter for the Professional Learning of Teachers and School Leaders all have an impact on classroom teaching and learning and in shaping teacher professional learning.

1.4 The Context of the Research: Australian Government Quality Teacher Programme

The previous section presented the national context for teacher professional learning, examining the overarching documentation of different accreditation bodies and organisations. This section presents the AGQTP, which is the context in which the study was conducted.

The AGQTP was an Australian federal government flagship initiative supporting quality teaching and school leadership, with $300 million allocated to the programme to the end of 2009. The programme was established in 2000, and since then, more than ‘240 000 professional development opportunities have been taken up by teachers’ (Australian Government Department of Education, Science and Training [DEST] 2007, para. 1). It was stated the programme’s ‘primary function is to fund professional learning activities for teachers under agreements with state and territory government and non-government education authorities’ (DEST, 2007, para. 1).

The AGQTP had three elements:

- State and Territory projects which were professional learning activities for teachers and school leaders delivered via agreements with state and territory government and non-government education authorities;
- National projects which were initiatives undertaken at a national level, addressing current or high priority teaching and professional learning issues;
- Teaching Australia which was established to give a “voice” to the teaching profession and to advance teaching in Australia. (DEST, 2007, para. 3)

The programme’s initial two objectives were

1. to update and improve teachers’ skills and understanding in priority areas (literacy, numeracy, mathematics, science, information technology and vocational education); and
2. to enhance the status of teaching in government and non-government schools. (DEST, 2007, para. 1)

Following an evaluation, the objectives of the 2005 to 2009 phases of the AGQTP were updated to include:

- to equip teachers with the skills and knowledge needed for teaching in the 21st Century;
- to provide national leadership in high priority areas of teacher professional learning needs; and
- to improve the professional standing of school teachers and leaders. (DEST, 2007, para. 4)

It was reported in 2006 that 180 professional learning activities were to take place across Australia in the state and territory areas, and these would involve more than 40,000 teachers. Activities covered priority areas including literacy, numeracy, leadership, information and communications technology (ICT), and general pedagogy. It was found that since the AGQTP inception, two types of subprojects had become evident: those that were explicitly content focused and those designed to set up a process for more locally determined activity. The initiative of the project of the research falls under the state and territory activities that focus on the content within a professional learning model. The design of the research and the project was both informed by and constrained by the AGQTP.[1]

1.5 The Research Aims and Questions

Both the national focus on teacher professional learning and the AGQTP created the context of the study. The aims of the research that guided the reading and the design of the study were

1. to draw on educational research to understand the importance of influences such as school location and school leadership on teacher professional learning;
2. to identify a teacher professional learning model that could be used as a vehicle for teacher change; and
3. to explore the potential implications of using the selected teacher professional learning model to lead change in teacher practice.

To address these aims, the following three questions, when answered, may describe the possible teacher change in classroom practice through professional learning in the primary mathematics classroom.

[1] Note: The AGQTP was discontinued at the end of 2013.

1. What changes are identified in teacher knowledge, beliefs, and practices as the result of a structured collaborative teacher professional learning model in a primary mathematics setting?
2. What factors are identified as influencing teacher professional learning as a result of the structured collaborative teacher professional learning model in a primary mathematics setting?
3. What are the implications for informing mathematics teaching professional learning?

In summary, Section 1.1 of this chapter presented my personal interest in teacher professional learning and my own journey through education, leading to the impetus for the research presented in Section 1.2. Section 1.3 outlined the national context for the research with teacher professional learning being a focus for national and state organisations, including those of teacher registration. Section 1.4 outlined the AGQTP as the project within which the research was framed. Section 1.5 presented the research aims and questions for this work.

The next two chapters summarise some of the research literature that informs the project. Chapter 2 presents the overall themes of teacher knowledge of the teaching of mathematics, as well as the beliefs surrounding these. Chapter 3 focuses on teacher professional learning: what it is, and how it is affected.

CHAPTER 2: LITERATURE REVIEW ABOUT THE TEACHING OF MATHEMATICS

This chapter presents in six sections a review of literature about teacher knowledge of the teaching of mathematics. Section 2.1 identifies the importance of mathematics and examines the perceived difference between numeracy and mathematics. Section 2.2 presents the context of mathematics teaching. Section 2.3 explores the importance of teachers' own understanding of mathematics content and the relevance of this in their teaching. This leads into Section 2.4, teacher pedagogical knowledge and teacher pedagogical content knowledge. Sections 2.5 and 2.6 explore teacher beliefs and teacher change. Section 2.7 summarises the implications of each section on the proposed study.

2.1 Numeracy and Mathematics Learning

This section identifies the importance of mathematics globally, nationally, and when considering teacher skills. 'Lifelong learning' is a term widely used in education. Chapman and Aspin (1997) explored the broader viewpoint of lifelong learning as the growth and development of a human being within a participant democracy as a result of influences of economic change and development. This includes the expansion of one's own skills, competences, and own cognitive repertoire. In education, economic change, development, and expectations can have a direct impact on classrooms as education can be seen as a vehicle to facilitate the development of a higher skilled workforce, a more informed democracy and inclusive society which could lead to more rewarding lives of citizens. Forming part of that learning is mathematics and numeracy, and the second part of this section explores the difference and tension between the terms of mathematics and numeracy.

2.1.1 The importance of mathematics: Globally

The importance of lifelong learning is acknowledged worldwide as a priority, and there are global efforts to meet these aims. It is clearly identified as the fourth goal of the United Nations (UN) sustainable development goals (SDGs), which state the need to 'ensure inclusive and equitable quality education for all and promote lifelong learning opportunities for all' (UN, 2015, para. 1). The first target of this goal, 4.1, is to 'ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes', and indicator 4.1.1 identifies the aim of having

> Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex. (UN, 2015, para. 3)

Within the 4.1.1 indicator, mathematics is identified as a content area, along with reading, as requiring a minimum proficiency level. This emphasis on mathematics is also reflected in major studies such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), where mathematics is one of the domains in each. The PISA study states that 'policy makers and educators alike attach great importance to mathematics education' (Thomson, De Bortoli, & Buckley, 2012 p. 323). This global identification in the importance of mathematics is reflected nationally.

2.1.2 The importance of mathematics: Nationally

As well as globally, the importance of mathematics is reflected in Australian national and state government policies and initiatives. The Australian Government Department of Education, Employment and Workplace Relations (DEEWR, 2012) states, 'Quality education means starting with foundation skills such as literacy and numeracy, being taught by high-quality teachers, and supporting disadvantaged students' (para. 6) and three aspects addressing disadvantage, supporting teachers and school leaders, while improving literacy and numeracy form the three main partnerships between state and federal governments (DEEWR, 2012). Across the period of the research, some of the Australian national government initiatives to address priorities in numeracy and mathematics learning have included the National Literacy and Numeracy Programme, the National Literacy and Numeracy Benchmarks; the Literacy, Numeracy and Special Learning Needs programme; as well as projects such as the National Numeracy Review, the AGQTP, and the Smarter Schools National Partnerships.

This acknowledgement of the importance of mathematics education is also evident in statements and initiatives from the Victorian State Government, Department of Education and Early Childhood Development (DEECD). The DEECD (2012a) states, 'For all Victorian students to have the best opportunities possible, it is essential for educators, schools and the system to maintain and extend a focus on literacy and numeracy education as the foundation for success in all other areas' (2012, para. 1). A central aim through these programmes and initiatives at all levels of government is to 'improve the quality and supply of specialist teachers to ensure our students can develop their skills to the highest level' (Department of Premier and Cabinet, 2008, p. 1), and a key outcome is improved mathematics learning. A number of previous DEECD initiatives involving numeracy have included the Literacy and Numeracy 6–18 Month Strategy: P–10 Improvement Schedule for School leaders; the Key Characteristics of Effective Numeracy Teaching P–6 and 7–10; and Numeracy Teaching within Domains.

2.1.3 The importance of mathematics: Teacher skills

Not only is the importance of mathematics learning highlighted for students, but it is seen as an area of importance in teacher skills, as well. The understanding of mathematics is seen as a foundational skill in teacher education, with at least one quarter of a year of equivalent full-time study load in a 4-year teaching degree dedicated to learning about the mathematics/numeracy discipline, specific curriculum, and pedagogical studies related to mathematics (AITSL, 2015b). PSTs are also required to pass a minimum standards test to indicate they possess 'levels of personal literacy and numeracy broadly equivalent to the top 30% of the population' (AITSL, 2015b, p. 12); thus, not only an understanding of mathematics and how to teach mathematics is important, but also a teacher's personal ability in mathematics. AITSL also emphasises the importance of understanding of mathematics/numeracy in the Australian Professional Standards for Teachers, which are a set of seven standards divided into three domains. Each standard is detailed with focus areas and then descriptors. Standard 2: Know the content and how to teach it, specifically identifies the requirements for teachers to

> apply knowledge and understanding of effective teaching strategies to support students' literacy and numeracy achievement, regardless of their specific content area of expertise. (AITSL, 2015b, para. 5)

These aspects of teacher understanding of mathematics/numeracy, teacher ability to apply this in other contexts, and the requirement for their own personal level of numeracy indicate the importance of mathematics in education.

This section has so far presented the importance of mathematics globally, nationally, and with respect to teacher skills. It will now explore the difference between mathematics and numeracy, as these terms appear to be used in different ways within this broad discussion.

2.1.4 The difference between mathematics and numeracy

Already it can be seen in the titles of programmes and policy documents that the terms mathematics and numeracy are used in different ways.

> There is a diversity of opinions expressed on the nature of numeracy, ranging from those of some mathematicians who claim that numeracy does not exist, to some educators who claim it is synonymous with mathematics; and others who argue that the term "numeracy" refers just to the use of mathematics in practical contexts. (Sullivan, 2011, p. 17)

The following discusses numeracy and then mathematics.

Numeracy is defined in the Australian Curriculum as that which

> encompasses the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations. It involves students "recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully" (ACARA, 2015, para. 1)

In the Australian Curriculum, it is indicated that numeracy is used across the whole curriculum and identified accordingly in curriculum documents (ACARA, 2015; Australian Association of Mathematics Teachers [AAMT], 1998). It appears that

> being numerate means having the confidence and skill to use numbers and mathematical approaches in all aspects of life—at work, in practical everyday activities at home and beyond, as consumers, in managing our finances, as parents helping our children learn, as patients making sense of health information, as citizens understanding the world about us. (National Numeracy, 2017, para. 1)

This is similar to

> numeracy [which] involves a disposition and willingness: . . . to use, in context, a combination of: underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic); mathematical thinking and strategies; general thinking skills; [and] grounded appreciation of context. (AAMT, 1998, p. 1)

This definition of numeracy resulted from extensive AAMT membership consultation, including a special purpose conference. It seems numeracy is the application, use, and ability to interpret mathematics in different contexts, both at school and more widely (Perso, 2011; Ljungdahl, 2009).

In contrast, mathematics, according to the Australian Curriculum, is the 'thing' that is applied into different situations (ACARA, 2015, para. 2). Mathematics is seen as a school subject, timetabled, particularly at secondary school, whereas numeracy is not (Stephens, 2009). Mathematics is abstract and provides absolute truths about numerical and non-numerical relationships (Steen, 1998), so it appears that mathematics is seen as a discipline. In TIMSS, mathematics is related to the intended and taught curriculum (Thomson, Wernert, O'Grady, & Rodrigues, 2016), reinforcing the notion of mathematics as a discipline. Moursund (n.d.) divided mathematics into three categories, acknowledging there is overlap of the categories: mathematics as a human endeavour, mathematics as a discipline, and mathematics as an interdisciplinary language and tool. It is in Moursund's description of mathematics as a human endeavour and mathematics as an interdisciplinary language and tool that a link to numeracy becomes evident. This link between numeracy and mathematics is also seen in PISA where mathematical literacy is measured by a mathematically literate student being one who recognises the role that 'mathematics plays in the world in order to make well-founded judgments and decisions needed by constructive, engaged and reflective citizens' (Organisation for Economic Co-operation and Development [OECD], 2016, para. 1).

So, it does appear that one cannot exist without the other:

> Numeracy is closely related to mathematics. Without a solid grounding in mathematical concepts and procedures, there can be no numeracy. On the other hand, knowledge of mathematical concepts and procedures alone is not enough to guarantee numeracy. (Stephens, 2009, p. 6)

Sullivan (2011) states,

> The term 'numeracy' was used to encapsulate and include all of the elements of practical mathematics, but it made the distinction that numeracy is different from the learning of the specialised mathematics that forms part of the goals of schooling. (p. 18)

It may therefore be helpful to think of numeracy as a key outcome of how mathematics is taught and learned, something that is acquired and integrated with what students learn in their other school subjects and in their wider experiences both in school and out of school.

In summary, this section presented the value of mathematics and numeracy at a global and national level. This created a justification for the study in researching professional learning in the field of mathematics.

This section also presented the importance of mathematics in relation to teacher skills, reinforcing the justification for study in this area of professional learning.

The final part of this section explored the tension between the use of the terms mathematics and numeracy. This was to develop my understanding of the use of the language for the duration of the study. Section 2.2 of this chapter presents an overview of mathematics teaching, specifically in the Australian context.

2.2 Mathematics Teaching

This section examines mathematics teaching. The first part of this section locates mathematics teaching within the framework of the Australian Professional Standards for Teachers (the Standards). The second part describes the AAMT overlay, with the AAMT Standards for Excellence framework. The third part of this section explores the idiosyncrasies of mathematics teaching.

2.2.1 Mathematics teaching and the Australian Professional Standards for Teachers

AITSL outlines a set of professional standards for Australian teachers (AITSL, 2014). This is a set of seven standards, which describe what teachers are expected to know and be able to do within the profession. The Standards are interconnected and illustrate the complexities of teaching. Table 1.1 shows these grouped in three domains: professional knowledge, professional practice, and professional engagement. Descriptors are provided for each standard, describing the different expectations of teachers' career stages: graduate, proficient, highly accomplished, and lead. The intent of the Standards is to provide a 'framework for teachers' career-long professional growth' (AAMT, 2006, para. 1).

For the purpose of this work, the definition of proficient teacher was used, and any discussions around the Standards will use this as a minimum as there were no graduate teachers on staff at the time of the project. AITSL (2014) defines proficient teachers as those who meet the 'requirements for full registration through demonstrating achievement of the seven Standards at this level' (AITSL, 2014, para. 1).

2.2.2 AAMT Standards for Excellence

AAMT developed a similar set of standards for teachers, which provide the mathematics overlay to the AITSL standards. This was initially developed between 1999 and 2002 and then reviewed and updated in 2006.

The AAMT set of standards represent the national consensus of the teaching profession and describe the knowledge, skills, and attributes required for effective teaching of mathematics. Like the AITSL standards, the AAMT standards are organised into three domains: professional knowledge, professional attributes, and professional practice.

Similar to the AITSL standards, Table 2.1 shows the AAMT standards listed against each domain of teaching.

Table 2.1: *The AAMT Domains of Teaching and the Teaching Professional Standards (AAMT, 2006)*

Domains of Teaching	**Standards**	
Professional Knowledge	1.1	Knowledge of students
	1.2	Knowledge of mathematics
	1.3	Knowledge of students learning of mathematics
	2.1	Personal attributes
Professional Attributes	2.2	Personal professional learning
	2.3	Community responsibilities
Professional Engagement	3.1	The learning environment
	3.2	Planning for learning
	3.3	Teaching in action
	3.4	Assessment

Examining Tables 1.1 and 2.1, similarities can be seen in the presentation of the structure of the domains and the standards with a different numbering system between the two. Two of the domains are titled the same, with differences in the number and content of standards. The other domains, professional practice (AITSL) and professional attributes (AAMT), have different standard titles. The AAMT standards have a specific focus on mathematics content, but there is an overlap between some of the AITSL and AAMT standards in these two domains.

In summary, this section presented the formalised standards of both AITSL and AAMT. The next section explores the features that make mathematics teaching unique.

2.2.3 The teaching of mathematics

There is a common perception that mathematics teaching and the teaching of other content areas are widely different. It is difficult to locate research that identifies exactly what makes mathematics teaching different from other content areas. Much of the research has tended to focus on student learning in mathematics classrooms and teacher knowledge of the content (Boaler, 2000), but as stated by Hurrell (2013), 'If society requires effective learning then effective teaching is necessary' (p. 54), so an understanding of the difference is required.

Mathematics learning and language learning seem to have similarities (Carbine, 2013). Carbine acknowledged that mathematics and science appear to develop logical–analytical intelligence, as defined by Gardner's (1993) theory of multiple intelligences, more so than a verbal–linguistic intelligence, arguing, however, that mathematics also has a large component of language within the content area. Carbine (2013) stated that the difference between mathematics and English classes is in the way they are taught and identifies the mathematics classroom as focused on 'problem solving, group work, discussion of multiple strategies, and skills practice through interactive modes' (para. 3), where getting the answer right, often by completing a calculation process, is as important as being able to explain the process.

It seems that teaching of the content itself is the difference. 'What constitutes good teaching is consistently controversial and will remain controversial' (Loef Frank, Kazemi, & Battey, 2007, p. 226). Teaching is a complex environment requiring participating, extracting and interpreting what students know, and considering students' learning trajectories, each complicated by the teacher's individual knowledge and beliefs (Loef Frank et al., 2007). This is overlaid with the difference between mathematics and numeracy and varying policies and research around the area of mathematics teaching. Grootenboer and Zevenbergen (2008) stated 'mathematical pedagogy is fundamentally different from other subject pedagogies, because the nature of practices of mathematics are fundamentally different from other disciplines' (p. 245). Sullivan (2011) presented two perspectives on the goals of mathematics teaching: 'On one side of the debate, commentators argue for the need to intertwine conventional discipline-based learning with practical perspectives, while those on the other side of the debate emphasise specifically mathematical issues in mathematical learning' (p. 3). Mathematics teaching is indeed more than just content; it is the complexities of teaching itself, combined with different ways of approaching teaching of the content, as well.

Ball (2003) stated that teaching mathematics is complex. It not only requires a 'respect for the integrity of the discipline' (p. 4) but also an understanding of mathematical connections and how mathematics develops as it is learned, which then needs to be interpreted for another person (a student) so that it is understood. Ball (2003) identified the following as skills of a mathematics teacher:

- Design mathematically accurate explanations that are comprehensible and useful for students;

- Use mathematically appropriate and comprehensible definitions;
- Represent ideas carefully, mapping between a physical or graphical model, the symbolic notation, and the operation or process;
- Interpret and make mathematical and pedagogical judgments about students' questions, solutions, problems, and insights (both predictable and unusual);
- Be able to respond productively to students' mathematical questions and curiosities;
- Make judgments about the mathematical quality of instructional materials and modify as necessary;
- Be able to pose good mathematical questions and problems that are productive for students' learning;
- Assess students' mathematics learning and take next steps. (p. 6)

Ball (2003) also identified other knowledge and skills that are important for mathematics teachers:

- Representing and connecting representations (e.g., symbols, graphs, geometric models);
- Mathematical language and definitions;
- Mathematical reasoning and justification;
- Good sense about mathematical precision; and
- Mathematical curiosity and interest. (p. 7)

Mathematics teaching is more than just taking mathematical knowledge and passing it on to students (Ball, 1990; Cobb, Wood, Yackel, & McNeal, 1992; Crockett, 2002; Grootenboer & Zevenbergen, 2008):

> What the teacher says and does is interpreted by the students in the context of their own experiences, and the message they hear and interpret may not be the same as the message that the teacher intended. Given this perspective, teaching cannot therefore be about the teacher filling the heads of the students with mathematical knowledge, but interacting with them while they engage with mathematics ideas for themselves. (Sullivan, 2011, p. 1)

This combination of knowledge of content and requirement of practical skills, accompanied with different views of teaching and then further complicated with different interpretations of these processes, reflects the complex and varied nature of mathematics teaching.

In summary, this section presented the two existing teaching standards frameworks for Australian teachers and specifically teachers of mathematics. This informed the study by creating an understanding of the environment and expectations within which teachers are working.

The second part of this section explored the idiosyncrasies of mathematics teaching and whether, in fact, it is different to other types of teaching. This deepened my understanding of mathematics teaching, highlighting that it is more than a textbook or purely content. This informed the classroom work with the teachers as part of this study.

Section 2.3 uses this overview of mathematics teaching as the starting point to further explore teacher mathematical knowledge. The section continues to link to the Australian Professional Standards for Teachers, but considers the importance of mathematical content in teacher learning and the impact of this on students.

2.3 Teacher Mathematical Knowledge

Section 2.2 examined mathematics teaching. This included the frameworks that teachers in Australia work within and the idiosyncrasies of mathematics teaching. This section delves into teacher mathematical knowledge. The first part presents the importance of mathematics content in teaching. The second part relates this knowledge to the Australian Professional Standards for Teachers. The third part presents the effect of teacher content knowledge on students. The fourth part identifies the nature of mathematics content being taught, and the final part presents the argument that teacher mathematical knowledge is more than just content.

The knowledge base for teachers is complex and includes 'all the required cognitive knowledge for creating effective teaching and learning environments' (OECD, 2014, p. 5). It includes teaching skills, knowledge about teaching, knowledge about the content and curriculum to be taught, knowledge of how to teach particular content, knowledge of the students and the wider context of education, and knowledge of the educational environment. All these forms of knowledge interact, overlap, and integrate in many ways.

Shulman (1986a) identified three different kinds of content knowledge: subject matter knowledge, pedagogical content knowledge, and curriculum. These aspects of knowledge interact and connect in different ways, depending on the environment, learning situation, and students. This reflects the complexity of teaching and its integrated nature. Shulman (1986a) defined subject matter knowledge as the amount and organisation of the knowledge of the particular content area (mathematics in this case) from the teacher's perspective and understanding. It includes both facts and concepts of the domain, but also why these facts and concepts are true and how they are generated and then structured within the discipline. Pedagogical content knowledge (PCK) is the process by which the subject is represented to make it comprehensible to others and includes an understanding of what makes the learning of the different concepts easy or difficult. PCK is essentially the link between knowing something yourself and being able to enable others to know it. Curriculum knowledge is the awareness of how concepts and content are arranged both within a school year and over time. It is also about knowing how to use curriculum resources and materials to organise a programme of study (Shulman, 1986b).

This section explored teacher mathematical or subject matter knowledge and the importance of this.

2.3.1 The importance of mathematics content in teaching

It makes sense that a solid knowledge of mathematics or subject matter knowledge would be a natural prerequisite for the teaching of mathematics (Mullis, Martin, Foy, & Arora, 2012). The subject matter knowledge identifies the amount and organisation of the knowledge of the particular content area (mathematics in this case) from the teacher's perspective and understanding. It includes both facts and concepts of the domain, but also why these facts and concepts are true, and how they are generated and then structured within the discipline (Mapolelo & Akinsola, 2015; Shulman, 1986b). It seems natural that for teachers to 'foster students' conceptual understanding, teachers must have rich and flexible knowledge of the subjects they teach' (Borko, 2004, p. 5). However, it appears this may not be so definitive, and it is an area for more research on the difference between student improvement and mathematical content knowledge (Ball & Bass, 2000; Buczynski & Hansen, 2010).

2.3.2 Mathematics content and the Australian Professional Standards for Teachers

The professional knowledge domain of the Australian Professional Standards for Teachers describes the skills and knowledge teachers are required to have about content and the curriculum (AITSL, 2014). It emphasises the importance of knowledge and understanding of the 'fundamental concepts, structure and enquiry processes relevant to the programs they [teachers] teach' (AITSL, 2014, para. 4). It also emphasises the requirement of teachers to develop 'students' literacy and numeracy within their subject areas', highlighting the importance of literacy and mathematics in all areas of teaching and learning. Under the domain of professional knowledge, Standard 2 is 'Know the content and how to teach it' (para. 6). Four of the five descriptors of Standard 2—2.1

content and teaching strategies of the teaching area; 2.2 content selection and organisation; 2.3 curriculum, assessment and reporting; and 2.5 literacy and numeracy strategies—relate specifically to the expectations of teacher content knowledge, which in this case is mathematics.

The AAMT Standards for Excellence in Teaching Mathematics in Australian Schools further defines the parallel standard of 1.2 knowledge of mathematics, stating,

> Excellent teachers of mathematics have a sound, coherent knowledge of the mathematics appropriate to the student level they teach, and which is situated in their knowledge and understanding of the broader mathematics curriculum. They understand how mathematics is represented and communicated, and why mathematics is taught. They are confident and competent users of mathematics who understand connections within mathematics, between mathematics and other subject areas, and how mathematics is related to society. (AAMT, 2006, p. 2)

This implies that a knowledge of the content, mathematics, appropriate to the level that teachers are teaching with an understanding of the broader context, is seen to be important.

2.3.3 Effect of content knowledge on students

There seems to be little evidence directly linking teacher preparation in mathematics to the achievement of their students. A meta-analysis of the effect of teachers' subject matter preparation on their students' achievement in mathematics and science found some studies showing a positive effect, but in general, results are mixed (Wilson, Floden, & Ferrini-Mundi, 2002, as cited in Mullis et al., 2012). A study using a direct measure of teachers' mathematics content knowledge as an indicator of teacher preparation found teachers' mathematics content knowledge related to gains in students' mathematics achievement in primary school (Hill, Rowan, & Ball, 2005, as cited in Mullis et al., 2012), and furthermore, studies have found that a positive attitude towards the teaching of mathematics has a direct influence on the students' levels of achievement (Kulm, 1980; Sullivan, 1987). Some literature suggests that once a teacher reaches a certain level of understanding of subject matter, further understanding of that subject does not contribute further to student achievement (Begel, 1979, as cited in National Research Council, 2001), alluding to a plateauing effect.

There is also evidence that many teachers have weaknesses and lack deep conceptual understanding of mathematics (Ball, Hill, & Bass, 2005; Ma, 1999). Studies support the idea that many teachers lack confidence and content knowledge when teaching mathematics (Ambrose, 2004; Evans, 2011). Jones, Hampton, Brown, and Leinenbach (2009) found that 'many teachers of children [Year 4, 5, and 6 students] believe that their content knowledge is sufficient to teach their students, and are more interested in professional development that provides techniques they can take directly to their classrooms' (p. 279), and that 'Teachers assume that they need ways to reach all students regardless of learning styles, and are interested in activities and strategies that will help their students understand mathematics' (p. 279) rather than focusing on their own personal content and conceptual knowledge.

The 2011 TIMSS showed that internationally across the fourth-grade cohorts across countries, 83% of students were taught by teachers who felt very well prepared to teach the TIMSS mathematics topics. Across the content domains, more students had teachers very well prepared to teach the number topics (87%), more than geometric shapes and measures topics (82%) or the data display topics (74%) (Mullis et al., 2012). On average across countries at the fourth grade, when considering teachers' confidence, teachers were most often very confident about answering student questions about mathematics (84% of students taught by such teachers) and showing students a variety of problem-solving strategies (75%), and less often very confident about helping students appreciate the value of learning mathematics (69%), adapting teaching to engage student interests (65%), and providing challenging tasks for capable students (59%) (Mullis et al., 2012).

It may seem from the TIMSS (2011) results, that teachers are well prepared for teaching mathematics, but results vary across the survey and across countries. For Australian teachers at the fourth grade, teachers were most often more confident, about answering students' questions about mathematics (86% compared to 84%) and showing students a variety of problem-solving strategies (83% compared to 75%), and less often, very confident about helping students appreciate the value of learning mathematics (67% compared to 69%), adapting teaching to engage student interests (63% compared to 65%), and providing challenging tasks for capable students (65% compared to 59%) (Mullis et al., 2012). It appears the data in the categories are similar, with all trends moving in the same direction except for providing challenging tasks for students. It also appears that Australian teachers are more confident in answering student questions about mathematics and showing students a variety of problem-solving strategies; while similar, the trends are not as strong in the other areas, and whether this links to the mathematics content itself is unclear.

2.3.4 What is the mathematical content?

One view is 'while 'the subject matters' in these settings, there is so much more going on simultaneously that at times the ever-important content differences can be swamped by other critical features of the context' (Shulman & Shulman, 2004, p. 269). This understanding of how content matters in practice appears to be quite an incomplete area of research (Ball & Bass, 2000). There seems to be little empirical support that teachers' subject matter knowledge influences their efforts to help students learn the subject matter. It appears there is a lacking in understanding of 'what and how mathematical knowledge is used in practice' (Ball & Bass, 2000, p. 86). There also seems to be an assumption that 'what teachers need to know is what they teach' (p. 86) and a broad perspective of where students will be going. Seldon (2003, cited in Mapolelo & Akinsola, 2015) argued that 'One needs a solid understanding of the mathematics at, and beyond, the level at which students [being observed] are working' (p. 3). The problem is that this assumes no other mathematical understanding or perspective is required. Post, Harel, Behr, and Lesh (1988) argued that more than just content but the underlying concepts within a mathematics framework are required, and that because 'many teachers simply do not know enough mathematics' (p. 212), links and connections cannot be made.

Stipek, Givvin, Salmon, and MacGyvers (2001) found that 'most American teachers have a conception of mathematics as a static body of knowledge, involving a set of rules and procedures that are applied to yield one right answer' (p. 214). These beliefs are often known as 'traditional' or 'classical'. Indeed, teachers frequently regard mathematics as a fixed body of facts and procedures that are learned by memorisation, and that view carries over into their instruction (National Research Council, 2001). Many have little appreciation of the ways in which mathematical knowledge is generated or justified. This view implies that a teacher's role is to communicate knowledge in a clear and structured way, to explain correct solutions, to give students clear and resolvable problems, and to ensure calm and concentration in the classroom (OECD, 2009). This understanding of content is often seen taught in schools, dominated by the traditional 'transmission view of knowledge' (Wood, Cobb, & Yackel, 1991, p. 590). On the other side of the traditional or transmission view is the constructivist view of teaching and learning, where ideas and concepts are built on previous understandings and students are not passive recipients of knowledge but are active participants in the process of constructing and acquiring knowledge. The development of thinking and thinking processes are more valued than the acquisition of specific knowledge (Staub & Stern, 2002; OECD, 2009; Peterson, Fennema, Carpenter, & Loef, 1989).

Exploring curriculum policy documents and government statements, mathematics is described as a much richer area in which idealistic statements are made. A few examples include:

> Learning mathematics creates opportunities for and enriches the lives of all Australians. (ACARA, 2015, para. 1)

and

> Mathematics has its own value and beauty and the Australian Curriculum: Mathematics aims to instil in students an appreciation of the elegance and power of mathematical reasoning. (ACARA, 2015, para. 2)

and

> They [the specifications in mathematics] should encourage students to develop confidence in, and a positive attitude towards mathematics and to recognise the importance of mathematics in their own lives and to society. (Department for Education [UK], 2013)

and

> Mathematicians and statisticians use symbols, graphs, and diagrams to help them find and communicate patterns and relationships, and they create models to represent both real-life and hypothetical situations. These situations are drawn from a wide range of social, cultural, scientific, technological, health, environmental, and economic contexts. (Ministry of Education New Zealand, 2013)

and

> Mathematics is the exploration and use of patterns and relationships in quantities, space, and time. Statistics is the exploration and use of patterns and relationships in data. These two disciplines are related but [are] different ways of thinking and of solving problems. Both equip students with effective means for investigating, interpreting, explaining, and making sense of the world in which they live. (Ministry of Education New Zealand, 2013)

Further examination of curriculum policy documents and government statements shows that the idealistic view is coupled with lists of content of what mathematics should be taught. Perhaps the way the curriculum and government statements about the content of mathematics are presented perpetuates the transmission or traditional view of mathematics. It seems teachers are not provided with detail or information about how to develop an approach to mathematics reasoning or how to translate classroom mathematics into real scenarios and models.

2.3.5 More than just content

Ball (2003) stated, 'Knowledge for teaching mathematics is different from the mathematical knowledge needed for other mathematically-intensive occupations and professions' (p. 8). The mathematical content and the use of the mathematics in teaching school mathematics are different from the mathematics used in other professions such as engineering, medicine, or science (Grootenboer & Zevenbergen, 2008). Not only do teachers need mathematical knowledge, but they require an understanding of the learning of mathematics as they need to be able to use the mathematics and then perform actions such as interpret someone else's error, represent ideas in multiple forms, develop alternative explanations, or choose a usable definition. 'These are genuine mathematical problems central to the work of teaching' (Ball, 2003, p. 8). The mathematical knowledge important for the work of teaching is a complex area, requiring so much more than just a grasp of mathematics subject knowledge (Ball, 1990; Fennema & Franke, 1992) and Ball, Thames and Phelps (2008) define this as 'specialised content knowledge' (p. 390). The idea that 'knowledge for teaching mathematics is different from the mathematical knowledge' (Ball, 2003, p. 8) is commonly known as teacher pedagogical content knowledge. Buczynski and Hansen (2010) argued teachers who do not have a sound understanding of the pedagogical content knowledge of the content matter (in this case, mathematics) are the ones who are most in the need of professional learning.

The importance of mathematics content in mathematics teaching is valid. The research tends to show a divide between subject matter and pedagogy (Ball & Bass, 2000). The teaching of mathematics is seen to be different to other subject areas. It appears that mathematical knowledge for teaching is a combination of content knowledge (mathematics which is not necessarily unique to teaching) and specialised content knowledge, which is the combination of the mathematical skills *and* knowledge particular to mathematics teaching (Hurrell, 2013). For example, a thorough knowledge of the formula for area is not the same as a thorough knowledge of the concept of area, but an understanding of both is required when teaching the content of area to students.

Mathematical content knowledge is linked to both subject content knowledge and pedagogical content knowledge (Shulman & Shulman, 2004), and Section 2.4 will present a discussion of teacher pedagogical knowledge.

In summary, this section consisted of five focus areas. The first was the importance of mathematical content in teaching and was supported by the second part of this section, relating mathematical content to the Australian Professional Standards for Teachers. This informed the content area of the study, which is a focus of mathematics in a primary teaching environment.

The third part of this section presented the effect of teachers' own content knowledge on students and the subsequent effect on student achievement in the mathematics classroom. While the impact of teacher change on student learning was not an area measured in this study, it is worthy of some discussion when considering the impact of teacher professional learning.

The mathematics content itself was presented in the fourth part of this section, defining the traditional and constructivist views of teaching and learning, while acknowledging that teaching is more than 'just the content' in the fifth part of this section. An understanding of the different views was used to inform discussions and ideas when working with the individual teachers in the teacher professional learning intervention. It was also important for me, as the mathematics educator, to understand the different views teachers may have about mathematics.

2.4 Teacher Pedagogical Knowledge

Section 2.3 examined teacher mathematical knowledge. It began with the importance of mathematical content in teaching mathematics, including an examination of the location of teacher mathematical knowledge in the Australian Professional Standards for Teachers. It included the effect of content knowledge on students and what mathematical content is. This section presents a discussion of teacher pedagogical knowledge and teacher pedagogical content knowledge, which is also related to the Australian Professional Standards for Teachers.

Shulman and Shulman (2004) stated, 'A teacher must be ready to teach' (p. 260) and 'must know and be able to do' (Shulman & Shulman, 2004, p. 262), and it is acknowledged that the area of understanding teaching is both large and complex. They included aspects such as disciplinary/content/interdisciplinary knowledge, curriculum understanding, pedagogical content knowledge, classroom management and organisation, classroom assessment, community, and understanding learners, stating that at the heart of teaching is ‘the capacity for intelligent and adaptive action’ (p. 263). So not only does the teacher need to be ready, willing, and have understanding, they also need to be ‘able to perform this kind of teaching, which is enormously complex in its practice’ (p. 263). Shulman and Shulman (2004) identified five clusters of the aforementioned attributes, which teaching develops: cognitive, dispositional, motivational, performance, and reflective.

Shulman (1987) divided teacher pedagogical knowledge into two categories: general pedagogical knowledge and PCK. Shulman (2000) stated, ‘Fundamentally, teaching involves just two processes’ (p. 133), which begins with understanding what is inside the learner’s head and trying to find out what is their prior knowledge. ‘Our first pedagogical challenge is to bring what is inside, out’ (p. 133). Shulman cautioned that the challenge is knowing whether you have all the prior knowledge as it appears in various representations and forms, so there are always inferences being made. Once this information is ‘external’, Shulman stated (2000) it is possible to work on this knowledge together, and that ‘you can test it, move it around, rearrange it, co-construct it, and repair it’ (p. 133) with the new goal of putting the knowledge ‘back inside’ so the process can begin again. Shulman summarises the ‘essence of pedagogy: putting the inside out, working on it together while it is out, then putting the outside back in’ (p. 133).

The next two parts of this section present definitions of teacher pedagogical knowledge and teacher PCK.

2.4.1 Pedagogical knowledge

Pedagogical knowledge is the knowledge encapsulating principles and strategies of classroom management (Shulman, 1987). It refers to the ‘specialised knowledge of teachers for creating effective teaching and learning environments for all students’ (OECD, 2014, p. 2). Some models of general pedagogical knowledge combine pedagogical and psychological aspects, whereas others do not make psychological aspects explicit. Psychological components account for the fact that learning occurs in a social context (OECD, 2014). Opfer and Pedder (2011) argued that this knowledge can also exist as a result of learning within a particular system.

2.4.2 Pedagogical content knowledge

PCK is the knowledge that integrates the content knowledge of a specific subject and the pedagogical knowledge for teaching that particular subject (Shulman, 1987). Shulman (1987), defined pedagogical content knowledge as

> the blending of content and pedagogy into an understanding of particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. (p. 8)

Park and Oliver (2008) provided a working definition of PCK as

> teachers' understanding and enactment of how to help a group of students understand specific subject matter using multiple instructional strategies, representations, and assessments, while working with the contextual, cultural, and solicit limitation in the learning environment. (p. 264)

Others argue that although the term is widely used, its potential is not really fully understood or realised (Ball, Thames, & Phelps, 2008). This is reflected in Shulman's (2000) statement that 'practitioners in teaching know a great deal more about teaching than our theories can yet account for' and identifies this as the 'wisdom of practice' (p. 134). Capraro, Capraro, Parker, Kulm, and Raulerson (2005) believe that the 'nexus' for developing PCK lies in the interaction between 'constructing relationships, extending and applying knowledge, reflecting about experiences, articulating what one knows, and making knowledge one's own and situated with sound mathematical preparation' (p. 3), stating it is the interaction between the mathematical knowledge and the pedagogy that forms PCK.

2.4.3 Professional knowledge and the Australian Professional Standards for Teachers

The complexity of teacher pedagogical knowledge is evident in the Australian Professional Standards for Teachers (AITSL, 2014) in the areas of professional knowledge and professional practice.

In the area of professional knowledge, teachers draw on a body of professional knowledge and research to respond to the needs of their students within their educational contexts; this includes knowledge about their students, their backgrounds, and the experiences students bring to the classroom. This knowledge is then used in the development of lessons and activities. It is also expected that teachers have knowledge of the content of their subjects and curriculum, which is also used in the development of lessons and activities (AITSL, 2014). This identification of teacher knowledge is also reflected in the Standards for Excellence in Teaching Mathematics in Australian Schools in Domain 1, professional knowledge, which exemplifies similar attributes (AAMT, 2006).

In the domain of professional practice of the AITSL standards, knowledge is required about teaching practice and strategies, assessment, and the development of teaching programmes and lessons (AITSL, 2015a). These skills are specifically explored in Standard 3. The AAMT Standards for Excellence in Teaching Mathematics in Australian Schools defines 1.3 knowledge of students' learning of mathematics:

> Excellent teachers of mathematics have rich knowledge of how students learn mathematics. They have an understanding of current theories relevant to the learning of mathematics. They have knowledge of the mathematical development of students including learning sequences, appropriate representations, models and language. They are aware of a range of effective strategies and techniques for teaching and learning mathematics; promoting enjoyment of learning and positive attitudes to mathematics; utilising information and communication technologies; encouraging and enabling parent involvement, and for being effective role models for students and the community in the ways they deal with mathematics. (AAMT, 2006, p. 2)

It does appear that the 'lines' are blurred between what is purely PCK, what is general content knowledge, and what is specialised content knowledge, within the complex context of teaching and relationships that exists between these different areas of knowledge and teacher learning (Hurrell, 2013; Wood et al., 1991).

The National Research Council (2001) suggested aligning teaching with mathematical teaching proficiencies, similar to what is outlined in strands of mathematical proficiency. The National Research Council (2001) proposed the following proficiencies:

- Conceptual understanding of the core knowledge required in the practice of teaching;
- Fluency in carrying out basic instructional routines;
- Strategic competence in planning effective instruction and solving problems that arise during instruction;
- Adaptive reasoning in justifying and explaining one's instructional practices and in reflecting on those practices so as to improve them; and

- Productive disposition toward mathematics, teaching, learning, and the improvement of practice. (p. 380)

Like the strands of mathematical proficiency, these components of mathematics teaching proficiency are interrelated. Acknowledging the complexities, it appears that mathematics teaching has its own unique set of knowledge, even within the realm of teaching itself.

2.4.4 Signature pedagogy of teaching

Shulman (2005) stated that different professions have 'signature pedagogies'. These are the pedagogies that align with each individual profession, for example, medicine, engineering, or law. It seems the signature pedagogy for teaching is difficult to identify, as teachers need to be prepared to be adaptable to a whole range of situations whether they have a complete set of information, or not. The signature pedagogy for teaching is unlike other professions, as the roles of the teacher and student are constantly changing, and it is often the action rather than the understanding of the full set of information that becomes more important. Shulman (2005) identified three characteristics of signature pedagogy of teaching: pedagogies of uncertainty, pedagogies of engagement, and pedagogies of formation. These are then overlaid with reflective practice. Shulman (2005) cautioned that 'no signature pedagogy is a replacement for deep content knowledge' (p. 1) and needs to be complemented with understanding that has developed experientially, as theory alone cannot determine and lead to action (Even & Markovitz, 1997); it is the reflection process on these actions that can lead to the development of PCK.

In summary, this section examined teacher pedagogical knowledge, general pedagogical knowledge, and pedagogical content knowledge. The Australian Professional Standards for Teachers (AITSL, 2014) and the Standards for Excellence in Teaching Mathematics (AAMT, 2006) have been included in this section and previous sections in the discussion of teacher knowledge and the teaching of mathematics, as they are the standards used to identify teacher skills and capabilities within the teaching profession in Australia.

An understanding of teacher pedagogical knowledge and PCK was used to deepen understanding around teacher knowledge when considering the teacher professional learning model of this study.

The last part of this section identified the signature pedagogy of teaching, which is acknowledged as being difficult to identify and constrain due to the fluid nature of the roles of teachers and students in the classroom. Being informed of this nature of pedagogy informed interactions with teachers in their classrooms during the professional learning intervention.

Section 2.5 looks at teachers' beliefs. This includes influences on these beliefs, what these beliefs may be in respect to mathematics teaching, and how they could be challenged or even changed.

2.5 Teachers' Beliefs

The previous section examined teacher pedagogical knowledge, teacher pedagogical content knowledge, and the signature pedagogy of teaching. This section presents a discussion around teacher beliefs. The first part presents a discussion of teacher beliefs about the nature of teaching and learning. The second part presents influences on these beliefs. The third part of the section contrasts between traditional and nontraditional beliefs when considering mathematics teaching. The fourth part presents ideas about changing teacher beliefs, and the final part of the section presents the importance of a shared understanding of teacher beliefs and the beliefs of the school.

There is a broad understanding that teachers' beliefs of the nature of teaching and learning influence and impact their teaching and learning experiences in the classroom (Beswick, 2012). Teacher's actual practices are associated with their beliefs, and teachers filter new information through these personal beliefs (Rashidi & Moghadam, 2015). Aiken (2002) defined beliefs as 'confidence in the truth or existence of something that is not immediately susceptible to rigorous proof' (p. 6). Where beliefs actually lie is contentious, with some who consider beliefs to be part of knowledge, while others consider beliefs to be part of attitude (Gagatsis, Panaoura, Deliyianni, & Elia, 2009). It appears that 'effective teaching practice is based on a coherent and integrated set of beliefs, knowledge, and values' (Timperley, 2008, p. 20), and this integration is complex (Shield, 1999).

In the Teaching and Learning International Survey (TALIS), the OECD (2009) found teachers' professional knowledge and actual practices differed not only among countries, but also among teachers within a country and even within a school, which leads to an assumption that there could be a difference in teachers' beliefs at all these different levels, as well (see Figure 2.1). The study examined the difference in beliefs between the direct transmission view and the constructivist view of student learning.

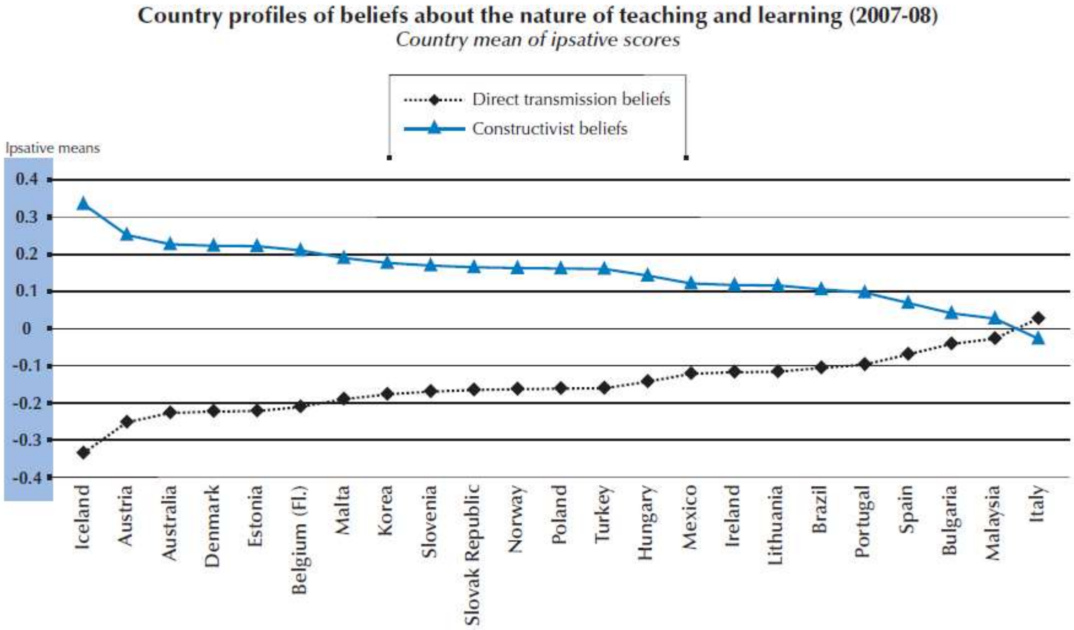

Figure 2.1: Country profiles of beliefs about the nature of teaching and learning (2007–2008). (OECD, 2009, p. 95).

Figure 2.1 shows the country profiles of beliefs about the nature of teaching and learning, plotting the difference between direct transmission and constructivist beliefs (OECD, 2009), with Australia showing that the 'average endorsement of constructivist beliefs is stronger than that of direct transmission beliefs' (p. 95), indicating that teachers believe students should be given opportunities to develop and build knowledge rather than just learn facts. The TALIS report also showed that the beliefs and practices of female and male teachers vary (OECD, 2009), and in a majority of participating countries, female teachers endorse direct transmission beliefs less strongly than male teachers. These beliefs naturally have an impact on classroom teaching. But what influences these beliefs? The next part of this section will explore this.

2.5.1 Influences on teacher's beliefs

There are many influences on teachers' beliefs (Shield, 1999), which impact teacher practice, attitude, and engagement. These are further effected by teacher training, professional learning experiences, employment status, and subject teaching area (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; OECD, 2009).

PSTs set out with well-developed personal beliefs about learning and teaching (Joram & Gabriele, 1998). They have various forms of mathematical knowledge when moving from school to study in their teaching courses, taking with them beliefs about the subject that have developed from their experience of school mathematics over a period of time (Daskalogianni & Simpson, 2000). Franke (1990) found that preservice elementary school teachers share many of the mathematical beliefs held by maths-anxious people. This is important, because as PSTs move into teaching, their beliefs about mathematics are deeply rooted, and peripheral changes such as curriculum or teaching materials cannot easily influence them (Furinghetti & Pehkonen, 2002).

Studies of teachers' beliefs in mathematics education have investigated beliefs about the nature of mathematics (Dossey, 1992), as well as the general conceptions of mathematics teaching and learning (Ball, 1990; Cobb et al., 1990). Research has shown that teachers' beliefs about teaching and learning of a particular subject area are significantly influenced by their performance in the classroom, and this is reflected in their students' learning (Crockett, 2002; Pajares, 1992; Thompson, 1992). Researchers generally report consistency between teacher beliefs and instructional practice (Ball et al., 2005; Thompson, 1992); however, some researchers have found inconsistencies between teachers' beliefs and classroom practices (Raymond, 1997). Stipek et al. (2001) found more traditional beliefs were associated with more traditional practices, and that teachers were less likely to give students autonomy, maintaining the idea that mistakes were to be avoided. They also found that these teachers tended to enjoy mathematics less and were not as enthusiastic in their classrooms. They (2001) noted that teachers' enjoyment of mathematics did not predict students' enjoyment of mathematics, but they found significant correlation between teachers' self-confidence as mathematics teachers and students' perceptions of their own competence as mathematics learners. They found that inquiry-orientated mathematics teaching appeared to 'conflict with more traditional beliefs about the nature of mathematics teaching and learning' (p. 224).

2.5.2 Traditional versus nontraditional beliefs of mathematics teaching

Stipek et al. (2001) found there are two main areas of beliefs regarding mathematics teaching. The first is the more traditional concept, where knowing mathematics means being skilful and efficient in performing procedures and manipulating symbols, often with a limited understanding of the mathematics. This is where the teacher is seen as being in control. The second is the inquiry-orientated mathematics teacher, who takes a more dynamic view of mathematics and who acknowledges that it is not a static content area. Here the teacher is seen as more of a facilitator and supports and guides the learning. Naturally, these beliefs are not 'necessarily contradictory' (p. 215), although they are often 'pitted against each other' in the literature (Stipek et al., 2001). However, it appears that more traditional beliefs are associated with more traditional practices, and vice versa.

Stipek et al. (2001) identified a set of five beliefs related to mathematics teaching and learning: the nature of mathematics, mathematics learning, who should control students' mathematical activity, the nature of mathematics ability, and the value of extrinsic rewards for getting students to engage in mathematics activities. They also examined teachers' self-confidence and enjoyment of mathematics and mathematics teaching in an endeavour to find any associations or connections that could be made between the belief areas. They found that the following beliefs were strongly associated with each other: mathematics is a set of operations to be learned, students' goals should be to obtain the correct solution, the teacher needs to exercise complete control over mathematics activities, and extrinsic rewards and grades are effective strategies for motivating students in engaging in mathematics. These are classed as the more traditional beliefs. Stipek et al. (2001) also found the following inquiry-based beliefs were associated together: mathematics is a tool for thought, the student's goal is to understand, students should have some autonomy, mathematics ability can change, and students will want to engage in mathematics if the tasks are interesting and challenging.

Stipek et al. (2001) also found links with confidence, revealing that teachers with more traditional beliefs had lower self-confidence and enjoyed teaching mathematics less compared to teachers with inquiry-based beliefs of the teaching and learning of mathematics. Stipek et al. (2001) stated, 'Building teachers' self confidence in mathematics, which requires building their mathematical understanding, could be an important, if not a necessary, ingredient in moving them towards more inquiry-orientated beliefs and practices' (p. 233). The literature suggests that traditional or transmission beliefs are not as ideal, and that a move towards constructivist beliefs is preferred. This requires challenging or even changing teachers' beliefs.

2.5.3 Changing beliefs

Challenging or even changing teacher's beliefs is not an easy process. Classroom experiences impact teachers' beliefs, and their beliefs influence what happens in the classroom. 'Teachers' daily experiences in their practice context shape their understandings, and their understandings shape their experiences' (Timperley, 2008, p. 6). Teachers are 'diverse in their understandings and assumptions about students and how they learn, what counts as valued knowledge, and how best to teach it' (p. 17). This complex web of beliefs is further overlaid with pedagogical and cultural traditions.

Professional learning activities have the potential to challenge or change teachers' beliefs and attitudes, but participation in such activities may itself be due to certain beliefs. Timperley (2008) stated, 'Participating teachers—whether or not they are volunteers—rarely believe that they will need to engage in in-depth learning or make substantive changes to their practice' (p. 16); often they are looking for professional learning that complements rather than challenges their current beliefs. Timperley (2008) found that 'teachers are likely to reject new ideas that conflict with their current ideas unless, as part of the professional learning, their existing understandings are engaged' (p. 17). Borko et al. (1997) also found that 'beliefs serve as filters through which new ideas are perceived and interpreted; therefore, it is not surprising that the teachers adopted some practices that were incompatible with our intentions' (p. 270) when discussing professional learning. Timperley (2008) found it is 'particularly important to engage existing theories when challenging teachers' beliefs about, and expectations of, those students who have traditionally underachieved' (p. 18). Therefore, the challenge lies in having teachers engage in professional learning that falls within their belief systems, before challenging their current ideas and beliefs. One way to approach this is working towards a shared or common understanding across a school.

2.5.4 A shared understanding

It seems that there is value in the school community identifying and defining their values and beliefs as a collective with regard to teaching and learning, and the making of these values and beliefs is the basis of action rather than reacting from an external pressure that leads to changes and achievements in learning (Beswick, 2016; Atkin, 1996). By forming a community of understanding, learning is viewed as a 'dynamic, interactive process' (p. 4) that is supported by the teachers' and schools' particular values and beliefs, which will form the basis of particular practices (Atkin, 1996). The process of reflection allows teachers to examine these practices in context of their values and beliefs, providing the opportunity for their values and beliefs to be revisited and refined: 'Reflection on classroom experiences has been shown to be effective in changing teachers' beliefs' (Stipek et al., 2001, p. 224).

The important process is the working towards what is valued and believed rather than having the values and beliefs imposed. Therefore, the most crucial feature of a school for learning is that the staff, including leadership, learn with a clear goal or focus. Atkin (1996) stated there will never be a set of completely 'right' practices. However, a learning teacher in a learning school will

- be able to identify their vision, values and beliefs that are the basis for particular practices;
- be engaged in reflecting how particular practices help them achieve what they value and believe; and
- continually revise and refine these values and beliefs.

Atkin (1996) stated that the process of both articulating and sharing values and beliefs is important. Through this process of discussing, trialling, and evaluating different or new practices in line with values and beliefs, true growth and learning will take place: 'It is one thing to identify and clarify our values; it is a different matter to examine our practices in terms of our values and beliefs' (Atkin, 1996, p. 13). The actual experience of viewing and evaluating practices against what is valued and believed is critical to the values and vision approach of teaching and learning.

Ideally, beliefs about learning should be formed with the knowledge about learning and then supported with knowledge of both the learning process and the conditions that enhance learning. The education process is not that simple or straightforward, and often values and beliefs are challenged and even compromised: 'Conflicts can arise between what a teacher believes is best for students and what can actually be achieved in the classroom' (Shield, 1999, p. 444), but when contradictions create 'conflicts, dilemmas, and surprises' they 'in turn prove to be learning opportunities' (Wood et al., 1991, p. 588). Through these challenges and conflicts, there is a possibility of leading to changes in practice and even change in beliefs about the teacher's role, the student's role, and the nature of mathematics. It is the nature of education that solutions to problems are not a single answer; rather, they require a dynamic, fluid, or flexible approach (Atkin, 1996).

Good or effective teaching is not just determined by the teacher's background, beliefs, and attitudes; it is also responsive to students' needs and various student, classroom, and school background factors. It is acknowledged in the research that there seem to be two major belief systems in mathematics teaching: traditional (transmission) and nontraditional (constructivist). The relationship between teacher beliefs and teacher behaviour is far from clear, as teacher beliefs are messy constructs with different interpretations and meanings (Pajares, 1992). Challenging or changing teachers' beliefs is not a simple process and indeed, not a linear one, being influenced by many factors including the community, the classroom, and leadership. It takes time and common understanding, and it appears that even when beliefs change, they may not be enacted. Therefore, the understanding of teaching change and teacher beliefs is important when considering teacher professional learning, and just like all content areas, mathematics teaching has its own varied belief systems overlaying the already complex belief systems of teacher practice.

In summary, this section presented a discussion of teachers' beliefs. It began by looking at teachers' beliefs about the nature of teaching and learning. This was important when considering how to challenge teachers' existing beliefs when attempting to have teachers change their practice through professional learning.

The next part of the section presented influences that impact teachers' beliefs and showed their beliefs develop over a period of time, influenced by their experiences in the classroom. These beliefs will be reinforced or challenged during the teacher professional learning intervention.

The third part of the section presented the main areas of beliefs of mathematics teaching, including the traditional and inquiry orientated, which included five identified beliefs of mathematics teaching and learning (Stipek et al., 2001). This informed my role as the mathematics educator in the professional learning intervention in raising awareness of teachers' differing beliefs.

The fourth part of the section looked at changing beliefs and the challenges associated with this, appearing that teachers often involve themselves in professional learning that aligns with their existing beliefs. This needed to be considered in this study, as teachers were involved in selecting the focus of their own learning in the professional learning intervention. The final part of the section looked at developing a shared school understanding of teacher beliefs of teaching and learning as a vehicle for changing teachers' beliefs and working towards teacher change.

The next section presents a discussion on teacher change. This includes the importance of the setting, of developing deep learning and trust, of community, and of reflective practice. The section ends by discussing how to identify whether change has taken place.

2.6 Teacher Change

The previous section presented research about teacher beliefs. This included influences on those beliefs, an exploration of the difference between traditional and nontraditional beliefs, how these beliefs could be changed, and the advantages of working towards a shared understanding of beliefs at the school level.

This section is divided into six parts. The first part considers the setting in which the learning takes place, and the second discusses the importance of developing deep learning and trust. The third part considers the importance of community, and the fourth part of this section examines the importance of reflective practice in the change process. The final part of this section considers how to identify whether change has taken place.

This study is based on an assumption or belief. It is assumed that teachers bring their experiences and beliefs to their teaching and own learning, just as it is assumed students bring prior knowledge to learning situations. For teachers, this may be from school, experiences through their degrees, and personal observations. Richardson (1996) identified three sources of teachers' pedagogical beliefs: personal experience, experience with school, and experience with formal pedagogical and subject knowledge. Similarly, staff of different schools can have their own collective beliefs and practices (Opfer & Pedder, 2011), which can influence an individual's beliefs and practices and hence, are not independent of one another.

It is acknowledged that the process to create change in teachers' pedagogical practice takes considerable time and professional involvement (Britt, Irwin, & Ritchie, 2001; Buchanan & Khamis, 1999; Higgins, 2002, 2003; King & Newmann, 2001, 2004; MacGilchrist, Myers, & Reed, 1997) and is difficult to achieve and sustain (Wood et al., 1991). Making change in teachers' practice is an ongoing process, which requires a clearly articulated vision (Hord, 1994) with continual support from the principal and leadership to sustain the change process. This may lead to the development of a true learning community (Hord, 1997). It must also be noted that change is not always embraced by all and can be met with resistance (Buchanan & Khamis, 1999).

Atkin's (1992) work presented a 'propositional definition of learning' (p. 5) and linked with the constructivist theory that supported Guskey's (1986) proposed framework of the process of teacher change (Figure 2.2), which 'typifies the dynamics of the teacher change process' (Guskey, 1986, p. 7).

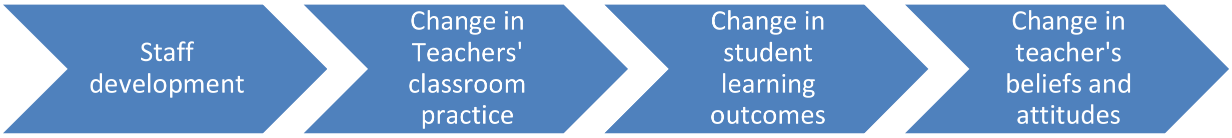

Figure 2.2: A model of the process of teacher change (Guskey, 1986).

Atkin's (1992) and Guskey's (1986) theories of how learning is constructed from direct experiences (staff development) and the process of reflection on these experiences (such as changes in student learning outcomes) leads to the integration of these experiences (change in teachers' beliefs and attitudes). Atkin (1992) indicated that these changes in learning are a cyclic process, building on different experiences as a result of reflective practice rather than by a linear process. Change may be difficult to measure and identify, as change may take place in a person's beliefs or in another's practice, or for another person in both beliefs and practice, or any combination of these may or may not affect student learning (Opfer & Pedder, 2011). Clarke and Hollingsworth (2002) articulated that for teacher learning or growth to occur, change must occur to multiple areas of influence. Some of these areas of influences are discussed in this section.

2.6.1 The setting

Borko et al. (1997) found that 'situating the change process in the actual teaching and learning contexts where the new ideas will be implemented is an effective strategy for helping teachers change their practice' (p. 267). This was exemplified with teachers meeting and discussing ideas in a workshop, then attempting to implement these ideas in their classrooms, and in subsequent workshops, reflecting and building on these experiences. Borko et al. (1997) noted that the sequence 'produced some of the biggest changes we observed in the ways teachers talked about assessment' (p. 267).

It appears that making the professional learning experiences relevant and in context is more likely to lead to change, as they are engaging the personal relevance of the learner (Atkin, 2002);

often this translates to having the professional learning located within the teacher's own school and even more ideally in their own class with their own students. Britt et al. (2001) found in a professional development programme involving 18 teachers over a 2-year period, that once teachers started to spend time observing their own students, a change in practice occurred, from a 'focus on transmission of knowledge to a focus on guiding students to a better understanding' (p. 30). Therefore, just the process of spending time observing students and classrooms in action could lead to a change in practice.

2.6.2 Deep learning and trust

For some people, observing a situation is enough to lead to change, but for others, completing professional learning in their own environment is still not enough to create change. Timperley (2008) stated, 'The integration of essential teacher knowledge and skills promotes deep teacher learning and effective changes in practice' (p. 11). Timperley found that learning in one's own environment needs to be strongly linked with theory and practice, and for effective professional development to occur, practical applications need to be developed alongside theory of areas such as curriculum, teaching practice, and assessment. This needs to be complemented with an environment of trust to allow the challenges in practice to occur (Timperley, 2008). Timperley further stated that 'change is as much about the emotions as it is about knowledge and skills' (p. 16), and Shulman (2000) stated, when a person's 'deeply held, private, intuitive theories' (p. 131) are being challenged, 'you are engaging them in a process that is as deeply emotional as it is cognitive. That is why conceptual change is so hard to negotiate' (p. 131). Teachers need to be both motivated and supported to examine their practice, and there may be many drivers for this (Atkin, 1994).

During professional learning experiences where practice is being examined, teachers' emotions should be considered (Bryk & Schneider, 2003; Kaur, 2008; Timperley, 2008). Timperley (2008) noted, 'If emotional issues are ignored, teachers may close themselves off to learning and adopt defensive posture to avoid exposing their inadequacies' (p. 16) and that 'Change involves risk' (p. 16); therefore, teachers need to trust that their efforts will be supported (Timperley, 2008) and 'feel safe to experiment with new practices' (Bryk & Schneider, 2003, p. 42). Atkin (1994) identified risk taking as key to the learning process: 'We don't learn unless we take risks and we won't take risks unless we have a secure base to fall back on' (p. 4). One way of developing trust is to allow teachers to have a sense of ownership over their learning; this ownership involves the ability to make and form one's own decisions, as well as make mistakes, set goals, and work at one's own pace. It may consist of teachers formulating and creating the learning or a new teaching process (Farmer, Gerretson, & Lassak, 2003). Mullis et al. (2012) found teachers who are more open to new ideas are less likely to experience emotional burnout. Bryk and Schneider (2003) stated that without trust, open and honest conversations around what works and what does not in practice are unlikely to occur. Therefore, for optimal learning to take place, the learner needs to be challenged but not threatened (Atkin, 1996).

2.6.3 The importance of community

As trust develops, people are more open, and a community of learning using ideas of social constructivism could then be developed as the members acquire shared meanings (Borko et al., 1997). Borko et al. (1997) found the community of learning to be 'an effective tool for the social construction of new ideas and practices' (p. 268), while Fleming and Leo (1999) found the use of 'research, synthesis and discussion' to be components of developing a professional learning community seen at staff meetings, in study groups, and in committee meetings. The development of these shared understandings and collaboration can lead to a school learning culture. Within a community, individuals are working together to try to understand and then implement teaching and learning ideas, leading to a change in practice and beliefs. Therefore, the culture shifts to an 'ongoing collective responsibility rather than an individual one' (Opfer & Pedder, 2011, p. 385).

The community needs to feel supported and include all involved. Supporting the community needs to involve the principal and leadership team. One of the ways support can be provided is through the provision of time and the articulation of a clear vision (Hord, 1994) for the common understandings to develop and beliefs to be challenged. Borko et al. (1997) found time to be 'a major obstacle to changing classroom practice. Competition among priorities for limited classroom time is particularly troublesome' (p. 272). However, Fleming and Leo (1999) found in a small study of three schools in the United States that once established, there was genuine enthusiasm for collective learning with evidence of small positive effects on student achievement.

Another influence on the community could be the expertise of people external to it who can help to 'facilitate change by introducing new ideas based on teachers' current levels of interest, understanding, and skill' (Borko et al., 1997, p. 269). Borko et al. (1997) found this to be an effective method leading to change, although Pritchard and McDiarmid (2006) found that if the process of reflective practice was developed, then it was not as necessary to look for expertise outside the learning community as ‘they are instrumental in developing themselves as practitioners’ (p. 438).

Developing a professional learning community can be taken further as schools work towards a professional learning culture. In the definition of professional learning provided by AITSL (2012), these learning experiences are undertaken by both teachers and school leaders. Characteristics of this culture include

- a high degree of leadership support for ongoing adult learning and risk taking;
- collective responsibility for improving practice;
- disciplined collaboration aimed at specific and relevant goals that relate to the learning needs of students;
- high levels of trust, interaction and inter-dependence;
- support for professional learning through school structures, explicit planning and the allocation of time; and
- a focus on the professional learning that is most likely to be effective in improving professional practice and student outcomes. (AITSL, 2012, p. 3)

The intensity of collaboration is an important factor to consider so that members of the community do not feel stifled or alternatively they do not feel there is not enough collaboration occurring. A balance is crucial and should be considered (Opfer & Pedder, 2011) when individuals are working together. By creating a community, clear leadership and clear professional learning intentions mean teachers are less likely to ignore new ideas or inappropriately apply them into their practice (Borko et al., 1997).

2.6.4 The importance of reflective practice

The importance of reflective practice on change cannot be underestimated (Borko et al., 1997; Franke, Carpenter, Fennema, Ansell, & Behrend, 1998; Kagan, 1992; Peterson et al., 1989; Wood et al., 1991). Stipek et al. (2001) stated,

> For meaningful and lasting change to occur, teachers need to engage in practice inquiry—to move back and forth among a variety of settings to learn about new instructional settings, to try them out in their own classrooms, and to reflect on what they observed in a collaborative setting. (p. 225)

Grootenboer (1999) examined the process of self-review (reflection) as a source of the generation of knowledge and skill in teaching. Reflective practice can lead to sustained change and the development of communities of practice (Pritchard & McDiarmid, 2006). Shulman and Shulman (2004) identified reflective practice as the 'key to teacher learning and development' (p. 264). Linking to ongoing learning, Shulman and Shulman (2004) stated, 'Teacher educators and professional developers need to analyse how such skill development can be identified, fostered, measured, repaired and sustained' (p. 263). Tied to this, they identified that at the heart of any learning process is critical reflection.

Amulya (2004) identified reflection as the foundation to purposeful learning, defined as a process of exploring one's own experience as a witness either briefly or in great depth, stating that 'the key to reflection is learning how to take perspective on one's own actions and experiences' (p. 1). In other words, reflection is the examination of the experience rather than just living the event. Amulya further stated that purposeful learning is a result of work, and indeed, life can provide an opportunity to explore actions and experiences, resulting in the possibility of learning through experience rather than purely from theory. Amulya identified a number of different kinds of experiences that lend readily to learning through reflection: struggles, dilemmas, situations of uncertainty, and breakthroughs in actions or thinking. Avalos (2011) stated, 'The studies in this decade centre primarily on reflection as an instrument for change and on the various ways in which reflection can be developed' (p. 11). Just because a teacher completes a reflective process does not mean it will result in a change in practice. It is important that learning experiences be designed to engage personal relevance. These experiences need to be reflected upon; therefore, the relevant language and symbols need to be developed and used in the process. This allows learners to make connections, see patterns, and develop relationships. Learners must also have the opportunity to express their learning in a variety of modes, such as kinaesthetic, and be allowed to try the result of their learning in their own classroom environment (Atkin, 2002).

Pritchard and McDiarmid (2006) also found that the lack of reflection on practices also means teachers are less likely to work towards an evidence-based inquiry approach: 'Reflective practitioners do not continually look to outside agencies for professional development; rather they are instrumental in developing themselves as practitioners' (p. 438). The practice of reflection is identified as being quite varied in terms of how often, how much, and purpose. For example, on the one hand, someone could reflect frequently, bringing awareness to thoughts and actions, while on the other hand, another person could take the time to reflect on patterns of thinking across a number of different situations. This spectrum also illustrates that reflection can be practiced at different frequencies, from reflecting regularly such as every day to more spasmodic over a number of years (Amulya, 2004). Reflection can also vary in depth, from noticing events to deep examination and analysis. Reflection on one's own practice takes time and intent (Buczynski & Hansen, 2010) and practice.

Reflective practice can be performed individually or collectively in groups at particular events (Amulya, 2004). Tillema (2002) found that reflection after practice had a positive effect on beliefs, but reflection prior to practice did not. Individual and collective reflection appears to be supportive of each other within the same learning process, and sometimes this is determined by the learning agenda. This agenda is important in the planning stages of an event or experience, as it helps to identify purpose and opportunities for the reflection to take place. Tillema (2002) stated that reflection needs to be at the right intervals, so there is an opportunity for sufficient depth to be explored. Reflective practice is fundamentally structured around inquiry, and the most powerful methods for examining experiences are through stories and dialogue. Stories are narrative accounts of experience, whereas dialogue is the process of thinking aloud as the experience is examined. These methods prove productive even if there is no clear problem or issue driving the reflection, as they can be used to examine the richness of the experience, as well as identify and evaluate emerging issues to be further examined. Deeper forms of reflection provide the possibility to identify particular questions or issues that need to be examined for an individual or group to advance their learning or work (Amulya, 2004).

Reflective practice is an important process, but should be part of a cycle that is coupled with action (Clarke & Peter, 1993). As new models of understanding are developed and tried within the classroom context, the reflective process should begin again to allow refinement of the ideas and practice, thereby building on different experiences as part of the reflective process and leading to change (Atkin, 1992). Therefore, reflective practice is an important component of the change process.

2.6.5 Identifying whether change takes place

To make lasting changes to practice, it is assumed this takes time and professional involvement (Britt et al., 2001). 'Success needs to be defined not in terms of teacher mastery of new strategies but in terms of the impact that changed practice has on valued outcomes' (Timperley, 2008, p. 8); however, this may not be immediate as evidence of these changes may not be seen in the teachers' and consequently students' abilities for a period of time (Timperley, 2008). Timperley cautioned that time is not the only condition leading to change, stating that 'teachers also need to have their current practice challenged and to be supported as they make changes' (p. 15) and that 'little professional learning takes place without challenge' (p. 16). Opfer and Pedder (2011) suggested the potential for teacher change is opened up when self-doubt or an event or incident occurs, creating the opportunity for reflection to occur.

Brown and Renshaw (2007) stated, 'Change in the mathematics classroom cannot exist in a vacuum or be insulated from the histories of the participants' (p. 105). They found that for the teacher to make change in their pedagogical techniques, they were required to examine the pedagogy of the past, maintaining techniques that work, and dispensing of those that do not. This aligns with change management models such as the ADKAR (Awareness, Desire, Knowledge, Ability and Reinforce) model (Mulder, 2014). The ADKAR model illustrates that there needs to be an awareness of the need to change and then a desire to participate in the change. A knowledge of how to change is required to facilitate the ability to implement the required skills or behaviours, and this needs to be complemented with reinforcement to sustain the change. It is argued that the five elements are the building blocks of change and, individuals as well as organisations move through each of the elements. Use of such models illustrate the complexity of change and in classrooms there is the additional element of working with students, thus to allow for

> transforming teacher practice in the mathematics classroom requires teachers to learn how to balance the complex interaction between content knowledge, pedagogical techniques, and contextual understandings with the institutional requirements of schooling. (Brown & Renshaw, 2007, p. 105)

Due to these complex interactions, change in teacher practice may or may not be obvious, may or may not be observed immediately, and may not be understood for a considerable amount of time.

It can be argued that for change to happen, it needs to come from the people; through the teachers, and then through the change of a number of individuals, a change in the school will start to take place (DuFour & Berkey, 1995; Fullan, 1993). Different areas of influence effect teacher change; these include the professional learning setting, the development of community and trust, and the use of reflective practice. 'Influencing teachers' beliefs . . . may be essential to changing classroom practices' (Stipek et al., 2001, p. 213); however, it is not a straightforward process.

> Teachers' knowledge and beliefs about teaching, learning, and subject matter are critical determinants of whether and how they implement new educational ideas. For teachers to change their pedagogical practices, they must have the knowledge necessary to implement the changes and beliefs to support them. Thus, efforts to help teachers make significant changes in their teaching practices must also help them to acquire new knowledge and beliefs. At the same time, teachers come to understand new practices through their existing knowledge and beliefs. (Borko et al., 1997, p. 272)

In summary, this section presented the different influences and factors of teacher change. The first part examined the classroom setting as being a location that provides the relevant context for teachers to examine their own practice. The classroom was the location for this research.

The second part of the section considered deep learning and trust and the impact this has on teacher professional learning. The professional learning intervention had the component of one-on-one time with the mathematics educator in the triads, to work on building trust. The teacher also selected their own professional learning partner, which may also facilitate the development of trust.

The third part of this section presented the importance of community, which included the involvement of school leaders. This study included the whole school staff in the professional learning intervention, which included the principal and leading teacher.

The importance of reflective practice, individually or in groups, in leading to teacher change was the fourth part of this section. It was identified that reflective practice coupled with action were crucial elements of the change cycle. Reflective practice was a core element of this study and was performed with teachers individually and collectively in the triad situation and as a whole staff.

The final part of this section acknowledged that change could occur to teacher beliefs, teacher practice, both, or even neither as a result of the teacher professional learning intervention. It was identified that the change process is complex with many influences, with change occurring with individuals and with organisations. This reflects the complex nature of the study when working with a group of teachers rather than one individual teacher.

2.7 Concluding Comments

A framework proposed by Sullivan, Borcek, Walker, and Rennie (2016) as shown in Figure 2.3 can be used to draw the aspects of Chapter 2 together.

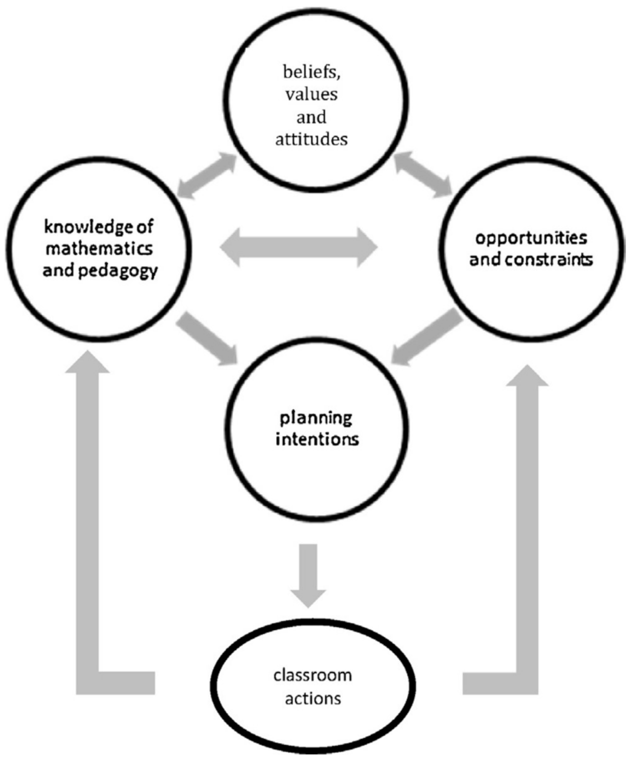

Figure 2.3: Proposed framework (Sullivan et al., 2016, p. 161).

The framework illustrates the complexity of interactions between the various aspects of teacher knowledge, teacher beliefs, opportunities, and constraints when planning intentions and classroom actions. This model can be applied to Chapter 2, where Sections 2.1 2.2, 2.3, and 2.4 are components of the knowledge of mathematics and its pedagogy. Sections 2.5 and 2.6 are components of the beliefs, values, and attitudes of the model (Sullivan et al., 2016).

In Section 2.1, I presented the relevance for the context of mathematics for the study at an international and national level. I also considered this from a teacher skill perspective and identified the tension between the terms mathematics and numeracy.

In Section 2.2, I presented the context for mathematics teaching, through the AITSL and AAMT teacher standards, to illustrate the environment that teachers of the study were working in. I also discussed the idiosyncrasies of mathematics teaching, explaining my own belief that teaching is more than content, being a complex mix of connections that impact mathematics, as it is developed while being learnt. These views of mathematics were used to guide the professional learning intervention with teachers in classrooms to challenge their beliefs about the teaching of mathematics.

In Section 2.3, I discussed the complexities of teacher mathematical knowledge. This included the impact of teachers' own mathematical knowledge on student classroom experiences, coupled with requirements to have particular levels of knowledge as outlined in the AITSL professional standards documentation. This informed and guided interactions with teachers in the professional learning intervention.

In Section 2.4, I discussed teacher pedagogical knowledge and teacher pedagogical content knowledge, which informed and guided discussions in the teacher professional learning intervention. In this section, I also explored the concept of signature pedagogies, of what this may look like for a teacher of mathematics in a fluid and dynamic classroom environment. This informed my understanding of the importance of teacher knowledge in teacher professional learning situations.

In Section 2.5, I explored teacher beliefs and the way these could be challenged and perhaps changed. This was the core of the study as the research investigated teacher change. Teacher belief systems are complex and influenced by many factors, including teaching experiences in the classroom, and this is reflected in Figure 2.3.

In Section 2.6, I examined teacher change, considering the setting, the concept of trust and the importance of community, and the processes of reflection. This section informed reflective processes that were included in the study to create the opportunity for teacher change as a result of the teacher professional learning intervention.

In the framework (Figure 2.3) there are two nodes: planning intentions and classroom activities. These are explored in Chapter 3. In Chapter 3, literature about teacher professional learning is presented as elements such as models of professional learning, coaching, and the triad model. The influences of location and the impact of school leadership on professional learning are explored in depth in Chapter 3.

CHAPTER 3: LITERATURE ABOUT TEACHER PROFESSIONAL LEARNING

This chapter presents a review of literature about teacher professional learning in six sections. Section 3.1 describes teacher professional learning: its importance and the different models. Section 3.2 presents elements of professional learning that are effective, which contrast with the elements of professional learning in Section 3.3 that appear less effective. Section 3.4 considers what happens after the professional learning, and Sections 3.5 and 3.6 present two major factors that impact professional learning: rural challenges and the impact of school leadership. Section 3.7 summarises the implications of each section on the study.

3.1 Teacher Professional Learning

This section examines teacher professional learning. The first two parts of the section consider the importance of teacher professional learning, both internationally and nationally. The term and meaning of teacher professional learning is discussed in the third part. The fourth part of this section presents a number of models of professional learning, particularly those related to the study. The fifth part of this section focuses specifically on experts entering the school, and the sixth part focuses on coaching. The trial model of professional learning is presented in the seventh part, and the eighth part of the section considers what professional learning appears to work and what does not.

> As professionals, teachers need to engage in reflective practice to critically think about their skills and knowledge, access professional development for improvement and become an active member of learning communities to meet their professional needs. (Jones & Jones, 2013, p. 74)

The aim of many different forms of professional learning is to make change in one or all areas of an individual's 'knowledge, understanding, behaviours, skills—[and] values and beliefs' (Hord, 1994, p. 1); however, this is often not possible. It needs to be acknowledged that schools are complex places and teacher professional learning is an ongoing process, rather than 'a task to be completed' (DuFour & Berkey, 1995, p. 5). Many elements affect teacher professional learning, which include the teacher, the school, and the learning activities (Opfer & Pedder, 2011). It takes time, and support needs to be sustained to allow the time for the change to take place. Professional learning is not a linear process, and just because teachers are involved in professional learning, it does not mean an improvement in student learning will be observed (Opfer & Pedder, 2011).

3.1.1 The importance of teacher professional learning internationally

The importance of professional learning is recognised on an international scale. The OECD (2012) stated, 'Given the complexity of teaching and learning, high quality professional development is necessary' (p. 73). The reasons for continual development after a teacher's initial training include:

- Update individuals' knowledge of a subject in light of recent advances in the area;
- Update individuals' skills and approaches in light of the development of new teaching techniques and objectives, new circumstances, and new educational research;
- Enable individuals to apply changes made to curricula or other aspects of teaching practice;
- Enable schools to develop and apply new strategies concerning the curriculum and other aspects of teaching practice;
- Exchange information and expertise among teachers and others, e.g. academics and industrialists; and/or
- Help weaker teachers become more effective. (OECD, 2012)

Similar reasons are reflected in many sources (Stewart, 2011), and reports of international assessments such as TIMSS and PISA also highlight the importance of teacher professional learning, as questions are included about teacher learning in the surveys and reported upon. The next part of this section presents the importance of teacher professional learning nationally.

3.1.2 The importance of professional learning nationally

The importance of teacher professional learning is recognised at a national level in Australia. In the *Australian Professional Standards for Teachers* (AITSL, 2014), the section titled Professional Engagement describes the expectations of teachers to engage with professional learning. The importance of ongoing learning is emphasised as well as the importance of modelling learning behaviour. Each of the following standards, relevant focus areas, and descriptors related to professional learning are included to illustrate this.

- Standard 6: Engage in professional learning:
    - 6.1 Identify and plan professional learning needs;
    - 6.2 Engage in professional learning and improve practice;

    - 6.3 Engage with colleagues and improve practice; and
    - 6.4 Apply professional learning and improve student learning.
- Standard 7: Engage professionally with colleagues, parents/carers and the community:

    . . .

    - 7.4 Engage with professional teaching networks and broader communities. (AITSL, 2014, para. 37)

The AAMT *Standards for Excellence in Teaching Mathematics in Australian Schools* in Domain 2, Professional Attributes, also identifies the importance of professional learning. The statement in 2.1 Personal Professional Development states:

> Excellent teachers of mathematics are committed to the continual improvement of their teaching practice and take opportunities for personal professional development. They undertake sustained, purposeful professional growth in their own knowledge, understanding and skills in mathematics, and in the teaching and learning of mathematics. The professional development they undertake enables them to develop informed views about relevant current trends (including teaching and learning resources, technologies, and changes to the curriculum with which they work) and to further their teaching expertise. They are involved in professional development processes that include collegial interaction, professional reading and active exploration of new teaching ideas, practices and resources in the classroom. They reflect on practice and the new knowledge they gain, and learn from their experiences. (AAMT, 2006, p. 3)

The AAMT standards provide detail about professional learning of professional knowledge of the teaching and learning of mathematics as well as broader professional learning of the context teachers work within. It is also a requirement in all states of Australia to maintain a certain level of professional learning for registration purposes. In Victoria (where the study was conducted) all teachers, including early childhood teachers, are required by the VIT to engage in at least 20 hours of professional learning activities each year (VIT, 2017a) to maintain their teacher registration.

Therefore, AITSL, AAMT, and teacher registering bodies, such as the VIT, not only emphasise strongly the importance of professional learning, but also require it as part of ongoing teacher registration. So, it can be seen, teacher professional learning is often driven by external factors, such as governing or registration bodies, but this as a driver of professional learning is found to be less effective than professional learning being completed for a school or self-initiated reason (Opfer & Pedder, 2011). The following section will examine what is teacher professional learning.

3.1.3 What is teacher professional learning?

The terms professional learning, professional development, and staff development appear interchange when related to the teaching profession. As this research examined teacher change through a learning intervention, the term professional learning has been used throughout the work, following the shift in terminology away from professional development seen across Australia (Mayer & Lloyd, 2011). Teacher professional learning is difficult to define as it depends on the 'uniqueness of the context, person and so on' (Opfer & Pedder, 2011, p. 379). It is effected by relationships between elements, which vary considerably depending on the situation, the context, and the people involved.

Shulman (1986a, 1987) explored teacher learning in terms of PCK and pedagogical reasoning and action related to the individual learner. Shulman (2002, 2003) later examined teacher learning in terms of theoretical models, which describe how teachers might learn through critical reflections that are not content specific. Shulman and Shulman (2004) identified the dimensions of an accomplished teacher as a 'member of a professional community who is ready, willing, and able to teach and to learn from his or her teaching experiences' (p. 259). The elements of the teacher learning theory are identified as being ready, willing, able, reflective, and communal and thus, Shulman and Shulman (2004) argued that the features of accomplished teacher development or teacher learning are 'Vision, Motivation, Understanding, Practice, Reflection and Community' (p. 259). These features are evident in the following discussion of teacher professional learning.

Shulman and Shulman (2004) acknowledged that there are many complex interactions within the learning sphere. These include the individual's own visions, motivations, understandings, and practices, numerous school communities, as well as the broader community of practice. These interactions of learning are both independent and interactive and are impacted by resources, leadership, and the environment of the teaching and learning: 'The analysis of teacher learning . . . has moved from a concern with individual teachers and their learning to a conception of teachers learning and developing with a broader context of community, institution, polity, and profession' (Shulman & Shulman, 2004, p. 268). Teacher professional learning is observed on a larger scale as well as at the individual level.

Mayer and Lloyd (2011) identified professional learning as being something one does, is provided to, or done to teachers. Professional learning is defined as 'activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher' (OECD, 2009, p. 49). This is also evident in work by Opfer and Pedder (2011). Stack et al. (2011) argued that 'effective professional development cannot take place without new learning' (p. 3), while Bartholomew, Baton, Kensington-Miller, and Patterson (2005) argued that it is 'less about instructing teachers in best practice and more about the creation of opportunities for teachers to look at what they do' (p. 1). These opportunities open the door for possible change in teaching practice to take place.

Professional learning is more about the possible change in a teacher's practice or capacity of practice, for example, professional knowledge (Mayer & Lloyd, 2011). It is an ongoing process of 'knowledge building and skill development in effective teaching practice' (Solis, 2009, p. 1). Teacher professional learning is about 'teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth' (Avalos, 2011, p. 10). The Victorian DEECD (2007) states that 'teacher professional learning can be defined as those processes and activities; formal and informal, designed to enhance the knowledge, skills and capacity of staff' (para. 1). This can include on-site or at-school learning, which may involve formal activities such as mentoring and working in project teams or informal activities such as the involvement in school discussions about policy. Teacher professional learning may also take place off-site, or as outside-school learning, or network activities, in the form of conferences, workshops, online training, and modular programmes over a period of time.

Some authors make the distinction between formal (professional development) and informal (professional learning) opportunities, while others indicate a merge between formal and informal in the learning process (Day & Sachs, 2004; Knapp, 2003). AITSL (2012) defines professional learning as 'the formal or informal experiences undertaken by teachers and school leaders that improve their individual professional practice, and a school's collective effectiveness, as measured by improved student learning, engagement with learning and wellbeing' (AITSL, p.

2). Therefore, it seems that teacher professional learning is seen as something to do to improve teachers' knowledge and/or practice.

Avalos (2011) found teacher professional learning to be a complex process as it requires both 'cognitive and emotional involvement of teachers individually and collectively' (p. 10). This is also reflected in Opfer and Pedder's (2011) work, which emphasises teacher professional learning as involving complex phenomena; it is influenced by teachers' own personal beliefs (Avalos, 2011) as well as by the larger system of the school and even educational department. Joyce and Showers' model (1980) presents five components of professional learning:

1. Presentation of theory or description of skill or strategy;
2. Modelling or demonstration of skills or models of teaching;
3. Practice in simulated and classroom settings;
4. Structure and open-ended feedback; and
5. Coaching for application. (p. x)

This could almost be seen as an effective teaching model. Hord (1994) found coaching for application (the fifth component) was the most effective and critical component in the contribution to change of practice in classrooms. The first component, presentation of theory or description of skill or strategy, reinforces the idea that teacher professional learning should be purposeful and research based, so that it links to the goals of the school (DuFour & Berkey, 1995). Each of the five components of professional learning (Joyce & Showers, 1980) applies to a cyclic approach to teacher professional learning (Guskey, 1997), as new ideas are implemented, reflected upon, and then involves an element of coaching that begins the cycle again.

3.1.4 Models of professional learning

There are many models or modes of teacher professional learning. Formal programmes represent one source for continued learning, although these are often seen as a passive form of professional learning that is quite removed from teachers' classrooms (Burbank & Kauchak, 2003). These formal or informal learning experiences may include conferences, seminars, lectures, and one-off visits to other schools; however, the OEDC (2012) reported that these show to have less impact compared to individual and collaborative research qualification programmes and informal dialogue, which were reported to have the greatest impact on teacher practice. Teachers' schools and classrooms can also become places for teachers as well as students to learn. Professional learning programmes that engage teachers in inquiry in their classrooms can provide the basis for teachers' learning to become generative so that their knowledge, conceptions, and practice continue to grow and evolve (National Research Council, 2001). Taylor, Yates, Meyer, and Kinsella (2011) found experienced teachers preferred to share expertise within schools, using observations and sharing practices in a more informal context, but this was greatly dependent on the availability of time.

It is important for teachers to know about professional learning programmes, the different variations of professional learning available, and how to access them (Willis, 2002). It is also important for teachers to recognise that if one form of professional learning is used, it does not mean that other forms of professional learning should be excluded (Neufeld & Roper, 2003). Professional learning should not be a one-size-fits-all model, as different learners will engage with different professional learning experiences.

The following subsections focus on different types of professional learning aspects conducted in schools, that directly inform the development of the professional learning intervention.

3.1.4.1 Lesson study

A lesson study is the process of teachers who jointly plan a lesson, observe what happens when the lesson is implemented, analyse what happened, come up with ideas for improvement, then try the lesson in their own classrooms. It is also known as a 'research lesson' or 'study lesson' (McGraw, Arbaugh, Lynch, & Brown, 2003; Willis, 2002). They are acknowledged as being 'high-quality (professional learning) programs' (p. 270). A popular form of this type of professional learning is the Japanese Lesson Study, which is where a small group of teachers meet to study a particular area of interest to develop a small number (one or two) highly refined lessons. The group begins by setting a goal, which sometimes is adapted from national level requirements or it might be a problematic curriculum area. A small number of lessons are identified to address the goal, and the group works over a period of time to develop and improve the lessons.

The lesson study groups meet regularly, such as once a week, to develop, test, and refine the improved lessons. A submodel is to divide the work into three phases: the first phase concentrates on research, the second phase is the design of the lessons, and the third phase is the testing and refinement of the lessons. The third phase includes teaching the lesson before other teachers, and even the whole staff, and then seeking feedback before refining the lessons further. The group finally reports on the processes and lessons (National Research Council, 2001). Adaptations of the model include assessing the students' work as a result of the lesson (Crockett, 2002).

An advantage of the lesson study is the collaborative nature of the work. It allows teachers the opportunity to discuss the teaching and learning experiences of the particular lesson. It also allows teachers to try and refine the lesson, with an accountability of reporting built in. A disadvantage of this form of professional learning is that it requires teachers to have time to work together, perhaps taking time away from their own classes. Some teachers may feel quite threatened when teaching in front of others. The lesson developed may not be in the style the individual teacher prefers to teach, and it may not be effective with their particular class.

3.1.4.2 Professional reading

McGraw et al. (2003) presented the professional learning model of 'book discussions'. These discussions were formed around the reading of a set of books. These book discussions developed from the finding that there should be a balance between curriculum development (the lessons) and reflection on issues related to the teaching and learning of mathematics. It was found that these readings and discussions contributed towards communities of learning and practice. The professional reading could also be extended to professional reading of papers and articles, as it is the discussion and the development of a common language that works towards the development of a community of practice that is important.

An advantage of professional reading is that it provides opportunity for teachers to learn about new and different ideas and methods. By completing this in groups, communities of learning and practice can develop. A disadvantage of this form of professional learning is that it is theoretical and not based on classroom practice. It requires teachers to take the ideas presented and translate these to implement into their own classroom environment.

3.1.4.3 Peer observation

Peer observation is a way of recognising the expertise teachers bring to their profession, as teachers work together, share their knowledge, and does not require an imported expert (Buchanan &

Khamis, 1999; Joyce & Showers, 1998; Taylor et al., 2011). Peer observation is often conducted as an observation of a colleague's taught lesson either at their own or a different school, followed by feedback or discussion. Sometimes the observation has specific goals or targets, and at other times, it is an open and general observation. The advantage of this type of professional learning is that it allows teachers to examine the complex context of the classroom that relates to them (Burbank & Kauchak, 2003).

Buchanan and Khamis (1999) found that peer observation gave teachers access to ideas, new strategies, content, and resources. They found that some teachers observed the implementation of strategies they may have previously rejected, and the observations allowed teachers to place their classes into the school's context. Unfortunately, although peer observation has been found to be a highly effective form of teacher professional learning, with many benefits for the teachers, it is not a widely used form of professional learning due to time constraints often found in schools (Buchanan & Khamis, 1999). Another disadvantage is that it is often seen as a 'high-risk' form of professional learning, as the teaching of the observed teacher is critically analysed in the discussion process. So, while the observation is effective, the observed teacher may feel exposed; therefore, trust needs to be developed and sometimes support mechanisms such as discussion protocols need to be put in place.

3.1.4.4 Professional conversations

Britt et al. (2001) argued that professional conversations are a part of professional learning. A complex task or process is shared and discussed in depth in order that an understanding of the task is developed. This may or may not include an observation cycle. Often these observations are centred on practice, and teachers need to 'learn how to analyse practice, both other teachers' practice and their own' (Willis, 2002, p. 1). To analyse means that 'they [teachers] need to think about the relationship between teaching and learning in a cause-and-effect kind of way' (Willis, 2002, p. 1). This idea of collaboration with other teachers in analysing practice is quite foreign and difficult for many teachers, as teaching has been a private thing in the past; however, 'the value is instantly apparent to teachers who do it' (Willis, 2002, p. 2). An advantage of professional conversations is that they can be with peers but may also include experts entering the school.

In summary, this subsection presented four different forms of professional learning: lesson study, professional reading, peer observation, and professional conversation. It is acknowledged that there are many more forms of professional learning, but these four were selected as they feature in the professional learning intervention of this study. All four forms of professional learning have advantages and disadvantages; however, it was anticipated that the combination of these within the professional learning intervention would create the opportunity for teachers to change their practice. The next part of this section will examine experts in teacher professional learning, including experts entering the school and practices of coaching.

3.1.5 Experts entering the school

Different forms of experts from outside the school can be involved in school professional learning situations. These could include an external presenter who attends the school for a short period of time, a coach (someone who comes to the school and works in a one-on-one situation), a mentor, or even a critical friend. There are many challenges with these expert roles, including determining the balance between feedback and confidentiality, which is dependent on establishing an element of trust. The issue of trust is seen as important in overcoming barriers, such as teachers who ignore or who do not want to work with external people entering the school (Neufeld & Roper, 2003). This section considers the external expert as someone entering the school in relation to professional learning.

An external expert could be within the school (e.g., a person external to the particular department) or from outside the school (such as a researcher) (Timperley, 2008), and these experts can 'challenge assumptions and present teachers with new possibilities' (Timperley, 2008, p. 20). It is important that the external expert is familiar with relevant curricula and teaching practices that 'make a difference for students' (p. 20). External experts are able to make new knowledge and skills meaningful to teachers and manageable in their teaching environments, as well as connecting theory and practice (Timperley, 2008).

The external expert is seen as one who has a deep knowledge of content, such as mathematics, and the way students learn it. They have the ability to act as a resource for other teachers in the school. They may 'consult with other teachers about specific issues, teach demonstration lessons, observe and offer suggestions, or provide special training sessions during the year' (National Research Council, 2001, p. 39).

One form of external expert is the critical friend. Bambino (2002) defined the term critical friend as being '*critical* because it challenges educators to improve their teaching practice' and 'involves *friends* who share a mission, offer strong support, and nurture a community of learners' (p. 27, emphasis in original). The role of a critical friend is to be on the outside, rather than being part of the community, but there is still a need for 'building the trust needed to engage in direct, honest, and productive conversations with colleagues about the complex art of teaching' (p. 25). Therefore, a critical friend is not as involved in the professional learning process as a coach or external expert is. A critical friend may not visit the school or meet with the staff as frequently as the other external experts, only being in contact from time to time.

Timperley (2008) stated, 'External experts who simply promote their own preferred practices are less effective than those who involve teachers in discussing and developing understandings that are meaningful in their particular practice contexts' (p. 21). An advantage of the external expert is they can be common to different experiences that teachers may have through the professional learning. Thus, they can be the link between teacher groups to create discussion, using a common language for observations and conversations with groups as a whole (Avalos, 2011) in developing a learning community. These learning communities can strengthen understanding and knowledge of the presented materials and ideas of the professional learning intervention, perhaps leading to change. One form of external expert is the coach, and this is examined in the next part of this section.

3.1.6 Coaching

Coaching is seen as having 'great promise for changing professional practice and the professional culture in which teachers work' (Neufeld & Roper, 2003, p. 28). One definition of coaching is that it is a 'personal interaction, either formal or informal, between a person who assumes the function of a coach and any set of other people' (Kinlaw, 1997, p. xv). Another definition of coaching is that of working side by side with principals and teachers, observing their work and offering critiques and models of effective practice. It is school-based professional learning, often instigated by external factors. Neufeld and Roper (2003) identified two types of coach: the change coach, who looks at whole-school organisational improvement and the content coach, who looks at specific content areas directly with teachers. Although the work of the content coach is more specific, it still needs to be considered in context of the school organisation and resources, and the coach's role may include putting teachers and principals in touch with the required resources. Both types of coaches need to customise what they are doing to meet each school's particular needs, so that the programme is coherent and not ad hoc. In both areas, the coaches tend to stay with schools over a period of time, helping to meet new challenges as they arise (Neufeld & Roper, 2003).

Coaching does more than just improve performance, as it acts to connect people with people and build a sense of trust. It is sometimes seen as a mechanism to build communities of learning as it is grounded in inquiry and reflection, which are participant driven (Neufeld & Roper, 2003). One of the main advantages of coaching is that it is a 'real-time response to issues, needs and opportunities as they develop' (Kinlaw, 1997, p. xv). The interpersonal nature of coaching allows people to learn and improve their performance, which in turn empowers people, as they are involved in the decisions being made. The coach provides the individual or team with feedback, guidance, challenge, and support. A true coaching conversation is mutual, balanced, and two-way (Kinlaw, 1997). The process of coaching can involve 'selective observation' (Kinlaw, 1997, p. 13) for learning, challenging, and improving practice. This provides information to people about their performance, which can be formal with planned and structured conversation or informal with words of encouragement or extended discussion.

Coaching is goal based, with the main aim of facilitating the achievement of set goals. It is sustained and ongoing, connected to and derived from teachers' work. It engages teachers in concrete tasks and is connected to other aspects of school change (Neufeld & Roper, 2003). The process of coaching delivers incremental learning and helps people achieve small successes. This helps to build people's confidence as well as competence and provides the opportunity to trial the developed capabilities.

All parties involved in the coaching need to believe in and be committed to the process, and this can be reflected in the amount of quality time devoted to the process. Thus, there needs to be a belief in people's potential to learn and desire that they do their best. Elements of successful coaching are identified as shared beliefs, quality of coaching, skills, and processes. Not only do participants learn in a coaching model, but coaches also learn (Kinlaw, 1997). One of the difficulties of coaching is that it is not a scripted role, and it is not always possible to preplan. The coaches guide teachers' learning, so in a sense they need to be 'more than one step ahead of the people they are coaching' (Neufeld & Roper, 2003, p. 14). However, coaches clearly 'cannot make the learners learn' (p. 18). Both coach and participant need to understand the purpose and direction of this form of professional learning, with common understandings of what is being asked. Another element is to provide people time to practice the new knowledge and skills in a safe environment. There needs to be a common understanding, as 'coaches cannot help others resolve problems without knowing how these other persons understand the problem and what they have done to resolve it' (p. 88). Kinlaw (1997) stated that all parties need to have equal opportunity to contribute; therefore, all parties share responsibility for the outcomes through the development of common understandings.

The skills of the coach include the ability to listen, observe, understand, and develop information, as well as convey support and confidence (Kinlaw, 1997). Coaches need to be available, sensitive to spontaneous and informal coaching opportunities, and initiate coaching interactions. The coach needs to be prepared to share their own knowledge as well as encourage contribution. The coach also needs to be willing to be influenced by other people, which may lead to a modification in their message or a change in their approach. Thus, a coach may not be a leader but a peer or someone entering the organisation.

Neufeld and Roper (2003) acknowledged that there is no widespread evidence that coaching will improve student achievement, but stated, 'There is good reason to believe coaching holds promise' (p. iv). One-to-one teacher professional learning in the form of mentoring or coaching is one model that can be used to work towards teacher change. This model may, for example, be a teacher meeting with the principal prior to class, the principal observing the teacher teaching the class, followed by a meeting after the class to review feedback on the observations. The model 'promotes [that] dialogue and reflection' can 'serve as a cornerstone of a peer observation model' (DuFour & Berkey, 1995, p. 4). It may be cost effective and involve leadership (the principal) in the professional learning, but it could also be viewed as hierarchical, with the principal assessing or judging the teacher in what may be seen as a performance matter. Kinlaw (1997) noted that not all leaders naturally make good coaches. Another version of this model, instead of involving leadership, is to have the coach/mentor come into the school as an external expert, working with the teacher in the classroom. A limitation with this form of professional learning is that the external coach/mentor is not in the school on a continuing basis and often the teacher needs support in the teaching environment to practice and develop the learning as a result of the professional learning (Timperley, 2008).

The next part of this section presents a model that uses a group of three, a triad, in the professional learning intervention.

3.1.7 Triad model

Triad models of professional learning have been explored as preferable to pairs of professionals working together in a form of peer coaching that involves ‘mutual consultation between teachers of equal status’ (Anstey & Clarke, 2010) or teacher mentoring, which implies some form of hierarchy such as the coaches or ‘expert teachers’ model examined by Anstey and Clarke (2010). Although there is evidence that coaching models have the potential to have high impact on classroom practice, a less traditional model for professional learning is explored.

Kenny (2009) introduced the use of ‘three-way partnerships or ‘triads’’ (p. 1) as an approach to the preparation of PSTs in science. Kenny (2009) argued that ‘a partnership implies a more equal arrangement than supervisor–novice situation(s)’ (p. 4), which can often be implied with a mentoring situation where one person is identified as the ‘expert’. In the model posed by Kenny (2009), the triadic partnership consists of the preservice primary teacher, an in-service colleague teacher (who may be a supervisor), and the science teacher–educator. One of the aims of the model is to acknowledge that each member of the triad brings different ‘experience, knowledge and skills to the situation’ (Kenny, 2009, p. 4). This is shown in Figure 3.1. The diagram implies equal degrees of communication between each of the members of the triad.

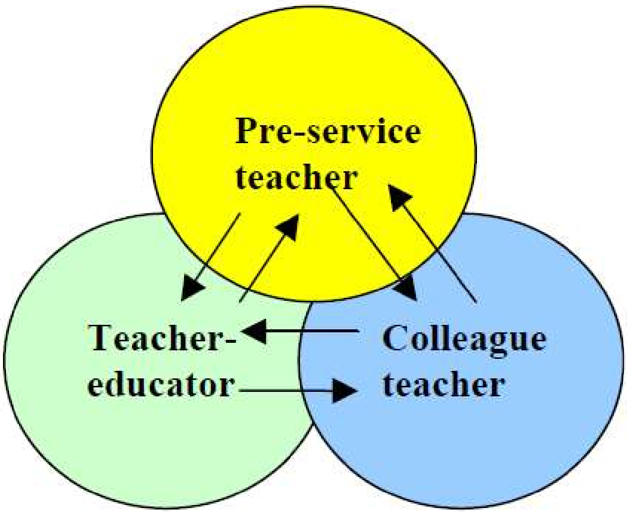

Figure 3.1: The professional learning triad (Kenny, 2009, p.4).

Kenny (2009) identified clear and distinct roles for each member of the triad, as well as the type of skills it is anticipated each member will bring to the triad. For example, colleague teachers are expected to support the PST's learning on aspects such as classroom management, pedagogy, and learning context rather than assess the PST, while having knowledge about the class group and school environment. The advantage of the triadic model is that it provides both authentic learning situations and key elements of mentoring (Hudson, 2005). Hudson (2005) identified five factors that characterise the quality of mentors: their personal attributes, their knowledge of system requirements, their pedagogical knowledge, their ability to model good practice, and their ability to provide constructive feedback. However, Haymore Sandholtz (2000) found that when cooperating teachers (in a PST environment) function in an advisory or mentoring role, the nature of collaboration changes and potentially lessens the opportunities for experimentation and risk taking by the team.

Other examples of triad models within teacher education programmes include normal practicum situations (McIntyre, Byrd, & Foxx, 1996) where the triad consists of the PST, the school supervising teacher, and the university mentor. Hastings and Squires' (2002) model, similar to Kenny's (2009), includes the teacher–educator as a school-based teacher rather than a university educator, making the triad the PST, the school supervising teacher, and a colleague teacher. Haymore Sandholtz (2000) proposed a model with two PSTs and a cooperating (supervising) teacher. These teams are mixed disciplines in a secondary context. This model, too, found that team members were able to draw on each other's strengths and expertise. Haymore Sandholtz (2000) found that using teams of three altered the 'expert–novice relationships' (p. 49), and this was further broken down through the use of interdisciplinary team members. It was found that by using a triad, there were fewer personality conflicts and this could be further minimised by allowing members to select their own teams. Haymore Sandholtz (2000) also found elements such as curriculum development a natural key aspect in enhancing professional growth. Time was identified as one of the major challenges when working in a team environment such as a triad professional learning model, where 'the bottom line tends to be: there is never a perfect time or enough time' (Haymore Sandholtz, 2000, p. 51), always a challenge when working with a number of people in a professional learning situation.

Walker, Kelly, and Hume (2002) presented a triad model involving different elements to three individual people in a medical learning context. They suggested that the professional learning model of mentoring comprising a mentor and 'protégé' can be shifted to a triad model comprising the organisation, mentor, and protégé, as they see the role of the organisation itself as important. They argued that as the development of the protégé occurs within the organisational context, this in itself adds to organisational learning, and so the organisation's role and influence cannot be ignored. Walker et al. (2002) advocated strongly for this type of triad model, identifying benefits such as that the traditional mentoring model of two elements tends to limit the protégé's exposure to a single source of opinions and views, and that the restrictive number of senior mentors may be limiting; however, no further evidence was presented to support the case. This type of triad model could also be argued for educational contexts, with the school environment and community forming part of the triad.

In all these triads, elements of coaching can be applied. Each interaction has a beginning, middle, and end, and as conversations are initiated, they go through a process of development and then conclude. This development is rarely linear; rather, it is cyclic, and Kinlaw (1997) suggested the model in Figure 3.2 where coaching supplements learning.

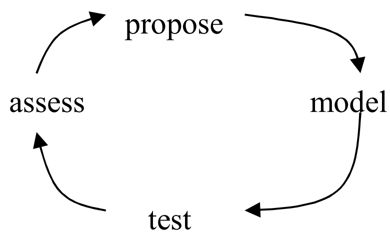

Figure 3.2: Cyclic process of coaching conversation interactions (Kinlaw, 1997, p. 4).

Coaching interactions can be brief or extended; they can be formal or informal. Coaching in the context of a triad model is more complex than between a coach and a single individual (Kinlaw, 1997). All members of the triad need to be included, and there should be an understanding or even culture of commitment, loyalty, and trust. The aim is not to tell people what to do; rather, by observation and discussion, members can find their own ways of improving their teaching practice (Britt et al., 2001).

An advantage of the triad model is that teachers can develop their own research through the process of learning and reflection. The 'expert' can slowly move, over time, from being the one in charge to allowing other members of the triad driving the discussion and reflection (Richardson, 1992). One of the other main advantages of a triad model of professional learning is that it allows for multiple perspectives. Using two or more perspectives, it creates opportunity for 'triangulation'. Through triangulating data and/or perspectives, it is possible to gain a fuller and more robust picture, enhancing claims to quality (Hamilton, 2011).

The different perspectives of what is being analysed or discussed need to be acknowledged. However, Opfer and Pedder (2011) stated that these should not be viewed as independent entities; rather, the learning comes from the interactions between the different perspectives being identified, analysed, and reflected upon in the learning situation.

3.1.8 What professional learning appears to work and what does not in teacher professional learning?

Many models of professional learning focus on structure and process. Missing are the 'nature of the content or understandings to be developed and the skills to be refined' (Taylor et al., 2011, p. 13). Taylor et al. (2011) indicated that teacher professional learning is often not representative of the true diverse nature of the teaching population and experiences of teachers. They found that most professional learning is focused on updating skills, but does not identify its impact on the teaching profession as a whole or on teaching careers. Similarly, many professional development workshops, presentations at professional meetings, publications for teachers, and other opportunities for teacher learning focus almost exclusively on activities or methods of teaching and rarely attempt to help teachers develop their own conceptual understanding of the underlying mathematical ideas, what students understand about those ideas, or how they learn them. Alternative forms of teacher education and professional development that attempt to teach mathematical content, psychology of learning, and methods of teaching need to be developed and evaluated to see whether prospective and practising teachers from such programmes can draw appropriate connections and apply the knowledge they have acquired to teach mathematics effectively (National Research Council, 2001).

Challenges for professional learning and activities, such as peer observation, include time for the professional learning to occur, time for reflective practices, and time taken away from the observer's own class. Lack of resources such as replacement teachers can be challenging and costly. The possibility of movement away from teaching the curriculum in some cases, as a result of the learning intervention, could be seen as unfavourable. Making changes in the classroom itself as a result of professional learning can also be challenging, perhaps due to existing structures (Buczynski & Hanson, 2010).

In summary, this section looked at successful approaches to professional learning, aspects that seem to be effective, and aspects that are not. For professional learning to be effective, teachers need to put into practice their professional learning experiences (Buczynski & Hanson, 2010) and the context of professional learning is important (Taylor et al., 2011). Taylor et al. (2011) stated that it is no longer appropriate to have a 'one-size-fits-all' approach to professional learning, but in fact should reflect teachers' different levels of experience, different contexts, and expertise. Unfortunately, much of the literature around professional learning focuses on PSTs or inexperienced teachers rather than those with experience (Borko, 2004). Sometimes it may not be that the professional learning is not working, but those involved in the process may not know exactly what their needs are (Stack et al., 2011).

This section also presented a number of elements of teacher professional learning. The first two parts justified teacher professional learning and ongoing professional learning in international and national contexts. The next part explored the terminology around professional learning and what it is, which informed the study generally. The fourth part looked at a number of different models of professional learning, which are all featured in the professional learning intervention. It presented both the advantages and disadvantages of each of these models.

As an external expert was a part of the professional learning intervention of this study, the fifth part of the section explored this, including the different types of external expert. The sixth part of this section looked at coaching in depth, as this was the role of the external expert in the professional learning intervention model of this study. The seventh part of this section explored triad models of professional learning, and this was the model utilised in the professional learning intervention. This was combined with the external expert in a coaching role, utilising professional learning such as lesson study, peer observation, and professional conversation.

The last part of the section presented what appears to work and what does not in teacher professional learning. This was introductory, as the next two sections of this chapter, Sections 3.2 and 3.3, present elements of professional learning that are effective and those that appear to be less effective.

3.2 Effective Elements of Professional Learning

The OECD (2012) states that effective professional development needs to be ongoing, include aspects such as observation and practising new approaches and feedback, as well as provide adequate time and follow-up support. Grootenboer (1999) argued, ‘Teacher inquiries into their own teaching—being their own researcher—is as empowering if not more empowering form of professional development than the more usual inservice modes’ (p. 1). Similarly, Ball and Cohen (1999) argued that teacher’s everyday work is a viable source of professional learning. It appears that these active approaches to professional learning are more effective methods than passive learning experiences such as lectures. The OECD reported, ‘Successful programs involve teachers in learning activities that are similar to those they will use with their students’ (2012, p. 73). Teacher professional learning is most effective ‘when it is relevant, collaborative and future focussed, and when it supports teachers to reflect on, question and consciously improve their practice' (AITSL, 2012, p. 4). General good teaching practices, such as engaging with professional learning materials, making the learning relevant, having active pedagogy, all contribute to effective professional learning (Opfer & Pedder, 2011). Ingvarson, Meiers, and Beavis (2003) reviewed a large amount of research literature and identified a number of characteristics of effective professional development: content focus, follow up, active learning, feedback, and collaborative examination of student work. These characteristics are reflected on and evident in the following sections.

3.2.1 Content

It is informative to provide some detail about what professional learning content teachers access in mathematics. As the school in this study was primary, TIMSS data examining the most common areas of mathematics professional learning for teachers of fourth-grade students were examined. It was found that the most common areas of professional learning were mathematics pedagogy/instruction, mathematical content, and mathematics curriculum. On average, 46% of students had teachers who had received professional learning in mathematics instruction or pedagogy, 44% had teachers who accessed professional learning in mathematics content, and 41% had teachers who accessed professional learning in mathematics curriculum. Mathematics assessment and integrating information technology into mathematics were less common areas, with 37% and 33% of students, respectively (Mullis, et al., 2012). While mathematical content in professional learning is important, it is not enough for the learning to focus only on content to be effective (Solis, 2009), but needs to be applied to the context in which it is to be used.

3.2.2 Time and the ongoing nature of professional learning

Time is a factor in everything, including teacher professional learning. Willis (2002) looked at the time factor broadly, stating, 'A profession is defined by a knowledge base, which allows the profession to improve its practices over time' (p. 3). Through day-to-day processes, learning is developed, which leads to a change in practice over a period of time. While a large amount of professional learning occurs in teaching, and it is a requirement for teacher registration, it appears that the teaching profession itself has not changed greatly over the past 100 years (Willis, 2002). It seems that an unrealistic expectation of professional learning is that there will be immediate results (Buczynski & Hansen, 2010). For substantial change in teacher practice to be observed, sufficient time must be allocated for teachers to master what is being explored though professional learning, which could reasonably be expected to be a number of years (Borko et al., 1997, Neufeld & Roper, 2003) before change in practice is observed, as teachers need time to practice their new knowledge (Opfer & Pedder, 2011).

It is well documented that ongoing professional learning activities over a longer period of time (Crockett, 2002; Willis, 2002), which include processes such as recording details and then reflecting upon them, are more successful than single, one-off events or shorter interventions (Avalos, 2011; Guskey, 2000; Lamb, Cooper, & Warren, 2007; OECD, 2012; Opfer & Pedder, 2011). Yoon, Duncan, Lee, Scarloss, and Shapley (cited in Mullis, et al., 2012) found that more than 14 hours of professional learning was required when attempting to change teacher practice and impact student results.

Finding time in schools is a challenge. Time is required in many ways including in the implementation of the professional learning itself, for example, time for observations, time for debriefing after viewing a lesson, and time for follow up, (Willis, 2002). However, it appears that if teachers find the professional learning valuable, 'suddenly it's not as hard to find the time' (p. 1). The ongoing and long-term nature of teacher professional learning lends itself to on-site implementation (Crockett, 2002; Willis, 2002) and Grootenboer and Edwards-Groves (2013) found the 'site is critical' for both teaching and learning development.

3.2.3 Active learning

Timperley (2008) found that initial engagement in the professional learning could be promoted through the identification of clear issues that relate to teachers, and then presenting a vision of where to go next. Subsequent engagement could be promoted through what the participants see as 'worthwhile learning activities and by opportunities to negotiate the meaning of existing and new theories' (p. 16) as well as the chance to explore them. The vehicle for this learning is often the classroom.

Jones et al. (2009) stated that professional development should strike a balance between 'the need for greater content knowledge and teachers' more immediate classroom needs' (p. 282). The authors argued that 'teachers are more likely to attend a professional development opportunity, and thereby more likely to gain great content and pedagogical content knowledge, if they see that their immediate classroom needs are being met as well' (p. 282). Borko et al. (1997) found that building a classroom component into professional learning is a 'valuable use of project resources' (p. 274). Teacher professional learning that is closely and explicitly tied to teachers' ongoing work appears to be more effective as it provides context and allows teachers to practice in order to improve teaching and learning (Neufeld & Roper, 2003; Opfer & Pedder, 2011).

If the professional learning is classroom based, it tends to be targeted and directly related to teacher practice and becomes part of a teacher's work, not something that is additional. Opfer and Pedder (2011) found professional learning to be more effective if teachers from the same school or department are involved, and Borko et al. (1997) stated, 'Professional development efforts are more likely to be successful if the staff development team works with teachers, preferably at the same school, rather than with individuals' (p. 275) as it leads to the development of shared understandings and communities of learning.

3.2.4 Collaboration

The DEECD (2012a) acknowledged the importance of ongoing professional learning, as 'all teachers need opportunities for professional development that encourage them to innovate, develop, and share teaching practices with their peers' (p. 6) to 'ensure that teachers are constantly striving to increase their professional knowledge and skills' (p. 6). Smith and Brown (2012) stated that individual teachers are responsible for 'taking control of his/her own learning' (para. 2), noting, 'The thing to keep in mind with that is . . . an individual doesn't always learn best alone' (para. 2).

Collaboration is an important component of professional learning (Jappinen, Leclerc & Tubin, 2016) and can lead to changes and adoptions of new approaches to teaching and learning and changes in teacher attitude, beliefs, and even student achievement (Joyce & Showers, 1988; Opfer & Pedder, 2011); by having ongoing contact, relationships can develop between those involved. Through these relationships, productive conditions for learning in a teacher culture develop, which encourage and value collaborative learning (Avalos, 2011). By working in teams, it is hoped teachers will be less isolated, be able to observe each other, and provide feedback. Kaur (2012) found that there is value in having the teachers involved in the development of the professional learning. It is well documented that learning communities or situations where multiple teachers are involved in professional learning have found improvement in student gains (Buczynski & Hansen, 2010; Timperley, 2008). Timperley (2008), however, found a 'weak relationship between participation in such communities and improved student outcomes' (p. 19), noting that involvement in learning communities is an integral part of professional learning, which impacts positively on students.

Neufeld and Roper (2003) found coaching with small groups to be more effective than one-to-one interactions. Interaction between coaches and groups of teachers was found to lead more quickly to the development of learning cultures. They also found models that relied on teachers' volunteerism did not work as well compared to those that had an expectation and encouragement for teachers to participate in the activities. Goal setting was found to aid the coaching process, as this leads to 'rich collegial conversations around instruction, deep analysis of student and school level data, and, eventually, a renewed sense of commitment to the work and/or a clear sense of direction regarding next steps' (Neufeld & Roper, 2003, p. 23). A specific model of coaching called the collaborative coaching model (CCL) was explored by Neufeld and Roper (2003). This model consists of a preconference, a classroom component such as a demonstration or observation, and a debriefing. There is a sense that the process is very coach driven, as the coach facilitates both the preconference and debriefing discussions to 'highlight best practices . . . observed during the demonstration as well as to offer suggestions for improvements and next steps' (p. 29). It was found that 'demonstrating teachers reported being nervous about making their teaching public; in the end they were glad to have had an opportunity to share their teaching with colleagues and receive feedback' (p. 33). It was also noted by the coach that there was a very fine line between 'trying to give constructive feedback and not sounding negative or too critical' (p. 33), and this was found to be one of the most challenging aspects of the work.

Effective elements of professional learning that appear to be effective are the use of appropriate content, the provision of time to create the opportunity for the ongoing nature of learning, an applicable context such as the classroom in which professional learning can be trialled and explored, and the provision for collaboration to occur.

3.3 Less Effective Elements of Professional Learning

Elements of professional learning that are effective can be considered in the reverse as ineffective, such as not allowing enough time, not having the professional learning presented in context, or on-site (Kaur, 2012), and not having teachers collaborate and work together. Other factors impact professional learning, and three in particular are explored in this section: external factors, the learning format, and teachers' beliefs.

3.3.1 External factors

Teacher professional learning is often driven by external factors such as departmental decisions, registration requirements, and curriculum needs, but these drivers are less effective than professional learning that has been completed for other reasons (Opfer & Pedder, 2011) such as personal interest, direct impact on students, and activities relevant to the classroom. Teachers, as shown in Section 3.2.3 tend to engage with professional learning that they deem relevant to their classrooms, and often they find it difficult to make that connection to decisions made by bodies external to the school. Kaur (2012) found this was also evident when there are multiple or contradictory messages or overwhelming amounts of innovation occurring.

3.3.2 Learning format of the professional learning

Traditional learning formats such as one-off workshops and conferences seem unlikely to lead to teacher change, so they appear less effective forms of professional learning (Ball, 1994; Neufeld & Roper, 2003; Opfer & Pedder, 2011) and a significant amount of research shows teachers are less likely to change practice as a result of 'learning activities that occur via presentation and the memorisation of new knowledge' (Opfer & Pedder, 2011, p. 385), which is often the format of these activities.

Professional learning that appears to be less effective is conventionally taught and too isolated from schools and classrooms (Buczynski & Hansen, 2010). Timperley (2008) stated that when designing teacher professional learning opportunities, it is just as important to consider teachers' preknowledge of areas, such as curriculum and assessment, and teachers' views on these areas, and to take into account 'teacher diversity' just as would be expected when planning teaching experiences in classrooms. Teachers should also be provided with multiple opportunities to absorb new information, process it, and then translate into practice, again paralleling good teaching models for students in a classroom environment (Timperley, 2008).

Teachers are often looking for a 'quick fix' and something to apply immediately into the classroom that will achieve immediate results, and it seems 'the popularity of particular professional development programmes is not necessarily matched by their impact on students'

(Timperley, 2008, p. 10). Teachers ‘rarely believe that they will need to engage in in-depth learning or make substantive changes to their practice’ (p. 16) even though it is acknowledged to be good practice, and Timperley (2008) found further that ‘those who provide the professional development typically do believe this but do not disclose it’ (2008, p. 16), leading to professional learning that does not provide in-depth learning opportunities. These professional learning experiences are also impacted by teacher beliefs.

3.3.3 Teacher beliefs

Often, teachers’ existing knowledge, beliefs, and attitudes ae not considered in the delivery of professional learning (Buczynski & Hansen, 2010). It is well researched that what teachers believe and do have a major impact on student learning (Solis, 2009). Stipek et al. (2001) suggested, ‘Professional development programs designed to help teachers implement inquiry-orientated mathematics instruction are minimally effective, in part because teachers filter what they learn through their existing beliefs’ (p. 214). Therefore, teacher beliefs can have an impact not only what teachers learn but what they attend. Teachers tend to gravitate towards professional learning that aligns with their belief systems (Opfer & Pedder, 2011) and not place themselves in situations that challenge those beliefs and practices.

There is an assumption that changing teachers’ beliefs will lead to a change in practice and ultimately, student results (Clarke & Peter, 1993), but this is not always true. Sometimes, a teacher’s beliefs may alter but then not put it into practice, or these beliefs may not align with the school they are working in. In summary, some of the elements of teacher professional learning that appear to be less effective include influences of external factors, certain formats of professional learning, the challenge of teachers’ own beliefs, and the impact of these on professional learning. The next section looks at what happens after professional learning.

3.4 After the Professional Learning

At the end of any professional learning, at least two things need to be considered: evaluation of the professional learning and the sustainability of the professional learning.

3.4.1 Evaluation

Evaluation of any teaching and learning experience is important, and in a classroom situation, it happens all the time. Likewise, professional learning should be evaluated. The regulatory organisations driving the need for professional learning such as the AITSL and the VIT also highlight the importance of evaluating professional learning. AITSL (2012) indicated that in the evaluation of professional learning, the following aspects should be considered: building the evaluation into the professional learning programme from the beginning; and evaluation should be at multiple levels, examining change over the short, medium, and long term with the driver being improved student outcomes. The OECD (2012) highlighted the importance of linking professional learning needs with the wider goals of the school while considering appraisal and feedback processes.

Assessing the true impact of any professional learning is acknowledged as challenging. In the past, questionnaires distributed at the door as teachers left the professional learning session sufficed, but now complex algorithms and the identified links between professional learning strategies, as well as the anticipated changes in teacher knowledge, classroom practices, and student outcomes form parts of the professional learning evaluation (Ingvarson et al., 2003) and need to be considered along with the professional teaching standards and how the professional learning relates to the standards (AITSL, 2012).

Effective professional learning does not just deal with existing problems, but aims to provide teachers with skills for future situations. AITSL (2012) identified characteristics of professional learning in terms of looking forward:

- Equips teachers and school leaders to deal with future as well as current challenges;
- Promotes action research and inquiry and develops teachers as researchers;
- Develops high level skills that allow teachers and school leaders to adapt and excel in a rapidly changing and hyper-connected world;
- Supports teachers and school leaders to explore research that challenges their thinking, encourages them to develop their own theories of practice and promotes use of a range of effective pedagogical practices; and
- Promotes innovation in teacher and school leader practice. (p. 5)

How to measure and evaluate whether such aims have been met are more problematic. Organisations now use follow-up surveys, review panels, or case studies in an attempt to identify the ongoing impact of professional learning experiences.

3.4.2 Sustainability

As schools and government departments are spending more money on professional learning, they are looking for research that can provide them with information and data about designing professional learning programmes that are more likely to lead to significant and sustained improvements (Ingvarson et al., 2003). Again, it is not enough to simply identify a programme that has been effective in one setting, as 'sustained improvement also depends on teachers developing professional, self-regulatory inquiry skills so that they can collect relevant evidence, use it to inquire into the effectiveness of their teaching, and make continuing adjustments to their practice' (Timperley, 2008, p. 24). Sustainability of the professional learning 'depends both on what happens during the professional learning experience and on the organisational conditions that are in place when external support is withdrawn' (Timperley, 2008, p. 24). It appears the process of learning and examining practice rather than content itself, although content is important, can lead to sustained impact (Farmer et al., 2003). The development of a school team culture could also provide an avenue of sustainability where 'teachers and principals develop capacity to pursue school improvement themselves' (Avalos, 2011, p. 27). The development of a learning community could lead to ongoing learning even when an external expert is unavailable.

In summary, teacher professional learning is a complex process (Farmer et al., 2003). There is the impetus for the professional learning, which leads into the content or experience delivered through a particular model or process. It may be an event held off-site, in-house, or external experts may come to the school. It may be a one-off event or ongoing. Professional learning is further impacted by the wider school culture, the community, and society the school is located in (Timperley, 2008) as well as teachers' own beliefs. Although the ultimate aim may be to change or at least challenge teachers' attitudes or beliefs, this may not be the reason that teachers embark on professional learning in the first place; a teacher's intent may be gathering ideas for the classroom or understanding curricula (Farmer et al., 2003).

Elements of professional learning that appear to be effective include relevant content and the opportunity to collaborate and work towards a community of learning. The relevance of the learning to a teacher's classroom is crucial to create the context for the learning. Time is a critical factor and includes time for the professional learning experience itself, time for the participant to practice and implement the learning, and time for results to be experienced.

Much of the literature has focused on which professional learning models work and which do not; however, 'synthesis of the research does not reveal that any particular activity is of itself more effective than another' (Timperley, 2008, p. 15). That does not mean one size fits all, however. Teacher professional learning, like teaching itself, needs to acknowledge unique learners in a range of contexts and settings, in which different strategies and ideas may be optimal on different days or not be effective at all on another day. Clearly important elements are that teacher professional learning needs to be ongoing and collaborative, and supported and believed in by those who are involved. 'School personnel must begin to think of professional growth, not in terms of workshops, but in terms of their workplace' (DuFour & Berkey, 1995, p. 5) and the application of the learning into that space.

In summary, this section considered what happens after the teacher professional learning. It included the importance of evaluation and sustainability of professional learning. The next section of this chapter presents two major factors that can impact professional learning experiences: the challenge of physical location for rural schools and the influence of leadership in the professional learning process.

3.5 Rural Challenges

This section examines the unique challenges facing primary schools in rural settings. The impact of rural challenges needs to be considered in terms of both student and teacher learning, as it is well documented that teacher access to professional learning has a direct impact on student learning. It appears that staffing, professional learning, resources, and learning experiences are all impacted in rural settings and may be associated with lower student achievement in rural and remote schools (Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006).

3.5.1 How the school is classified

The school involved in the research is located in North West Victoria, Australia. According to the MCEETYA Schools Geographic Location Classification (MGSLC) (Jones, 2002), the area in which the school is located is identified in the category of Provincial Zone by geographic location. A Provincial Zone is defined by having a population of 25,000 to 49,999. The Australian Bureau of Statistics (ABS) defines rural as all residences and population centres of fewer than 1,000 people, whereas the Commonwealth Government defines populations fewer than 100,000 as rural

(Stokes, Stafford, & Holdsworth, 2000). The town in which the school is located has an approximate population of 5,060 (ABS, 2016) and the nearest large centre has an approximate population of 60,000, both of which fall under the rural definition of the Commonwealth Government. The school is identified as a small school with a staff of 10 (Lamb, Glover, & Walstab, 2014), which is considerably smaller than urban schools. This can have disadvantages as well as benefits.

3.5.2 Impact of geographic location and population

International studies including PISA and TIMSS have completed comparative studies in educational achievement. They place the performance of students, schools, and countries in the context of their social background and identify important educational policies and practices that are associated with educational success. In the area of mathematical proficiency, Australia is characterised as 'high in quality but low in equity' (DEEWR, 2007, p. 11) as 'students in metropolitan areas performed better than regional students who, in turn outperformed rural students' (p. 11). There appears to be a correlation between socioeconomic status, location, and mathematical/numeracy achievement (Green & Reid, 2004).

PISA uses the MGSLC to categorise schools by their geographic location. Three broad categories are used: metropolitan, provincial, and remote. The 2012 PISA study reported,

> Students who attended schools in metropolitan areas achieved significantly higher scores than those in provincial or remote areas, and students who attended schools in provincial areas performed significantly higher than those in remote areas. (cited in Thomson et al., 2012, p. 35)

Two graphs focusing on mathematical literacy in Australia from the 2012 PISA report illustrate this. Figure 3.3 shows the mean scores and distribution of students' performance on the mathematical literacy scale by geographic location, and Figure 3.4 shows the percentage of students across the mathematical literacy proficiency scale in terms of levels by geographical location.

Geographic location	Mean score	SE	Confidence interval	Difference between 5th and 95th percentiles
Metropolitan	511	2.0	508–515	317
Provincial	486	2.4	481–491	298
Remote	444	15.6	413–475	359

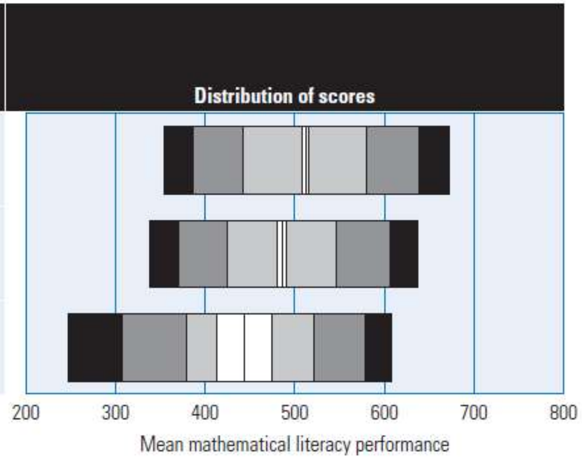

Figure 3.3: Mean scores and distribution of students' performance on the mathematical literacy scale by geographic location (Thompson et al., 2012, p. 36).

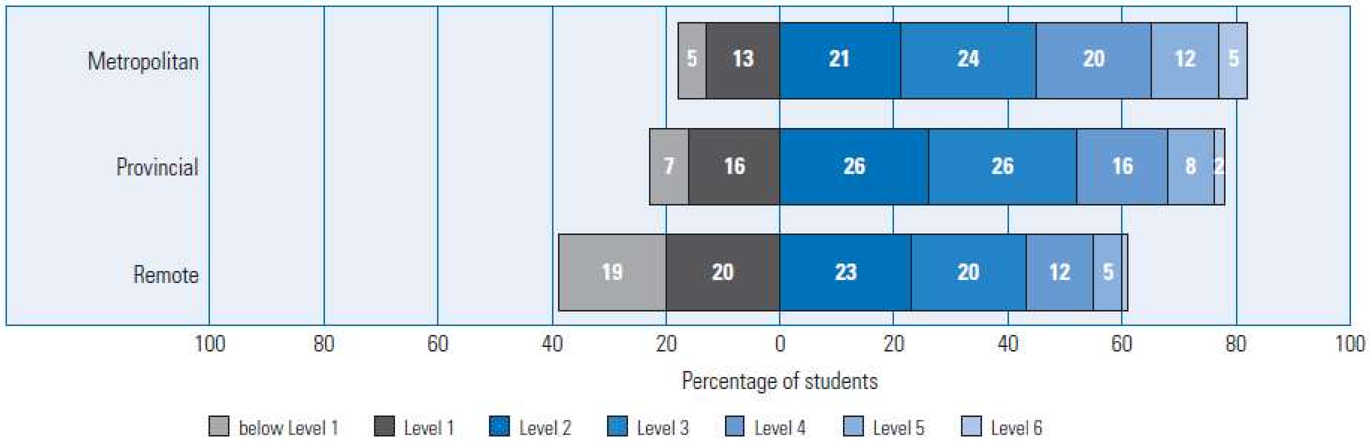

Figure 3.4: Percentage of students across the mathematical literacy proficiency scale by geographical location (Thompson et al., 2012, p. 35).

Figure 3.3 shows that the spread of students' mean scores is greater for rural students and the overall mean score is lower (17 points) than metropolitan students, which equates to just under 'half a year of schooling' (Lamb et al., 2014). In Figure 3.4, the spread of the percentage of rural students is lower than that of provincial and metropolitan students, with a larger percentage below Level 1 and very few at the upper levels of Level 5 or 6. Thus, there appears to be an impact of geographical location on students' mathematical literacy (Williams, 2005).

> The effect of population size is presented in the 2011 TIMSS report, which found that depending on each country's characteristics, a school's location can have a substantial impact on whether the students attending that school typically are from economically and educationally advantaged home backgrounds. . . . the location of the school can provide access to important additional resources (e.g., libraries, media centres, or museums) or mean that the school is relatively isolated. (Mullis et al., 2012, p. 206)

The report shows generally that students attending schools in the largest cities have the highest average mathematics achievement, followed by students in medium-sized cities, and then those in smaller towns and rural areas. Figure 3.5 is an extract of a table showing the percentage of students, together with their average achievement for fourth grade, in schools located in three population categories: cities with a population of more than 100,000, cities/towns with a population of 15,001 to 100,000, and towns/rural areas with a population of 15,000 or fewer. Figure 3.5 shows that in Australia, the highest average mathematics achievement was in the largest cities, then the smaller towns/rural locations, followed by medium-sized cities.

Reported by Principals

Country		Population Size of City, Town, or Area Where School Is Located					
		More than 100,000		15,001 to 100,000		15,000 or Fewer	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		27 (3.0)	464 (5.2)	26 (3.4)	455 (6.1)	46 (3.2)	443 (6.5)
Australia		42 (3.3)	532 (4.6)	30 (3.9)	502 (5.7)	28 (4.1)	511 (5.3)
Austria		24 (1.5)	502 (5.2)	9 (1.9)	502 (5.0)	66 (2.3)	511 (3.2)
Azerbaijan		16 (2.9)	464 (8.7)	21 (2.9)	481 (14.9)	63 (3.5)	456 (7.2)
Bahrain		11 (3.3)	443 (10.8)	28 (5.1)	431 (8.4)	61 (5.5)	437 (5.0)
Belgium (Flemish)		6 (1.9)	539 (12.3)	55 (4.1)	545 (2.4)	39 (3.8)	559 (2.8)
Chile		56 (3.5)	476 (3.9)	28 (3.3)	453 (5.9)	16 (2.5)	437 (6.4)
Chinese Taipei		56 (3.5)	603 (2.4)	39 (3.3)	576 (3.2)	6 (2.0)	572 (10.6)
Croatia		16 (2.2)	509 (3.9)	23 (3.3)	493 (3.5)	61 (3.7)	484 (2.8)
Czech Republic		15 (2.5)	518 (9.0)	33 (3.1)	513 (3.5)	52 (3.2)	507 (3.3)
Denmark	r	15 (2.6)	524 (8.3)	37 (3.6)	550 (4.3)	48 (3.2)	536 (3.1)
England		40 (5.2)	533 (6.9)	38 (5.0)	533 (7.2)	23 (3.9)	569 (6.3)
Finland		31 (3.9)	545 (4.2)	39 (4.2)	549 (2.7)	30 (3.3)	540 (5.4)
Georgia		37 (2.9)	472 (5.7)	17 (2.3)	449 (6.9)	46 (2.4)	432 (6.0)
Germany		25 (3.2)	518 (4.6)	33 (3.7)	527 (3.9)	42 (3.5)	537 (2.4)
Hong Kong SAR	r	84 (3.4)	603 (5.0)	15 (3.2)	611 (7.5)	1 (1.2)	~ ~
Hungary		25 (2.6)	537 (6.9)	29 (3.2)	536 (4.8)	46 (2.2)	492 (6.4)
Iran, Islamic Rep. of		45 (3.5)	455 (6.0)	18 (2.9)	433 (9.1)	36 (3.4)	399 (4.8)
Ireland		16 (3.0)	515 (7.7)	27 (3.2)	519 (5.7)	57 (3.0)	536 (3.9)

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Figure 3.5: Extract of population size of city, town, or area where school is located, fourth-grade students (Mullis et al., 2012, p. 208).

Figure 3.6 is an extract of a table of the same context for eighth-grade students. It shows that Australia follows the trend of the highest average mathematics achievement in the largest cities, compared with the smaller towns/rural areas, which had the lowest.

it 5.2: **School Location**

TIMSS 2011 Mathematics 8th Grade

Reported by Principals

Country	Population Size of City, Town, or Area Where School Is Located					
	More than 100,000		15,001 to 100,000		15,000 or Fewer	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	24 (2.8)	492 (5.4)	24 (3.5)	475 (7.5)	52 (3.5)	451 (4.5)
Australia	55 (3.2)	523 (7.2)	28 (3.5)	504 (9.0)	16 (2.9)	464 (6.1)
Bahrain	17 (0.3)	412 (4.9)	42 (0.3)	404 (3.3)	41 (0.3)	418 (3.2)
Chile	55 (3.5)	431 (4.6)	29 (3.8)	401 (6.8)	16 (2.9)	403 (7.3)
Chinese Taipei	63 (3.5)	624 (3.8)	34 (3.6)	586 (7.9)	3 (1.3)	570 (33.9)
England	49 (5.0)	507 (8.0)	36 (4.6)	502 (10.3)	15 (3.2)	536 (15.9)
Finland	24 (3.3)	514 (6.1)	42 (4.1)	514 (3.2)	34 (3.4)	512 (3.6)
Georgia	31 (2.4)	455 (5.9)	17 (2.4)	442 (14.4)	52 (2.5)	412 (5.2)
Ghana	19 (3.0)	370 (7.8)	13 (2.5)	343 (12.5)	68 (3.2)	317 (5.4)
Hong Kong SAR	88 (3.1)	588 (4.6)	9 (2.9)	564 (22.2)	3 (1.8)	630 (13.5)
Hungary	27 (2.4)	526 (7.4)	27 (3.1)	523 (5.2)	46 (2.4)	483 (4.3)
Indonesia	68 (4.1)	394 (6.2)	20 (4.1)	373 (7.6)	12 (3.0)	361 (11.5)
Iran, Islamic Rep. of	48 (3.4)	445 (7.2)	20 (2.7)	404 (7.0)	32 (3.4)	377 (6.0)
Israel	26 (3.0)	547 (6.5)	45 (4.0)	508 (8.8)	29 (3.2)	507 (8.3)
Italy	17 (2.7)	507 (6.2)	39 (3.4)	493 (5.1)	43 (3.7)	499 (3.4)

RCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Figure 3.6: Extract of population size of city, town, or area where school is located, eighth-grade students (Mullis et al., 2012, p. 209).

This variation of student achievement across geographic divisions is also evident in work by Lyons et al. (2006), who found schools located in a rural area, with a small community population, could expect to see different results in their mathematics in comparison to metropolitan students. It seems that even wealthier private schools that service regional areas have lower mathematics results than comparable city schools. There appears to be a direct relationship between community size and average mathematics scores (Williams, 2005). While location is a significant factor in students' mathematics scores, it appears that location is not the only factor.

3.5.3 Impact of community

It appears that the challenges of location and population of rural settings have an impact on students' learning of mathematics. From the data, it would seem that 'an adequate base for mathematics learning and teaching in rural areas does not exist' (Bush, 2005, p. 1), and it is difficult to attract and retain teachers in rural areas, particularly for the teaching of mathematics, science, and ICT (Mills & Gale, 2003). Community is another factor also seems to have an effect on students' learning of mathematics, as rural families tend to adopt more traditional values as 'social norms of rural areas value place, community and family over more distant national priorities' (Bush, 2005, p. 2). Rural and regional students are also more likely than urban students are to come from families with lower socioeconomic backgrounds (Lamb et al., 2014). These community and social values can have an impact on the beliefs and nature of the teaching and learning of mathematics and consequently, student outcomes (Trinidad, Frid, Sparrow, & Treagust, 2007). Influences such as established family connections, less confidence in the education system, and the community have impact on teaching and learning, both positive and negative (Lamb et al., 2014; Trinidad et al., 2007). These issues create conflict for teachers, as they live and work in a community while trying to teach mathematics that is deemed important at state or national levels. It is a challenge, as for many rural students the mathematics they are being taught seems disconnected and not related to their local lives. One of the positive influences identified by Trinidad et al. (2007) was that in the past, teachers at rural schools had the ability to develop their own curricula; however, with the move to a national curriculum, this may be restricted for teachers. Williams (2005) sees the opportunity to develop a greater sense of community can also be a strength, because at larger schools, students and staff can appear lost in the numbers.

3.5.4 Professional learning in rural areas

Teacher professional learning is identified as being a ‘critical factor in both support for teachers and in helping children achieve their potential’ (Lyons et al., 2006, p. 6); however, existing opportunities and content often do not meet the needs of rural and remote teachers (Trinidad et al., 2007). Trinidad et al. (2007) found it was ‘essential to consider the holistic contextual features of regional and remote schools’ (p. 10). Many factors impact teaching and learning, including the professional environment, professional learning opportunities, the nature of school and community relationships, school leadership, distance, and isolation. These factors are interrelated in complex ways, with some factors being direct and others being indirect influences. It could be argued that some factors could be advantageous, such as school and community relationships, as the core of teaching is often seen to be about relationships. However, as indicated in Section 3.5.3, the conflict presented to teachers when living and working in small communities can have both positive and negative impacts, and the advantage of strong relationships is not enough when considering students’ mathematics results.

Due to the nature of rural teachers’ work requiring skills of adaptability and resourcefulness with influences of the community; it seems that ‘professional development for teachers in [remote] schools needs to be not only accessible, but to reflect their specific needs and aspirations’ (Trinidad et al., 2007, p. 8). Professional learning for rural and remote teachers needs to be ongoing and interactive. Trinidad et al. (2007) found specific areas that rural and remote teachers felt could be improved, such as content knowledge, which is ‘an area where improved professional development could contribute to better teaching and learning’ (p. 8). Bush (2005) also found that a lack of confidence or content knowledge restricted what a teacher could to do to support students’ learning. However, the need to professionally develop teachers takes time, which is further impacted by high staff turnover in both rural and remote areas (Lamb et al., 2014).

The DEECD (2012) illustrated the difficult-to-fill vacancies for teaching by geographic location (see Figure 3.7). The western part of the state, in which the school in this study lies, falls into the High category.

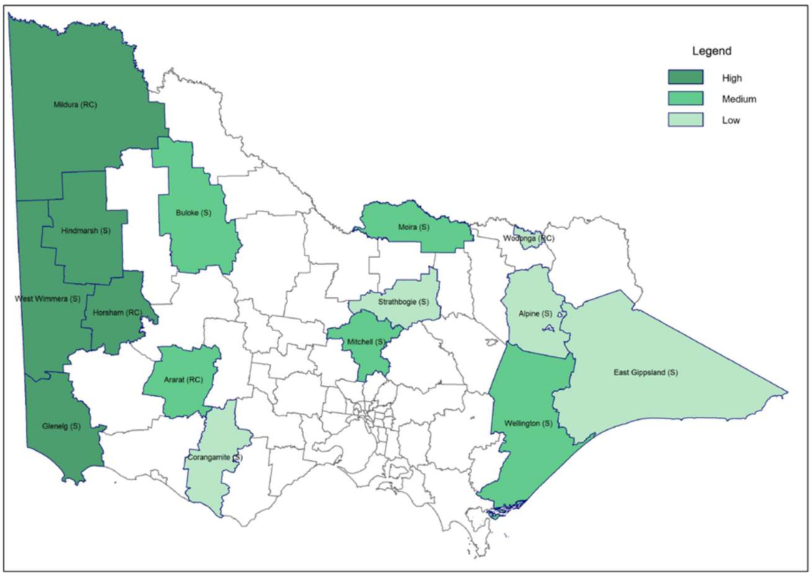

Figure 3.7: Teacher supply and demand for Victoria with difficult-to-fill vacancies, 2009–2011 (DECCD, 2012).

Figure 3.8 shows the difficult-to-fill vacancies by geographic location for mathematics. The western part of the state, in which the school in this study lies, again falls into the High category.

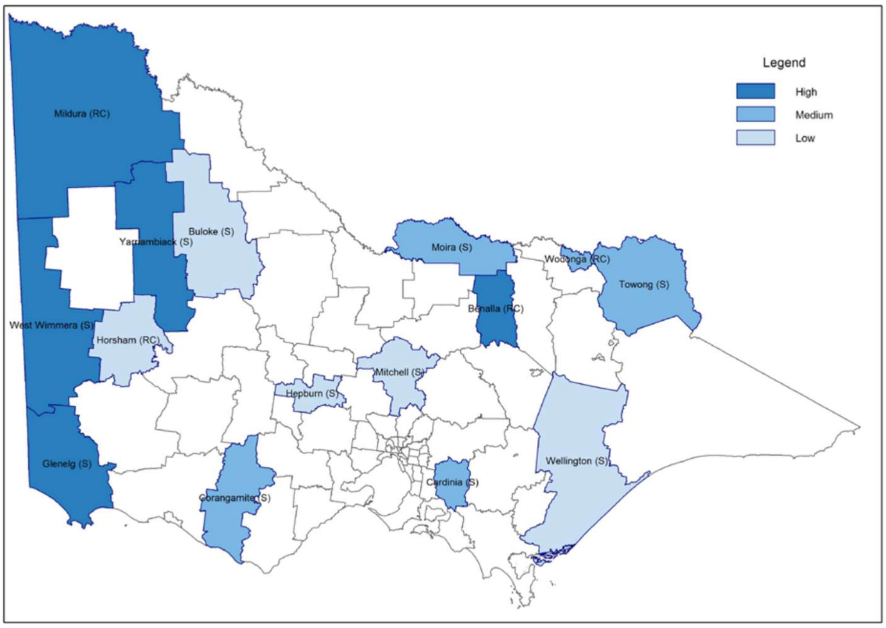

Figure 3.8: Teacher supply and demand for Victoria with difficult-to-fill vacancies for mathematics, 2009–2011 (DECCD, 2012).

Therefore, not only are teaching positions in rural areas often difficult to fill, it is particularly challenging for mathematics. It seems it is difficult to attract and retain staff in these areas (Gale & Mills, 2003; Plunket & Dyson, 2011), which again has implications for professional learning.

Consideration is not always given to these issues when planning professional learning for rural and remote areas, together with factors such as the need for travel, the cost, the impact of the teacher being away from the school (as well as from their own family), the higher number of teachers teaching outside their speciality areas (which often requires greater support), and the additional need to find replacement teachers during professional learning (Beswick & Brown, 2006; Bush, 2005; Harmon, Gordanier, Henry, & George, 2007; Trinidad et al., 2007). As well, adequate funding is not always allocated to these additional factors. Trinidad et al. (2007) argued that professional learning could be improved by sending specialist people to specific locations, as it is cheaper to move one person rather than a number of staff; however, Harmon et al. (2007) found the opposite, that with smaller numbers of teachers in specific content areas, the delivering of professional learning at the school or district was usually viewed as impractical and uneconomical.

3.5.5 School leadership

To address some of these obstacles, school leadership can play a vital role: 'Leaders in rural school districts know the importance of improving the professional practice of teachers—high quality teachers get great results from students' (Harmon et al., 2007). Harmon et al. (2007) suggested that teachers value being able to network with other teachers and spend time sharing and discussing practices to improve student learning, which can be achieved with the support of school leadership, although it is not an easy task (Bartholomew et al., 2005). Time needs to be provided to allow professional learning experiences such as mentoring and collaborative work, as they are important elements leading to improvements in professional practice (Lyons et al., 2006). Lyons et al. (2006) found that primary teachers outside metropolitan areas indicated a higher 'unmet need for professional development opportunities such as mentoring, release time for professional development and collaboration with colleagues' (p. vii) and this appears to be more so with mathematics teachers.

In summary, rural schools face many challenges in terms of teaching and learning. These include natural distance, local community influences, locating replacement teachers, teachers often working outside their speciality areas, cost, and time factors. There appears to be no one cost-effective solution; however, school leadership can acknowledge and address some of these challenges when aiming to meet teachers' professional learning needs.

The school involved in this research is identified as rural and falls into one of the geographic region that are hard to staff, particularly in the area of mathematics. The school leader (principal) decided to employ a mathematics educator who would regularly visit the school over the period of a year. This would help to alleviate the cost of travel, as well as reduce the need to have staff away from the school and their own families. By having the mathematics educator work at the school, the professional learning was embedded in the teaching and learning experiences at the school, acknowledging community and local social values (Trinidad et al., 2007). This allowed for the opportunity for ongoing and interactive professional learning (Trinidad et al., 2007), often with teachers in their own classrooms, negating the need for replacement teachers. The weakness in the model is that the teachers did not have the opportunity to network with teachers from other schools (Harmon et al., 2007).

The next section of this chapter explores the impact the principal can have in professional learning situations.

3.6 Impact of School Leadership

The impact of school leadership in the professional learning process cannot be underestimated: 'Leadership is essential not only in sparking reform but in sustaining it' (Timperley, 2008, p. 4). The role of the principal and/or senior school leadership in professional learning is to facilitate, model, and support it.

3.6.1 The leader's role

'If teachers do not know their change destination, the journey may take them anywhere' (Hord, 1994, p. 4). In any professional learning experience, the aim or focus of the professional learning needs to be clear and achievable. Timperley (2008) stated that 'designated educational leaders have a key role in developing expectations for improved student outcomes and organising and promoting engagement in professional learning opportunities' (p. 22). This role may take on many forms, but Timperley (2008) identified three crucial roles for gaining interest in professional learning and then ensuring it is ongoing: developing a vision of new possibilities, leading learning, and organising learning opportunities.

Timperley (2008) stated that ‘schools do not thrive on visions alone’ (p. 23), so it is important that these visions be translated into realistic expectations and that the professional learning is ‘well managed and organised’ (p. 23). A shared vision ensures a common set of goals and expectations (Hord, 1994). However, it should be acknowledged that people, not programmes and materials, create change (DuFour & Berkey, 1995, p. 1), so the vision needs to be shared and owned by both the principal and the teachers (DuFour & Berkey, 1995).

There is value in exploring professional learning across common teaching areas because ‘if everybody’s teaching different things, it is much more difficult to share professional knowledge’ (Willis, 2002, p. 3). This is not to say that professional learning cannot be personalised for different people or different needs. To maximise learning, there is an argument for systematic collaboration to occur throughout the school (DuFour & Berkey, 1995). Timperley (2015) stated, ‘Professionals, including leaders, talk in generalities, fail to make tacit knowledge explicit, gloss over differences so as not to offend, rarely seek clarification from one another or revert to telling others what they should do’ (2015, p. 4). This may require a structure to be put into place to allow the appropriate conditions for extended engagement to take place. Leaders participating in professional learning allows them to ‘develop the understanding they need to create conditions that will support their teachers’ ongoing learning’ (Timperley, 2015, p. 23).

The principal’s role is to create opportunities for professional learning to take place, whether it is structuring the timetable, time release, or creating opportunities for teachers to discuss their learning (Fleming & Leo, 1999; Stack et al., 2011). It is often assumed that teachers will be shown something new and immediately be able to implement it without support and development (Hord, 1994), so principals should encourage experimentation and looking at things from a different perspective (DuFour & Berkey, 1995). The principal’s role is to champion the professional learning and support the team implementing it and the different aspects of the learning process (Stack et al., 2011). This should be complemented with the principal’s acceptance that things may not work and results may not be what was first perceived.

3.6.2 Developing trust

In any learning situation, learners may be present, but just because they are there physically it does not mean they are engaged and/or learning. The development of trust in leadership and the professional learning can create a more ideal learning space and opportunity. Principals need to encourage their teachers as they acquire new skills, and support is needed as they try out those new skills. Equally important is encouragement, as with student learning; teachers need to be encouraged and their efforts recognised (DuFour & Berkey, 1995). By creating an environment of trust, Fleming and Leo (1999) found this was 'consistently rewarded with good results' (p. 2). Timperley (2008) found that sometimes, leadership allows the professional learning to be voluntary; however, just like attending, 'prior commitment does not guarantee greater engagement' (p. 16) and found that 'both voluntary and mandatory teacher participation have co-occurred with positive and negative outcomes for students' (p. 16). Timperley (2008) also stated that it is not the method of involvement in professional learning (voluntary versus mandatory) that impacts student outcomes, but the engagement and the rationale or reason for involvement. Developing trust and support can lead to the development of professional learning communities and a culture of staff learning within the school.

Therefore, one of the key roles in developing and sustaining trust within a staff is the principal's actions (Bryk & Schneider, 2003). Trust is difficult to achieve if there is not an established culture of trust in the school, and this takes time to develop. One way that this could be achieved is through the development of professional learning communities.

3.6.3 Developing professional learning communities

Wenger (1998) stated,

> Learning . . . is not a separate activity. It is not something we do when we do nothing else or stop doing when we do something else . . . Learning is an integral part of our everyday lives. It is part of our participation in our communities and organizations. The problem is not that we do not know this, but rather we do not have very systematic ways of talking about this familiar experience. (p. 8)

The importance of teacher collaboration in relation to professional learning is evident (Buchanan & Khamis, 1999; Joyce & Showers, 1988). A fundamental role the principal can play in professional learning is in laying the foundations for the development of professional learning communities (Fleming & Leo, 1999; OECD, 2012). One of the ways a principal can aid the development of learning communities of practice is by devoting time and attention to their own professional learning and making it visible to their staff (Fleming & Leo, 1999). This modelling leads to developing trust within the staff and between the leadership and teachers. The principal needs to commit to their own personal growth and development (DuFour & Berkey, 1995), and this may be in their own involvement of the professional learning experience. Some of the processes that could aid the development of the professional learning communities could be through communication methods such as newsletters, daily bulletins, and verbal communication, and through less formal settings such as morning teas (Fleming & Leo, 1999).

Wenger (1998, 2006) defines these learning communities of practice as communities that are developed and defined by members collectively engaged in a joint enterprise: 'Communities of practice are groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly' (Wenger, 2006). Learning can be the reason the community comes together, or it can be an outcome due to members' interactions or collaboration (Mullis, Martin, Foy, & Arora, 2012). Generally, communities of practice are informal structures dependent on the way members interact rather than formal groups or ones focused on the attainment of specific goals. Features of these communities include: shared ways of engaging in doing things; rapid flow of information among members; absence of introductory preambles; quick setup of a problem to be discussed; knowing what others can contribute; ability to assess the appropriateness of actions or products, specific tools, representations, and other artefacts; local lore; shared stories and inside jokes; and jargon and shortcuts to communication (Wenger, 1998). Wenger identified three characteristics of communities of practice:

- The domain: this is an identity defined by a shared domain of interest. Membership of the community implies a commitment to the domain. Therefore, members are distinguished from other people through their shared competence;
- The community: this is where members engage in joint activities and discussions. They help each other and share information in their common pursuit of the domain. Members build and establish relationships that enable them to learn from each other; and
- The practice: this is where the members of the community are practitioners. They develop a set of shared resources such as; experiences, stories, tools, etc. The development of these resources takes time and sustained interaction. (p. 5)

These three characteristics of a community of practice can come in a variety of sizes, including small, very large, local, or global. It is often a core group with many peripheral members or stakeholders. Some communities of practice only meet face to face, others are online, some are within an organisation, others include members of many organisations, some are formal, and others informal. McGraw et al. (2003) believed that the communities of practice as defined by Wenger (2008) could be 'fertile ground for teacher learning' (p. 271). These communities are dynamic and involve learning on the part of everyone.

3.6.4 Sustainability

Pritchard and McDiarmid (2006) found that 'sustainability of in-depth professional development is dependent on a variety of factors coexisting' (p. 438). These include shared values, a focus on learning, collaboration, and reflective dialogue, which are also elements of communities of practice. A key aim in developing communities of practice is in empowering teachers as professionals as a result of a shared focus on teaching and learning (Bartholomew et al., 2005). By developing communities of learning and engaging in inquiry around common problems, then mathematics learning and professional learning could be sustained (National Research Council, 2001). One of the key people in this process is the principal. A strong principal is essential to ensuring that on-site professional development continues over a prolonged period. A principal with a strong focus on the result leads to changes. For example, 'If you're trying to improve student learning, keep everything focused on student learning, not changing practice' (Willis, 2002, p. 3), as persistence leads to change and builds sustainable practice. Developing a staff culture where conditions are 'optimal for teachers to adapt to new ways of working in the school' (Fleming & Leo, 1999, p. 2) is reliant on both the structures of the school and relationships within the community of the school. This aligns with the following list identified by Hargreaves, Earl, Moore, & Manning (2001) for leaders when considering professional learning:

- To support teachers and where necessary, push them to be able to implement appropriate changes that matter;
- To ensure that the changes that teachers make can be sustained over time; and
- To ensure that the changes can be generalised beyond a few enthusiastic teachers. (Hargreaves et al., 2001, p. 157)

Therefore, school leaders have a role in the professional learning experiences of their staff, in supporting them, leading change and ensuring the change can be sustained.

In summary, school leadership is essential in the professional learning process. It is key in developing and articulating the vision, organising professional learning opportunities, and demonstrating a personal commitment to the goals of professional learning. Principals are instrumental in creating the opportunities for the development of an environment of trust and laying the foundations for professional learning communities and the sustainability of teacher learning. By creating these environments, teachers feel safe, valued, and supported in their professional learning experiences, which create the conditions for change in teaching and learning practice.

3.7 Concluding Comments

The framework introduced in Chapter 2 (Sullivan et al., 2016), as shown in Figure 2.3, can be used to draw the aspects of Chapter 3 together. The framework illustrates how aspects of professional learning can integrate with the various aspects of teacher knowledge, teacher beliefs, opportunities, and constraints when considering planning intentions and classroom actions. It illustrates how teachers' beliefs impact teacher knowledge and how these aspects interact with professional learning opportunities and constraints.

This chapter presented literature about teacher professional learning. Section 3.1 examined teacher professional learning, including its importance nationally and internationally, which provided the overall justification for the study. This was followed by a discussion of teacher professional learning in the broad sense, presenting a number of different professional learning elements and models.

The triad model was presented in depth, as this is not a traditional professional learning model and incorporates various elements of professional learning into the model, including lesson study, peer observation, and the use of an external expert. The lesson study aligned with the prediscussion, teaching, and reflection component of the triad model, with peer observation at the heart of the model supported by professional conversations. Although the lessons were not taught, adjusted and retaught, elements of the lessons were analysed, reviewed, and applied to new teaching and learning situations. Peer observation was identified as being a highly effective form of professional learning, and this was deemed essential to include within the model. An external expert in the role of a mentor was utilised in the triad model as one of the members to provide both expertise and support. The mathematics educator (mentor), in this study had expertise in mathematics teaching and learning, as well as a background in mathematical content. Their role in the triad professional learning model was to work one-to-one with teachers. Professional reading was utilised to provide teachers with the theory to support the practice.

Section 3.2 examined elements of professional learning, which included aspects such as content, time, location, and collaboration. Section 3.3 examined elements of professional learning that appear less effective, which included external factors such as learning format and the impact of teacher beliefs. Both these sections informed the development of different aspects of the professional learning intervention. Elements were built into the triad intervention.

Section 3.4 considered what happens after the professional learning, including evaluation and sustainability. The sustainability aspect was of interest to all involved in the professional learning intervention, with one of the aims of the professional learning not to be a ‘one-off experience’.

Sections 3.5 and 3.6 presented two main influences on professional learning. The first was rural challenges, as the school involved in the professional learning is located in a rural setting; these challenges included the tyranny of distance, influences of community, and general challenges. The second was the influence of school leadership on teacher professional learning, considering their role as a leader, in developing trust in professional learning communities and their roles in sustaining the learning. The principal was a key person in the professional learning intervention and was worthy of study.

CHAPTER 4: METHODOLOGY AND METHODS

Chapters 2 and 3 examined literature that influenced this study. In this chapter, the nature of the research and the methods of data collection are described. Due to the complexity of the professional learning intervention, this is described at the beginning of the chapter. The study is design-based research located in the classroom setting. This informs the development of the professional learning intervention of which a triad model is central. The data collection for this project is interpretive and consists of both qualitative and quantitative processes. This chapter also explores issues of reporting, validity, limitations, and ethical considerations.

4.1 Introduction

Shulman (1986b) defined a research programme as 'the genres of inquiry found in the study of teaching' (p. 4) as opposed to a distinct paradigm. He stated that there is a trend to mix different research designs which acknowledge the 'richness of teaching' (p. 4), however found that this is at the risk of 'chaos' if the designs are not well informed. My research was design based, as one of its features was the development of an intervention. The nature of this intervention is complex and comprises a number of layers. For this reason, details of the intervention are provided in the next section to enable the discussion of methodology and methods to be contextualised.

4.2 The Educational Intervention

4.2.1 Background

Atkin's (1996) work on the principles of effective learning and teaching was the starting point for this research. It formed the background to the professional learning intervention at the school and informed the principal's initial thinking. Atkin's (1996) framework of six beliefs and accompanying principles were pivotal in informing the project:

- Belief 1: In a climate of trust and mutual respect, humans inspire and encourage each other.
- Belief 2: Humans move towards experiences from which they gain a sense of self-worth and achievement.
- Belief 3: Learner driven learning is more likely to be effective and meaningful.
- Belief 4: Learning is constructing and reconstructing meaning from our experiences.
- Belief 5: The human brain–mind–body system is capable of multiple ways of knowing. 'Knowing' is deepened and amplified when there is an integration of our ways of knowing.
- Belief 6: Human psychic drives differ in different life phases. (Atkin, 1996, p. 23)

These beliefs, along with the literature review, informed the development of this project.

As mentioned in Chapter 1, I was invited to lead the professional learning intervention at the school and worked with the principal to develop the model and the intervention. It was an ambitious project with the principal wanting to have all teachers involved in professional learning in the content area of mathematics. Even though the school was considered small, it was still important to develop a model that enabled all staff to feel included.

The following objectives for the professional learning were identified:

- To have staff examine their own teaching practice of mathematics;
- To work with a partner in the professional learning intervention;
- To have the opportunity to work individually with a mathematics educator, focusing on personal teaching and learning goals; and
- To work with a partner and mathematics educator in a professional learning intervention.

This led to the use of a triad model within a broader professional learning intervention. Figure 4.1 shows the two main components of the professional learning intervention: the triad model and the other elements such as mentoring, class visits, and model lessons. The overall professional learning intervention included

- a full day of staff professional learning to begin the project;
- three week-long visits over a period of 9 months (in Terms 1, 2 and 3);
- a structured timetable using the triad model of professional learning for each of the visit weeks, accompanied by other elements such as the teaching of model lessons; and
- a concluding professional learning day.

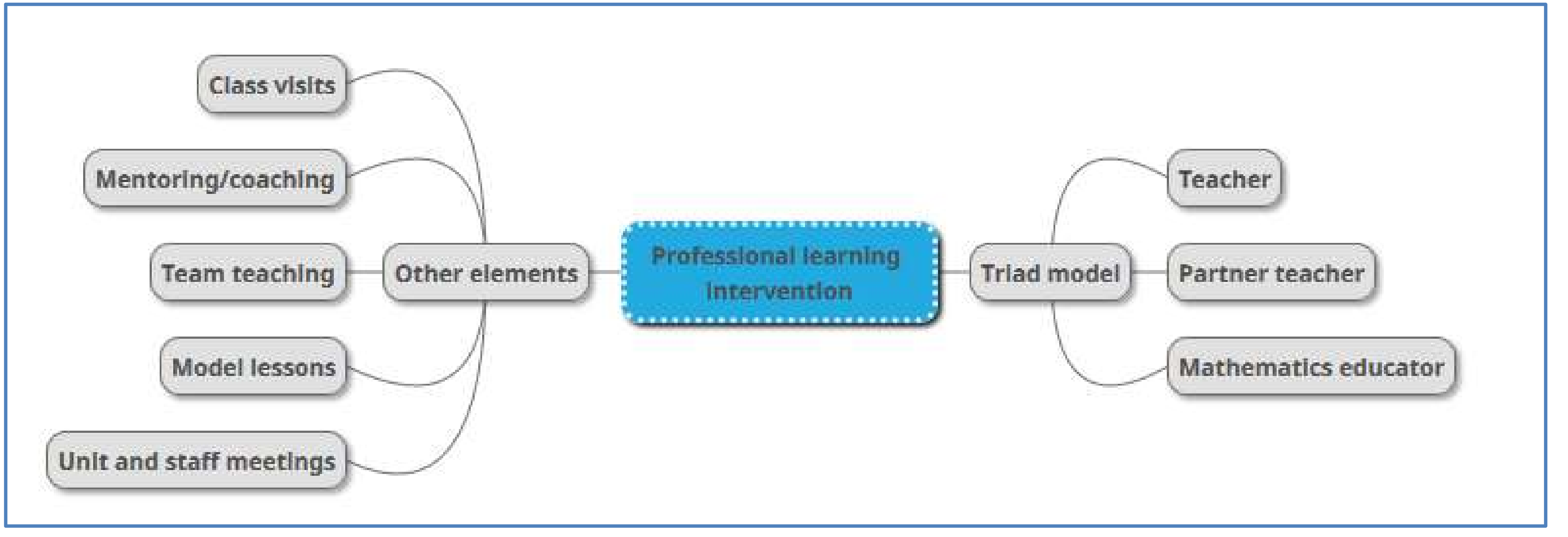

Figure 4.1: The professional learning intervention.

4.2.2 The triad model

The triad model was used as a component of the teacher professional learning intervention. It was developed by the principal and the mathematics educator working together. In this case, I was the mathematics educator, the education ‘expert’ acting in a coaching role. In this project, the educator had skills in mathematics teaching and learning, as well as mathematical content, but this is not the same as an expert of pure content, such as a mathematician in residence.

The triad consisted of the mathematics educator, the teacher, and partner, or ‘buddy’, teacher, as shown in Figure 4.1. My role as mathematics educator was that of a coach, with the aim that I would slowly move, during the professional learning intervention, from being the leader and facilitator towards allowing the teachers to drive the discussions and reflective practices (Richardson, 1992). All teachers (including the principal) were involved in the professional learning intervention, creating the opportunity for a community of learning to develop, as everyone was embedded in the professional learning, speaking the same language, and working towards a common goal. The model itself had classroom observation at its core, with the aim of improving teacher practice through the collaboration of teachers and mathematics educator (AITSL, 2015). By using teachers in the model, it acknowledged the expertise that existed within the staff and school (Hattie, 2013), supported by the external mathematics educator.

The selection of this model was made for a number of reasons. It allowed the teacher to select their own learning focus, thus making the learning relevant for the teachers and providing teacher ownership over their learning. The teacher could select and then receive advice and support on their own learning focus area. For the teacher, the triad provided the opportunity for them to work individually with the mathematics educator and collaboratively with a partner. The use of a second teacher, or partner, provided the teacher with collegial support through the professional learning intervention, making it a less isolating experience.

The role of the partner teacher was initially to provide support to their colleague. However, their role was also to provide another perspective in the lesson observations. The observations of another teacher’s class provided a rich learning opportunity for the observing teacher, particularly as teachers often spend a lot of time as the focus of the classroom, even in team teaching situations. These observations allowed the teachers to purely observe a class, teacher, and students in action. The teachers working together in the triad provided the opportunity for them to learn about another teacher's experience and an opportunity for a common language to develop as they discussed together elements of teaching and learning.

The use of triads in classroom observation situations provided multiple perspectives on the teaching activities and for the discussion sessions after the teaching. The involvement of three people created the opportunity for discussion. The involvement of a partner teacher ensured the discussion was focused on teaching and maintained relevance to the context of the school. The involvement of the mathematics educator provided an external and impartial view of the teaching and learning experience.

The role of the mathematics educator was to act as the 'expert' in mathematics education. The role consisted of providing advice, resources, and teaching of model lessons. The mathematics educator was not a member of staff, so they were independent to the school and the day-to-day issues, an external person entering the school. The role also provided the opportunity to create a link between each of the triad groups. The mathematics educator was common across all groups and had a sense of the professional learning intervention across the whole school.

The principal supported the teachers' learning in a number of ways, including providing the time for the learning to occur and the money for a relief teacher to cover the partner teacher's class to allow for the observation. The involvement of the principal as a member of one of the triads and hence the teaching experiences, was not only intended to demonstrate to the staff the value that the school leadership was placing on the professional learning intervention but it was learning the principal wanted to experience themselves.

4.2.3 The professional learning intervention

The professional learning was conducted on-site at the school in teachers' classrooms and was developed similar to a program, with a full-day professional learning session for staff to become familiar with the mathematics educator, the process, and how the professional learning aligned with the school's leadership expectations. The professional learning then consisted of three week long sessions held throughout the year at the school with a timetable established. These weeks were spaced apart and fell into Terms 1, 2 and 3 of the school year. Teachers, with the support of the mathematics educator, set their own learning goals in the area of mathematics teaching. During the three weeks, some broader project goals were set to provide the learning context, and these were slightly varied to maintain freshness of the project, although teachers could opt to maintain their own focus for their personal learning, allowing them ownership over their learning experience. In the first week, the focus was goal setting and establishing the project, the second week was teaching and observing with model lessons aimed at teachers of similar year levels, and the third week focused on reflection and ending the lesson. In summary, the professional learning intervention (see Figure 4.2) consisted of

- staff setting personal goals (personalisation);
- staff having one-on-one time with the mathematics educator (collaboration);
- staff working in pairs with a partner (collaboration);
- peer-reviewed teaching lessons (targeted observation);
- model lessons taught or team taught with the mathematics educator (targeted teaching); and
- time spent in classrooms with the mathematics educator (critique and reflection).

The aim of the professional learning intervention was to raise teachers' awareness and sensitivity to students' ways of thinking in mathematics, to expand teacher capacity to analyse teacher responses to students' questions on the subject matter, and to develop teachers' abilities to reflect on their own practice (Even & Markovitz, 1997). Additionally, it was hoped that teachers would review and critically think about teaching practice: 'Teachers need to learn how to analyse practice—both other teachers' practice and their own' (Willis, 2002), and this was supported with the use of the triad model.

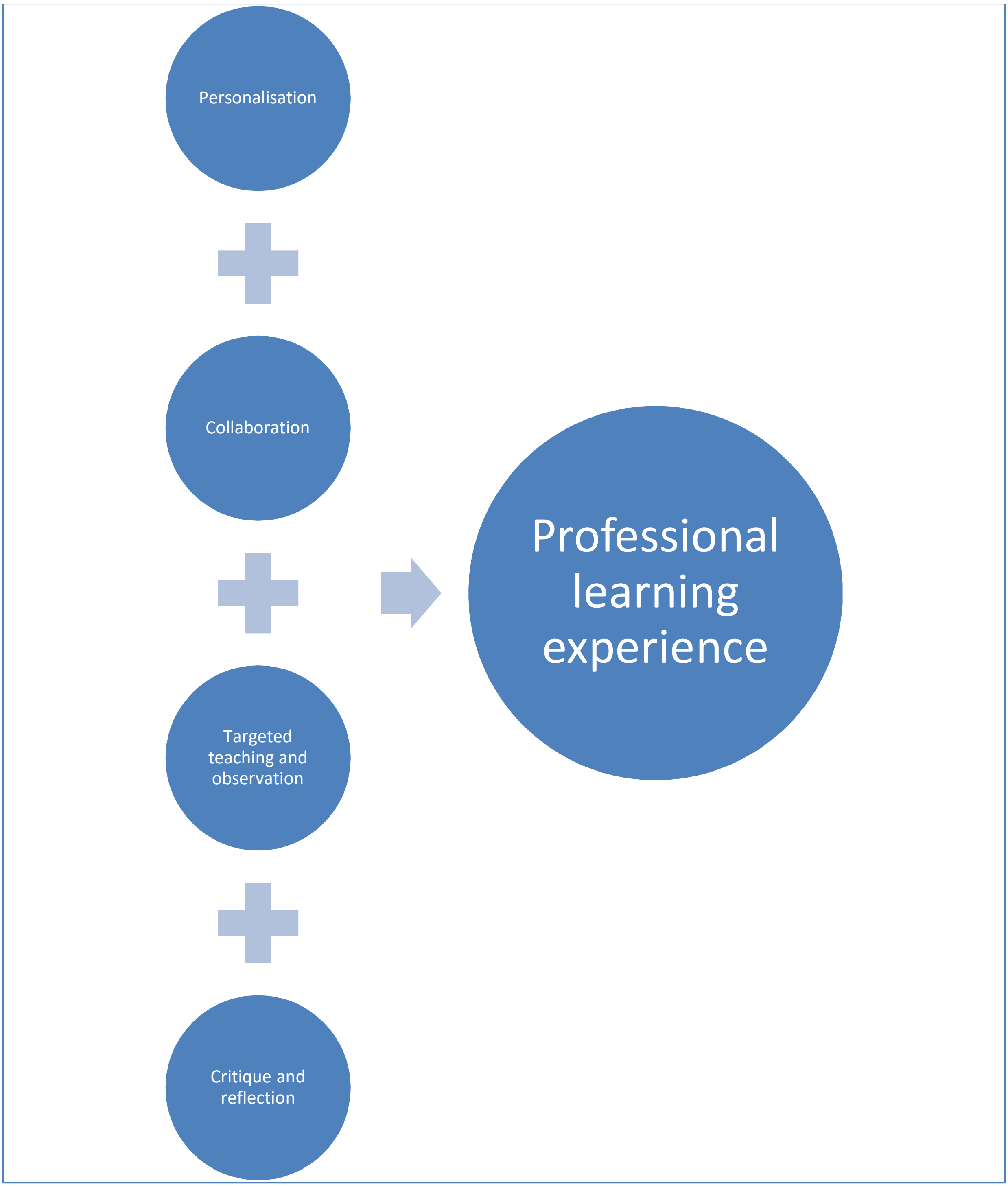

Figure 4.2: Visual representation of the learning elements of the professional learning intervention.

The next section describes the structure of each week of professional learning.

4.2.4 The weeks of professional learning

The structure of each week of the teacher professional learning intervention is described in this section. Week 1 has more detail, whereas Weeks 2 and 3 describe the differences to previous week(s). Week 1 was conducted in Term 1, Week 2 in Term 2 and Week 3 in Term 3.

To introduce the project and the week, a one-day professional learning session was held with all staff. This included the principal as a participant. This allowed the staff and the mathematics educator to become familiar with each other and to set the scene for the following week. The session was very informal. Staff completed some mathematics activities and discussed mathematics education in general. Some discussion about the teaching programme being used ensued. The overall project was introduced, aims shared, and Week 2 outlined.

Staff were provided with reading and a questionnaire. They organised themselves into 'teaching pairs' and a timetable was established (Table 4.1). All staff were required to be involved in the teaching/observation process for the week, including the principal.

The model for Week 1 is shown in Table 4.1 and comprised

- a half-hour interview with the teacher prior to the lesson, discussing the lesson to take place, any concerns about their own teaching and/or learning, and identification of any goals for the lesson;
- the lesson (allocated 1 hour) with the mathematics educator and teaching partner observing; and
- a half-hour debriefing and reflection session with the teacher, mathematics educator, and partner teacher.

This process was reversed for the next triad session; that is, discussion with the partner teacher, the teaching of the session, and the following reflection. Each of the two-hour blocks was scheduled against either a recess or lunchbreak, so there was flexibility in the timetable if the class or discussion took longer than anticipated. The afternoon sessions, 2.30 p.m. to 3.15 p.m., were left free to allow the mathematics educator time to revisit classes or work with teachers in a one-on-one situation or work with leadership staff such as the principal. This dedication of time illustrated the school and leadership commitment to the professional learning intervention. After school, time was also set aside for professional learning sessions or professional discussions such as working with unit teams, working with the whole staff, or meeting with staff individually.

Table 4.1: *Staff Timetable Illustrating Teachers Working with Teaching Partners*

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
9:00 – 9:30	Teacher A	Teacher C	Teacher E	Teacher G	Teacher I
9:30 – 10:30	Teacher A teaching	Teacher C teaching	Teacher E teaching	Teacher G teaching	Teacher I teaching
	Teacher B viewing	Teacher D viewing	Teacher F viewing	Teacher H viewing	Teacher J viewing
10:30 – 11:00	Debrief Teachers A & B	Debrief Teachers C & D	Debrief Teachers E & F	Debrief Teachers G & H	Debrief Teachers I & J
Recess					
11:30 – 12:00	Teacher B	Teacher D	Teacher F	Teacher H	Teacher J
12:00 – 1:00	Teacher B teaching	Teacher D teaching	Teacher F teaching	Teacher H teaching	Teacher J teaching
	Teacher A viewing	Teacher C viewing	Teacher E viewing	Teacher G viewing	Teacher I viewing
1:00 – 1: 30	Debrief teachers B & A	Debrief teachers D & C	Debrief teachers F & E	Debrief teachers H & G	Debrief teachers J & I
Lunch					
2:15 – 3:15	Available time for mathematics educator to meet with staff				
After school					

The timetable shown in Table 4.1 was altered for each visit. For the Week 2 visit, the order in which the partners taught their lesson was reversed as shown in Table 4.2. The table shows the order of teachers A and B has been reversed compared to Table 4.1. This was to provide teachers the opportunity of reversing the process of the person teaching and observing.

The model implemented for the Week 2 visit was based on the model used in Week 1, consisting of the interview prior to the lesson, the lesson itself, and the debrief and reflection session. This process was then reversed for the next triad session; that is, discussion with the partner teacher, the teaching of the session, and the following reflection, as seen in Table 4.2. Teachers were swapped around; for example, Teacher B went first in Week 2, compared to Week 1 where they went second.

Table 4.2: *Staff Timetable Illustrating the Reversed Nature of Teaching Partners*

	Monday
9:00 – 9:30	Teacher B
9:30 – 10:30	Teacher B teaching Teacher A viewing
10:30 – 11:00	Debrief teachers B & A
	Recess
11:30 – 12:00	Teacher A
12:00 – 1:00	Teacher A teaching Teacher B viewing
1:00 – 1: 30	Debrief teachers A & B
	Lunch
2:15 – 3:15	Available time for mathematics educator to meet with staff
After school	

The model implemented in Week 3 of the professional learning was based on the model used in Week 1 (Table 4.1) and is shown in Table 4.3. The model for the week was the same as the other two weeks; however, the order of teaching pairs was reversed from previous visits, allowing different teachers to 'go first', for example pair AB were moved to Thursday.

4.2.5 The mathematics educator

My role as mathematics educator within the professional learning intervention was that of facilitator, teacher, co-learner, and researcher. As mentioned in Chapter 1, I was invited to take on the role, and initially the principal and I worked together to conceptualise what the role might entail, but large components of the role developed during the professional learning intervention.

Parts of the role were of facilitation, and the single full days commencing and closing the experience were facilitated by the mathematics educator. The facilitation role also included ensuring the timetable ran on time and conducting the discussion sessions.

Table 4.3: *Staff Timetable Illustrating Change in Presentation Order of Teachers and Their Teaching Partners*

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
9:00 – 9:30	Teacher G	Teacher E	Teacher I	Teacher A	Teacher C
9:30 – 10:30	Teacher G teaching	Teacher E teaching	Teacher I teaching	Teacher A teaching	Teacher C teaching
	Teacher H viewing	Teacher F viewing	Teacher J viewing	Teacher B viewing	Teacher D viewing
10:30 – 11:00	Debrief teachers H & G	Debrief teachers E & F	Debrief teachers I & J	Debrief teachers A & B	Debrief teachers C & D
Recess					
11:30 – 12:00	Teacher H	Teacher F	Teacher J	Teacher B	Teacher D
12:00 – 1:00	Teacher H teaching	Teacher F teaching	Teacher J teaching	Teacher B teaching	Teacher D teaching
	Teacher G viewing	Teacher E viewing	Teacher I viewing	Teacher A viewing	Teacher C viewing
1:00 – 1: 30	Debrief teachers G & H	Debrief teachers F & E	Debrief teachers J & I	Debrief teachers B & A	Debrief teachers D & C
Lunch					
2:15 – 3:15	Available time for mathematics educator to meet with staff				
After school					

During the three weeks, in my role as the mathematics educator, I met with each of the staff members prior to the professional learning intervention. This was to explore goals, identify the focus of the lesson, and discuss any concerns. In Week 1, concerns were also alleviated and the process discussed. Any targeted areas for the observation were also shared. During the lesson observations, I observed the lesson and took observation notes, particularly noting any targeted areas such as questioning. The focus of the lesson was the teacher. After the taught lesson in Week 1, I facilitated the discussions, asking the teacher to reflect on the lesson. The teacher partner was then asked to comment, and then finally, I, as the mathematics educator, offered observations. My role also required being mindful of time and trying to reach a ‘what next’ point, such as what the teacher might focus on next in their teaching, or whether they needed support resources, and so on. For subsequent professional learning weeks, this facilitating role after the lesson was modified so that all teachers could lead the discussion and reflection process. The collection of observations and data also provided the opportunity to observe patterns and trends, and consider the focus for each week of professional learning.

Time was built into the timetable, 2.15 p.m. to 3.15 p.m., as shown in Table 4.1, which provided opportunity for me to revisit classes, team teach, or conduct model lessons. This also provided the flexibility to support teachers who wanted more time out of the structured programme. After school, I attended staff and unit meetings, again having mathematics as the focus. Sometimes I presented; other times, I was an observer or participant.

Another aspect of the role was to provide access to support between each week of professional learning, acting in a mentoring role. Teachers were given my contact details and could seek assistance between weeks if and as required.

As a consultant, I was also required to complete reports. These included a report to leadership and to the AGQTP funding body after each full week. As I was a component of the professional learning intervention and the researcher, I was mindful of issues such as subjectivity. I utilised the questionnaire as one of the main forms of data collection, and analysis to account for the possibility of subjectivity and the observations collected formed the teachers' stories rather than rigorous case studies. In my role as the mathematics educator, I navigated various professional roles: consultant, classroom educator, and researcher.

The next section explores how the professional learning intervention aligned with the methodology of design-based research.

4.3 Design-Based Research

When research is innovative and is designed by the researcher and the community in which it is being implemented, it is known as design-based research. It is a methodology that seeks to improve practice as a result of transferring and translating educational research (Anderson & Shattuck, 2012). Wang and Hannafin identify design-based research involving

> the adoption, adaptation and innovation of a variety of methods, and define it as systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings. (2005, p.6)

Wang and Hannafin (2005) identify the five basic characteristics of design-based research as pragmatic; grounded; interactive, iterative, and flexible; integrative; and contextual. The design of the professional learning intervention, including the timetable, how the triads operated, and the ongoing nature of the intervention were developed by me in collaboration with the principal and the teachers and reflects these characteristics, with two of the main features being flexibility and iteration (Anderson & Shattuck, 2012). The programme for each of the weeks underwent iterations based on teacher requirements and the evolving nature of the professional learning intervention. Each iteration consisted of two phases, design/development and use/evaluation and it was the experiences and lessons learnt from these iterations that informed and defined the direction of the next phase, indicating a system of multiple iterations (Anderson & Shattuck, 2012). This is shown in Tables 4.1, 4.2, and 4.3, which show the changes made to the timetable for each week.

Bereiter (2002) explored the concept of design-based research, defined by the goals of those who pursue it rather than the methods. The school, principal, and staff were 'constituted within communities of practices that have certain characteristics of innovativeness, responsiveness to evidence, connectivity to basic science, and dedication to continual improvement' (Bereiter, 2002, p. 321). Throughout the professional learning intervention, findings were fed back into further cycles of innovative design. Design research is not defined by methodology and different methods can be employed (Bereiter, 2002). As stated by Kelly and Lesh (2002), 'the use of the word 'design' allows us a broad canvas for productive thought and conversation' (p. 2), which was required in the study, providing teachers with the flexibility to explore different aspects of teaching and learning. Design research is often influenced by other forms of research, but the best design research has a visionary quality that cannot be derived from those other kinds of research, nor does it often arise from practice; 'It requires a research community driven by potentiality' (Bereiter, 2002, p. 331). Design research can be seen as a strong vehicle to move towards seeing 'educational research as ultimately a service to teachers and students to improve teaching and learning in the 'real world'' (Kelly & Lesh, 2002, p. 2), being the teachers' classrooms and reflected in the on-site nature of the research.

The professional learning intervention developed as the project progressed; Kelly and Lesh (2002) stated, 'Design experiments typically unfold somewhat haphazardly with little guiding protocol' (p. 2). Other than the use of the triad model within the timetable, there were few constraints and structure, as there are with other forms of research. These studies occur on many different time scales, which naturally have implications for both researching and reporting. Design research requires researchers to work closely with practitioners, who need to be receptive to innovation and prepared to experiment with different and often unproven methods (Bereiter, 2002); this links to the building of trust with the mathematics educator. However, when successful, with these relationships in education, ‘the personal and social consequences of innovation are the potential’ (p. 325) of this form of research.

One of the criticisms of design-based research is that the researcher is involved in the design and development of the study and researching it, which can make trustworthiness and credibility a challenge. Anderson and Shattuck (2012) argued that the inside knowledge the researcher has as a result of their involvement ‘adds as much as it detracts from the research validity’ (p. 11); there is overlap, and care needs to be taken as this is one of the defining features of this form of research.

In summary, design-based research informs the development of the professional learning intervention of which the triad model is the focus. The study was predominately located in the classroom, and while discussion and activities such as staff meetings occurred outside the classroom, the focus was on the teaching and learning in the primary setting. The situational nature of the research focused on one school rather than on a regional area or multiple schools, so the research is intensive in nature. No single factor was identified and studied in isolation; in fact, the qualitative data collected were from observations and were used to inform later parts of the intervention.

Teachers were encouraged to approach the professional learning intervention by focusing on areas they wished to explore and processes they would like to change throughout the intervention, with aspects such as the structure of the professional learning intervention each week based on their previous experiences and weeks. Therefore, the research was iterative in nature, and the flexibility of design aligned the study as design research, allowing changes to occur during the intervention. Bereiter (2002) stated, ‘There is always innovation. The trick is sustained innovation’ (p. 321). The research for this study was a ‘hybrid’ of processes, such as cognitive psychology and social anthropology, as the question was not what teaching is most effective, but ‘what meaning is given to (or by) the teaching and what are the grounds for those constructions’ (Shulman, 1986a, p. 18). The ‘hybrid designs’ (p. 4) of research are seen by Shulman (1986a) as ‘exciting new developments in the study of teaching’ (p. 4). The ‘enormously difficult job’ (p. 6) of exploring classroom behaviour is acknowledged, and this needs to be informed by an understanding of different types of knowledge, as ‘there exists no particular sequence or order of approaches that is generally optimal' (Shulman, 1986a, p. 33). Thus, design research is an appropriate form of research, as not only did the study evolve, but also teachers individually worked on their own learning, which was evaluated and enacted upon during the intervention.

4.4 Research Aims and Questions

Based on the literature reviewed in Chapters 2 and 3, the proposed research utilised a mix of research methods in an attempt to investigate teacher change as a result of the professional learning intervention, using the triad model.

As stated in Chapter 1, my research aims were

1. to draw on educational research to understand the importance of influences such as school location and school leadership on teacher professional learning;
2. to identify a teacher professional learning model that could be used as a vehicle for teacher change; and
3. to explore the potential implications of using the selected teacher professional learning model to lead change in teacher practice.

To address these aims, the following three questions when answered may describe the possible teacher change in classroom practice through professional learning in the primary mathematics classroom:

1. What changes are identified in teacher knowledge, beliefs, and practices as the result of a structured collaborative teacher professional learning model in a primary mathematics setting?
2. What factors are identified as influencing teacher professional learning as a result of the structured collaborative teacher professional learning model in a primary mathematics setting?
3. What are the implications for informing mathematics teaching professional learning?

The next section describes the research perspectives and theoretical underpinnings.

4.5 Research Approach

The methods for this research were interpretive and included both qualitative and quantitative data collection.

4.5.1 Interpretive research

Erickson (1986) stated that interpretative research refers to the whole family of approaches that focus on action, not behaviour. These different approaches include participant observation, case studies, symbolic interaction, and phenomenological and constructivist methods. The methods of participant observation seem to be more naturalistic (Erickson, 1986), and this was one of the main methods utilised in this study. Shulman (1986a) explained that interpretive scholars see classrooms as social and culturally organised environments. They engage in continuing intervention and the reformulation of new meanings, and these 'personal meanings' (Shulman, 1986a, p. 20) become the focus of inquiry.

The continual intervention by the mathematics educator identified this study as interpretive. As events occurred, different perspectives and new meanings were developed through the discussion process. Interpretive research methods can be labour intensive compared to predetermined coding categories, but they allow variability in relationships between behaviour and the intended meaning to be explored in classroom situations. Erickson (1986) highlighted that the form of observation data collected during the peer-taught lessons, or the teacher stories that were developed during the project, are 'locally unique' (p. 139) in that they both examine particular instances in close detail. Erickson discussed the importance of both looking into the classroom and looking out from the classroom when utilising observations and case studies. While the research tended to focus on what is happening in the classroom, the overall context of curriculum, teacher standards, and other external factors such as local community impacts are acknowledged.

Erickson (1986) stated, 'Fieldwork research requires skills of observation, comparison, contrast, and reflection that all humans possess. In order to get through life everyone must do interpretive fieldwork' (p. 157). An external researcher has the capacity to assist the classroom teacher in making the familiar 'strange and interesting' (p. 158), although the tension between teacher effectiveness and research effectiveness needs to be considered. Erickson (1986) saw interpretive research of teaching not only as an 'alternative method but an alternative view of how society works and of how schools, classrooms, teachers and students work in society' (p. 158).

4.5.2 Researching in the classroom

The setting for a large portion of my research was the classroom. The classroom is a complex environment (Erickson, 1986; Salomon, 1991; Shulman, 1986a), a learning environment for both the teacher and the student (Wood et al., 1991), and, like any study involving people, there are few fixed variables. Classrooms are a mix of ‘interdependent variables, events, perceptions, attitudes, expectations and behaviours’ (Salomon, 1991, p. 11). There is no one ideal method for research, as the study of such complex and changing events cannot be approached in the same way as the study of single events and single variables. The DEECD (2007) stated that there is difficultly in ‘articulating and documenting’ (p. 1) the richness of the different types of knowledge and experience generated by teachers.

Spindler and Spindler (1992) stated that there is no rule about what is a sufficient amount of time to spend on-site. The project was developed so that teachers worked with their professional partner in one single day, with each of them teaching and observing during each of the professional learning weeks across three school terms, so they had at least three personalised peer-observed experiences and three observing opportunities across the life of the project. A study conducted in the classroom over a period of time has elements of a number of methodologies, as the research responds to teachers’ learning needs and the environment.

The intensive nature of working in classrooms led to a mixed methods approach in this study (Erickson, 1986; Salomon, 1991; Shulman, 1986a), as in a classroom, no single event can be easily isolated from another because there is always a complex integration of influences. Salomon (1991) stated that the complementary nature of different approaches, such as analytical and systematic, lead to informed research, as each of the methods can inform and guide the other. It is necessary to accept the ‘cohabitation’ of methods such as qualitative and quantitative if ‘any fruitful outcomes are ever expected to emerge’ (Salomon, 1991, p. 16). Grootenboer (1999) stated that some of the criticisms of conventional educational research are the ‘Research is largely irrelevant to the practical concerns of teachers, and that it is often invalid because it is separated from the subject of concern, notably the classroom practice’ (p. 2). In more recent times, there has been a growing acceptance of the qualitative perspective when researching a classroom environment (Salomon, 1991), which allows the link to classroom practice to be more easily identified. In this study, both qualitative and quantitative methods were utilised and are explored in subsequent sections. Teacher stories were used to provide the qualitative data, and these are discussed in Section 4.6 before the methods of the study are described.

4.5.3 Framework

Shulman (1986a) stated that 'to understand adequately the choices teachers make in classrooms . . . we must study their thought process before, during and after teaching' (p. 23). Shulman's (1986b) work, identifying six key elements of pedagogical content knowledge (knowledge base), was used as a framework to sort and categorise collected quantitative data. The elements of Shulman's (1986b) work are:

> (1) Knowledge of representations of subject matter (content knowledge);
>
> (2) Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter;
>
> (3) General pedagogical knowledge (or teaching strategies);
>
> (4) Curriculum knowledge;
>
> (5) Knowledge of educational contexts; and
>
> (6) Knowledge of the purposes of education. (Shulman, 1986b, p. 4)

For this study, the framework was used to group the questionnaire statements. Groupings for each element were used to organise the comparison graphs for the purpose of analysis. The purpose of using the framework was to identify in which areas change in practice or beliefs may have taken place. It was decided to use this framework rather than the framework of Sullivan et al. (2016) of Figure 2.3 as it was felt the statements of the questionnaire were a better fit, and Sullivan's framework was more applicable to the literature construct.

4.5.3 Teacher stories

Each classroom has a unique microculture (Erickson, 1986), and real-time observation of that environment makes the research interpretive in nature (Spindler & Spindler, 1992). There are two types of observations: participant and nonparticipant. In this study, as my role was mathematics educator, I was a nonparticipant when observing taught lessons and a participant when in my role as mathematics educator. As the observations took place over an extended period of time, relationships were developed, which led to more natural environments (Cohen & Manion, 1994), particularly as teachers and their classrooms became more familiar with the professional learning intervention.

Criticisms of this form of research include that the observations are 'subjective, biased, impressionistic, idiosyncratic and lacking in the precise quantifiable measurements that are the hallmark of survey research and experimentation' (Cohen & Manion, 1994, p. 110). This was a risk in the project; however, I was mindful of it at all times. One of the project aims was sustainability, and over the period of the project, I attempted to step back and allow teachers to take responsibility and leadership, lessening my involvement. There were also concerns with the note taking of observations, and strategies such as taking notes in dot point format, supplemented with detail prior to the next set of observations, were put in place.

For this thesis, I decided to present two teacher stories rather than traditional case studies. Two stories were developed, as this is one-fifth of the total staff. An experienced and less experienced teacher were selected, who were working in different year levels at the school. The purpose of the teacher stories was to observe and probe deeply with a view to establishing generalisations about the wider population (Cohen & Manion, 1994). The time spent in real-time observations and the time spent on-site in each of the classrooms was at least three lessons in each of the classrooms viewing the two teachers who were the basis of the two developed stories, as well as three lessons working with the two teachers and their professional partners in the triad professional learning model. The teachers were also involved in two days of whole-school professional learning. Additional time was spent with these teachers as the project evolved once they were identified. This included working one-to-one with the teachers, peer teaching in their classrooms, and mentoring via email.

4.6 Methods

The aims and questions were reviewed and consideration was made on how the professional learning intervention was to be conducted in the school. The measurement to inform these aims and questions, was to address two areas: teacher change and identification of factors influencing the teacher professional learning intervention. The first area attempted to identify whether there had been any teacher change by examining teacher knowledge, teacher beliefs, and teacher practice. The second area attempted to identify factors that influenced the teacher professional learning intervention.

A mixed methods approach was used to elicit responses from the predetermined questionnaire. Different aspects and phenomena of these data were described and particular observations and accounts were included in the reporting.

4.6.1 Data collection

Data collection in education fieldwork is generally seen as moving relatively quickly, from a general overview of the community to a continuous focus study such as the classroom. The collected data is then used to examine aspects of influence (Erickson, 1986). Each classroom has a unique microculture, which is 'distinctive to that particular set of individuals' (Erickson, 1986, p. 128); hence, interpretive research is the 'moment-to-moment enactment of social action in real time' (p. 129). This real-time aspect is evident in this study, which provides the local character. The design element of the research is evident within the evolving model of the professional learning and in the differentiation of learning for each teacher. The world beyond face-to-face interactions, or what is seen, is the element that provides the nonlocal characteristics, and it is these that are difficult to control.

Spindler and Spindler (1992) explored the 'ingredients' for research in schooling, which include the time to be spent on-site, recorded data, problem establishment, and instrumentation. They stated that there is no rule about what is a sufficient amount of time to spend on-site, but cautioned that the validity of the observation is based on time to allow the researcher to see things happen, not just once but repeatedly. The opportunity in this study was created with repeated visits to the school and time spent with each classroom teacher. Spindler and Spindler (1992) recommended that the researcher should not work out specific hypotheses or categories of observation prior to study, but should be encouraged to keep an open mind, so that the researcher does not predetermine what is observed or is elicited from participants. This does not mean the researcher works in a vacuum. The problem area is pre-identified; in this case, examining teacher practice in the mathematics classroom, the specific problem with related hypotheses was developed as the fieldwork progressed. This uniqueness of each situation and event can be well supported with collected and recorded data, such as lesson plans and worksheets, to help establish the context. Spindler and Spindler (1992) saw the context of the community as important and that 'the only limits in pursuing context . . . are those imposed by time, energy and funding' (p. 80).

The data collection tools used for this study were a 25-statement questionnaire implemented at the beginning and the end of the intervention, a set of open-ended questions provided to participants at the beginning of the intervention, observations collected from the triad lessons and other viewed classes, notes from the discussion sessions before and after the peer-teaching experiences, and my personal reflective journal. Each of these tools will be described further in Section 4.9.

4.6.2 Participants

All members of the teaching staff at the school, including the principal, were participants in the study. The principal was a participant in the study experiencing the triad in the same way as the other teachers, who were involved in the single days of professional learning and staff meetings. The professional learning intervention was a whole-school approach as determined by the principal. Casual relief staff were not involved in the professional learning intervention or in the data collection. The staff consisted of two male and eight female members. 'In primary schools eight out of every ten teachers are female. This has not changed in over ten years' (Weldon, 2015, p. 6), so the balance of the school's staff in this school was typical.

Two of the participants had leadership roles: one was the principal and the other was the assistant principal/leading teacher. The staff members worked with the school leaders as coprofessionals (Fleming & Leo, 1999). There were no 'first year' teachers within the group, and experience ranged from third year through to teachers with more than 20 years of experience. Some of the teachers had been at the school for a short period of time, one to two years, and others had been at the school for more than 10 years. Simple demographics were collected and included gender, number of years of experience, and number of years the teacher had been employed at the school. Demographics around disability, ethnic background, and religion were not deemed relevant to this project and hence, were not collected. For all participants, English was their first language. Steel and McLaren (2008) suggested that the population frame must be updated to incorporate changes in the population as quickly as possible, and in this case, the sample was small and unchanged throughout the duration of the project.

All teachers were involved in all aspects of the professional learning intervention, including the triad experiences of discussions before the teaching experience, the teaching, and the discussions after the teaching experience. All teachers completed the questionnaires, set questions, and agreed to have observations recorded.

4.7 Validity and Reliability

Erickson (1986) identified five major types of evidentiary inadequacies: inadequate amounts of evidence, inadequate variety in the kinds of evidence, faulty interpretive status of evidence, inadequate disconfirming evidence, and inadequate discrepant case analysis. Throughout this study, I was mindful of possible situations that threatened the validity and/or reliability of the research and took measures to reduce or eliminate these. Adding to identified inadequacies are unintended influences, such as personal frameworks like the cultural frames in which the data was observed. These frameworks and inadequacies, combined with ethical principles, are the aspects that Erickson (1986) identified as needing to be considered within data collection, particularly when relationships are developed between researchers and participants. I was particularly mindful of validity, as the mathematics educator, and attempted to record observations impartially.

Erickson (1986) stated that limits on information processing capacity can be addressed by varying the focus of attention during observations. This leads to a major limitation of partialness of the view of any single event. Two sets of procedural decisions are identified: the decision of where to be in space and time in the field setting, and the decision about the focus of attention in any one occasion of observation. In the study, as the observer, I was present at all teacher pre discussions, teaching experiences, and post discussions. I took notes at all sessions. When observing a teaching session, I sat at back of the classroom slightly removed from the students, so as not to interrupt the flow of the class. I also sat apart from the teacher partner, so as not to influence them or create opportunity for distraction. Each lesson also had a focus for observation often determined by the teacher, which was identified for me and the observing teacher before the lesson. This helped to target the observations.

Erickson (1986) described that bias generally occurs due to the researcher attending to actions that confirm the induced theory opposed to those that disconfirm the theory. Disconfirming evidence needs to be sought to reduce the situation of 'problem typification' (Erickson, 1986, p. 144) where the researcher tends to leap to conclusions early in the research. I attempted to minimise this by not looking for specific influences until the end of the professional learning intervention. The literature about teacher change indicated that it would take time, and this made me cautious about identifying whether any change had taken place as a result of the professional learning intervention. Erickson (1986) suggested that this could be reduced with the use of video or audio recordings. I decided not to record the lessons either with video or audio because for many teachers, the experience of having two people observing a lesson and providing feedback is daunting enough. Perhaps teachers may have become accustomed to the process, but as there were a small number of observations for each teacher, I was reluctant to change the mode of recording data once the intervention had commenced.

My original interpretation of the data was that the triad model was the critical element of the intervention, so if there was any personal bias, it would have been only towards the triad model. However, during the study, the research focus became about teacher change and the influences of this rather than a specific model of professional learning, and this occurred when the data analysis commenced. This developing interpretation could be seen as both a strength and a weakness, as it limited my ability to really probe for clarifying detail during discussions about change in practice; however, this limitation may have meant my personal bias may have been a reduced factor.

Erickson (1986) stated that validity depends on assertions that account for patterns found across both frequent and rare events, which lead to demonstrating plausibility. Erickson explored three major types of content in a report of fieldwork: particular description, general description, and interpretive commentary. These types of content provided connections between the particular and general. The content had two main aims: to make it clear to the reader what is meant by the various assertions with evidence and to clarify assertions with multiple examples and particular descriptions. I attempted to do this by examining all comparison graphs, seeking change between both the pre and post intervention data collection for each statement, and also seeking change in the ratings between each statement for each teacher. All data comparisons are presented in Chapter 5, and not particular cases selected. I also include the two teacher stories to further exemplify findings and provide a different perspective on the data that may have not been identified through the analysis of the questionnaires.

The foundation of an effective fieldwork research report is analytic narrative, which gives the reader a sense of being there (Erickson, 1986). The narrative has three functions and should be rhetorical, analytical, and evidentiary. It needs to be rich and contain interpretive perspective, but needs supporting evidence such as quotations and data tables. In my reporting, all of these aspects are included. It is acknowledged that even a highly detailed vignette is a reduced account with a focus on select features, which highlight the author's interpretive perspective. Shulman (1986a) cautioned that research often grows from a particular perspective which illuminates 'some part of the field of teaching while ignoring the rest' (p. 4). This can lead to a natural bias in results and findings. I attempted to minimise this by including a lot of detail around the sets of comparison data, presenting from different views and supported by two teacher stories.

The interpretive commentary itself can show generalisations about where the specific example fits in the bigger picture to illustrate the validity of assertions of the significance of the instance. The interpretation precedes and follows an instance in the text and the theoretical discussion of the more general significance of the patterns identifying the events. It can illustrate and account for the changes that occurred in the author's changing point of view during the course of inquiry. Erickson (1986) suggested that it is necessary for an author to show openness to perceiving, recording, and reflecting on evidence that may disconfirm the author's preconceived notions, and to show specific change in interpretive thinking and perspective as well as data collection. During the data collection, teachers sometimes opted not to complete parts of the questionnaire, and these non responses are included in the comparisons because a nonresponse or evidence of no change is still interesting and worthy of reporting and discussing. This is one of the reasons that all comparison graphs are included.

Shulman (1986a) acknowledged that a limitation of studies in the classroom is that they are often single, detailed cases, rather than a number of cases, with the aim of fully developing a model of the situation that will lead to generalisations. I acknowledge that my research is small scale and this could be viewed as a liability or limitation. This could also be viewed as an asset, as the study is intensive in nature with a focus on the detail. Shulman (1986a) stated that 'to understand adequately the choices teachers make in classrooms . . . we must study their thought processes before, during and after teaching' (p. 23). I have attempted to do this by collecting quantitative data via the pre intervention data collection before the professional learning intervention, collecting qualitative data via observations leading to the development of the teacher stories during the intervention, and collecting quantitative data via the post questionnaire after the professional learning intervention. I also collected data prior to the taught lesson, from observations during the lesson, and in the discussion after the lesson, as part of the triad intervention. Finally, I keep my own reflective researcher journal throughout the study.

In conclusion, I acknowledge the importance of putting steps and processes into place to minimise error, and identify that this is difficult to do when working in such complex and integrated environments and when personally involved in the professional learning intervention. This is further complicated by the design features of the learning intervention.

The next section presents the different types of data collection and the instruments used. The types of data collected are quantitative, which provided information about quantities and in this research consisted of responses to the pre and post intervention data collection, and qualitative, which consisted of responses to the questions and observations. These is discussed further in the following sections.

4.8 Quantitative Data

The instrument used for quantitative data collection was the questionnaire, which was designed based on Barell's (2001) work, which was felt met the school's needs (see Figure 4.3) at the time of the research. The questionnaire was selected because at the time, it appeared that the statements in the questionnaire were unambiguous and in language that staff could understand, based on work they had already been completing at the school. Barell's questionnaire (2001) was 20 statements long. The rating system used with Barell's questionnaire was the one used in the research. The principal and I worked together to review Barell's questionnaire. We altered a number of the statements to include the term 'mathematics' as this was the focus. For example, Barell's statement was 'Students pose thought-provoking questions related to content', and this was altered to 'Students pose thought-provoking questions during maths'. We decided not to use a number of Barell's original statements that were not relevant to the school, such as 'Most answers to questions can be found in textbooks'. These statements were replaced and an additional number of statements were constructed, taking the questionnaire to 25 statements. Barell was acknowledged on the questionnaire presented to staff (Figure 4.3).

The purpose of the questionnaire (Cohen & Manion, 1994) was to collect teachers' perceptions about their own mathematics teaching prior to the commencement of the professional learning intervention and the same questionnaire was implemented at the end of the initiative. It was conducted initially to provide some baseline data for the initiative as well as to give the mathematics educator insights into the experiences and thinking of the teachers. The questionnaire (Figure 4.3) focused on what the teacher does when teaching mathematics, the way they organise students, questioning, assessment, content, and curriculum as well as how the staff work together.

The questionnaire presented to the staff (Figure 4.3) consisted of 25 statements adapted from Barell (2001), and teachers were asked to respond with the subject of mathematics in mind. Teachers ranked each of the statements on a 5-point Likert scale as 1 *(hardly ever)*, 2 *(seldom),* 3 *(sometimes)*, 4 *(often)*, or 5 *(very often)*. The scale was used to allow the person completing the questionnaire to assess a situation, in this case teaching mathematics in a primary classroom, along a continuum of values (Boulton, 2012). Jamieson (2004) suggested that Likert scales are often used to measure attitude, providing a range of responses to a given question or statement. The scale often consists of five categories of response such as *strongly disagree* to *strongly agree*. It is noted that although Likert scales are often based on a rank order such as 1 *(strongly disagree)* through to 5 *(strongly agree)*, the intervals between the values cannot be presumed equal (Blaikie, 2003; Cohen, Manion, & Morrison, 2000; Jamieson, 2004) such that the 'intensity of feeling' (Jamieson, 2004, p. 1217) between the different intervals cannot be assumed to be the same.

Some teachers opted not to respond to some questions for a variety of reasons, and others wrote additional comments. The same questionnaire was implemented at the end of the study to examine whether teachers' responses had changed. Data were then tabulated in an Excel spreadsheet, de-identified, and graphs were created for ease of analysis, and these are presented in Chapter 6.

Raw data are presented in the form of summary tables developed in Excel. These were created into column graphs to provide a visual representation of the data to look for patterns. By doing this I moved away from a large amount of statistical analysis of raw data which would be problematic with small participant numbers, and not representative of a wider population. The tables and graphs are both used to seek change. It is acknowledged that all questionnaires and respective analysis do have some bias or inaccuracies (Queensland Government Statistician's Office, 2014). This is particularly true as visual observations were made.

The format of the questionnaire was selected to obtain a ‘broad picture’ of the group of teachers (Boulton, 2012). It was designed to be both the starting point for inquiry into the teachers’ beliefs about mathematics learning and instructional practices of the research and also the finishing point. By repeating the questionnaire, it was hoped this could assist in the identification of change in teaching beliefs over time (Queensland Government Statistician’s Office, 2014). For some variables, a 12-month period between repeated questionnaires may be appropriate, but this could be a shorter or longer period (Steel & McLaren, 2008). In this case, it was decided to implement the questionnaire at the start and end of the professional learning intervention, which became a 9-month period, spread across a number of school terms.

Self- Reflection on Our Own Models of Teaching Maths
Adapted from John Barell in "Developing Minds"

Name:______________________________ Year Level:_________ Date: __________

Please rate your beliefs and practices using the scale of 1 to 5 on the following items:
5 = Very Often 4 = Often 3 = Sometimes 2 = Seldom 1 = Hardly Ever

PRACTICES	RATING
1. When teaching maths I usually work at or near my desk.	
2. I display examples of students' work in maths around the room.	
3. I group students in different ways during my maths class for instructional purposes	
4. I ask most of the questions during class.	
5. Students pose thought-provoking questions during maths.	
6. Students reflect on their work, progress, and thought processes in maths orally or in writing.	
7. I often ask "How did you arrive at that answer, solution or idea?"	
8. Students spend time working collaboratively in our maths class.	
9. Students support their answers in maths with evidence, giving reasons for their thinking.	
10. I think that maths questions should be marked as either right or wrong.	
11. I model thoughtful behaviour in maths.	
12. I give adequate time to thinking and reflecting in the maths session.	
13. I encourage students to seek alternative ways of approaching problems, interpretations and solutions.	
14. Students spontaneously comment on each others responses and ideas.	
15. We ask questions in class that require complex thought processes.	
16. Students confidently and willingly discuss their thinking in maths.	
17. Students have the opportunity to use a variety of materials to explore concept	
18. Students respond to my questions with short, one or two-word answers.	
19. Covering content and CSF 11 outcomes is one of my major goals.	
20. I use a wide variety of assessment experiences in maths and use the information to drive my teaching.	
21. I am flexible in my lessons, I allow students' questions to divert me form the planned lesson.	
22. One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.	
23. We work to build a community of inquiry in our maths class.	
24. We discuss teaching strategies at unit or staff meetings.	
25. As a staff we work to reach a consensus on what it means to be an effective maths teacher.	

(Barell, 2001)

Figure 4.3: Questionnaire (pre and post) presented to staff.

4.9 Qualitative Data

Qualitative data collection was completed from a number of sources via a number of methods: set questions, detailed observation notes of the triads, and general observations.

4.9.1 Set questions

A set of three questions were provided to all teachers at the beginning of the professional learning intervention:

1. How do you feel about having a mathematics educator work with you?
2. How do you feel about having someone coming to view your teaching?
3. Would you prefer to attend external professional learning?

The questions were provided at the start of the professional learning intervention, which was at the beginning of the first full-day session of professional learning. Teachers were provided with as much time as they required to complete the questions. The questions were created by the researcher and provided to the staff. After Week 1 of the professional learning intervention, a follow-up question was emailed to all staff by the researcher and teachers responded via email.

4. After the first week working with the mathematics educator, how do you feel about the professional learning intervention?

The purpose of the questions was to collect some general feedback specifically around how the participants felt about having someone working in their classrooms. This was different from the questionnaire, which collected data about teachers' perceptions about their own mathematics teaching. Open-ended questions were used as the aim was not to restrict answers or make comparisons but to allow participants to share as much or as little as they wished, and perhaps something that was not anticipated (Farrell, 2016).

4.9.2 Observations

For each triad interaction, notes were taken in each of the sessions conducted. Observation notes refer to the notes taken while viewing the teacher lessons in the triad model. Notes refer to the data collected from discussions, meetings, and other experiences such as team teaching. These included the half-hour discussion before and after a teaching session. The notes in these sessions between the teacher and the mathematics educator were generally dot point to allow the discussion to flow.

These notes were expanded on later in the day. They also consisted of recording the teacher's goals, both project and lesson.

The observation notes during classroom teaching were two-fold: one aspect collected detail around the goal set by the teacher for the lesson observation and the other noted any activity or moment of interest. The notes after the peer-observed lesson moved back to dot point format. The notes were then expanded on as soon as possible after each triad intervention. The collection of the notes took place in the natural setting of the school (Cohen & Manion, 1994). The teaching component of the professional learning model used targeted (guided) observation, where the observer looked for a specific teaching or classroom behaviour (Anderson, Barksdale, & Hite, 2005), such as questioning techniques, during the class.

Initially, my observation notes of the teaching experiences were unstructured, but by the end of the first triad intervention, I became overwhelmed by the extent of detail. I then developed a template, used for each observation, which recorded the lesson goal, the timing, and two columns for observation comments (see Figure 4.4). The timing aspect proved to be useful during the triad discussions after the teaching experience. The targeted observations column was used for the result of the lesson goal, and the general observations column was used for anything else observed, such as displaying of student work around the classroom.

Lesson goal:

Timing	Targeted observation	General observations

Figure 4.4: Observation template.

There were two purposes for the detailed notes. Initially, they helped to keep and maintain a record of what was happening during the professional learning intervention, which was used for reporting back to the school and the AGQTP funding body, and second, they were used to add detail into the teacher stories, because 'at the heart of every case study lies a method of observation' (Cohen & Manion, 1994, p. 107), adding depth to the quantitative data.

General notes were also taken for activities outside the triad intervention. Notes were made when extra visits were made to classes, when modelled lessons were taught, or meetings were attended. The observation notes on the extra class visits were similar to the peer-observed lessons. The notes on the modelled lessons were a recount and personal reflection, as I was the one conducting the model lesson. This was also the result when notes were recorded of team taught lessons. Notes made at staff meetings used the general format of meeting minutes with detail and were only collected if relevant to the project, such as when discussing teaching and learning strategies, but day-to-day reminders to staff about activities outside the project such as sports were not.

4.9.3 Reflective journal

My role in the professional learning intervention was multifaceted. I was the mathematics educator, a partner teacher, a designer of the intervention, and a researcher–participant. To develop my understanding of my own personal learnings, I maintained a researcher journal. This was reflective in nature. I reflected on what was happening during the intervention, as well my reactions, learnings and development throughout the process. The researcher journal was used in the development of Chapter 7, and informed both the discussion and self-reflection.

4.10 Ethical Considerations and Dilemmas

Ethics approval was sought from and granted by La Trobe University (Appendix 1) and the Department of Education and Training, Victoria. Letters of request to research were sent to the principal and the teachers (Appendix 2) with a plain language statement (Appendix 3) and signed letters of consent were collected from the principal and teachers.

A number of ethical considerations and dilemmas were considered in relation to the study. Participants were provided with the option of not completing any question or questionnaire at the beginning of the professional learning intervention. Anonymity of the questionnaire was preserved by de-identifying the questionnaires and allocating participants a number. This was used for matching between the pre and post intervention data collection. Participants were made aware of this at the time of completion.

It is acknowledged that the topic of mathematics teaching can be a sensitive one, particularly if individual teachers felt their own mathematical knowledge was being challenged, and participants were provided with the opportunity not to complete the questionnaires or rank any particular statement they felt were an issue. Some teachers chose not to respond to some of the questions and chose not to rate some of the statements of the questionnaire, and this is seen in the data in Chapter 5.

For each of the triad sessions, participants were asked permission to allow me to record notes and observations, and they always had the option of not permitting the data to be collected. In some of the discussions where personal information was divulged, this was not recorded. As the project advanced, teachers became more familiar with the structure and the mathematics educator as the researcher. The discussions were more open and extra care was taken to ensure teachers were aware they could still opt for notes and observations not to be collected as teachers were reminded at the beginning of each of their triad interventions that notes were being recorded. In all presentations of data, the data are de-identified and pseudonyms are used for the presentations of the teacher stories. The principal and school are de-identified for reporting.

4.11 Limitations

A number of limitations around the data collected are included at this point, and overall project limitations are discussed in Chapter 9. The main limitation is that the sample size is small, only 10 teachers. Each of the quantitative and qualitative instruments and data limitations are discussed separately.

The questionnaire was developed from Barell (2001) and was found to be useful at the time. It may now be considered to have poor layout or sequencing (Queensland Government Statistician's Office, 2014). This could have been overcome with testing of the questionnaire at a different location prior to implementation at the school. Throughout the time of the research, technology significantly developed, and now a similar questionnaire could be delivered online, improving general presentation and user experience. Being a self-completing questionnaire, it is acknowledged there was the risk of participants not completing some of or the entire questionnaire. There was also no opportunity to clarify answers. The advantage of using a questionnaire is that it eliminates interview errors (Queensland Government Statistician's Office, 2014).

The set questions were not developed with any particular methodology in mind at the time and may be considered too open ended. They were not trialled prior to implementation, so expected responses could not be anticipated. The nature of the responses ranged from one or two words to paragraphs, which meant they were difficult to collate and use for comparison purposes.

Observation notes can be a valuable supplement to questionnaire data; however, these results are not representative of a teaching population as a whole (Queensland Government Statistician's Office, 2014). It is also possible that I made assumptions, misunderstood, or mis-recorded comments (Queensland Government Statistician's Office, 2014), as I was trying to focus on what teachers were saying and attempting to record details simultaneously. I was reluctant to halt discussion to make notes, as this would have altered the flow. This could be minimised by learning more about fieldwork prior to the interviews.

The development of the teacher stories is limited to what I, as the researcher, chose to select and say, and in this case, I become the 'primary instrument of data collection and analysis' (Marriam, 2009, para. 5). Another limitation of such stories are they are often single cases, which is often seen to be too specific to be relevant to other contexts (Burbank & Kauchak, 2003; Cohen & Manion, 1994). It is argued that such stories are important and provide an illustrative example of the complex and challenging nature of researching and reporting on activities and interactions occurring in a classroom environment. They provide the story of what the data are attempting to show.

4.12 Trustworthiness and Transferability

Trustworthiness requires the study to persuade the audience and me that the findings of the inquiry are worth taking note of or paying attention to (Siegle, n.d.), and as I had elements of quantitative and qualitative research, this required aspects such as validity, credibility, and transferability.

The multimethod approach to collecting quantitative and qualitative data in contrast to a single method provided the opportunity to triangulate the data (Cohen & Manion, 1994). All data collected from the questionnaire were used in the comparison exercise, and these were included in the use of Shulman's (1986b) framework analysis. The developed teacher stories were created to illustrate aspects that the quantitative data could not show, so only a small selection was utilised in the development of the stories, and the stories demonstrate the main aspects of the teachers' learning experience. Some of the observation data and notes are used throughout the thesis to illustrate particular points. The aim of using both qualitative and quantitative data was to explore the complexity of teacher behaviour from a number of viewpoints. This meant replicating the study, and results may be problematic, particularly as this study was looking for teacher change; what activities or experiences are effective for one person may not be effective for another (Timperley, 2008). The strength of the intervention was the ability to structure the learning to each teacher's needs; however, the challenge was then how to collect data and report on them.

4.13 Concluding Comments

This chapter presented the methodology and methods used in investigating teacher change through professional learning around the teaching of primary mathematics. The first section was introductory. The second section of the chapter restated the research aims and questions. The third section described the research approach, acknowledging that classrooms are complex environments to research in, and the many components of this professional learning intervention make it an even more challenging task. The research was identified under the umbrella of interpretive research with aspects of design research located within classrooms. The fourth section described the data collection process and the participants of the study. Reliability and validity were then discussed before describing the instruments and process of collecting qualitative and quantitative data. The chapter then presented aspects of ethics, limitations, trustworthiness, and transferability before concluding.

Chapter 5 presents the findings of the study.

CHAPTER 5: FINDINGS MAKING COMPARISONS

Chapter 4 presented the methodology for the study, identifying it as design research as a subsection of interpretative research. It provided detail about the quantitative and qualitative data collection. This chapter presents the quantitative data and their interpretation by making comparisons between pre and post intervention data collection ratings for each of the statements, and between teachers' pre and post intervention data collection ratings.

5.1 Introduction

The questionnaire consisted of 25 statements, which participants rated on a 5-point Likert scale ranging from 1 = *Hardly ever* to 5 = *Very often* and is presented in Section 4.2. The same questionnaire was used for both the pre and post intervention data collection. Section 5.2 presents the pre and post intervention raw data and the justification for moving to a comparative analysis. One of the aims of the research was to investigate whether the utilised professional learning model would leads to change in teacher practice. This chapter explores this in a number of ways. Shulman's (1986a) framework is used to group the questionnaire statements. Then a comparison of the pre and post intervention data collection ratings of each statement as side-by-side column graphs with commentary is presented. Each individual teacher's ratings to the pre and post intervention data collection, also as side-by-side column graphs and summary, is provided. Concluding statements are made drawing these analyses together.

5.2 Pre intervention data collection

Teachers completed the ratings to the statements of the questionnaire on a hard copy. The ratings were collated using Microsoft Excel. Data were organised and de-identified (Table 5.1) with teachers allocated a number 1 to 10 for matching purposes between the pre and post intervention data collection.

Table 5.1 presents the pre intervention data collection ratings of each of the statements. These ratings were collected on the first day the professional learning intervention was introduced. This was a starting point to the intervention. As discussed in Chapter 4, teachers were provided the option of not rating any of the statements or even completing the questionnaire at all.

Table 5.1: *Pre Intervention Data Ratings by Each Teacher Against Each Statement*

		Teacher									
Statement Number	**Statement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	When teaching maths I usually work at or near my desk.	1	1	2	1	3	1		1	1	1
2	I display examples of students' work in maths around the room.	5	3	3	4	3	3	5	3	5	3
3	I group students in different ways during my maths class for instructional purposes.	4	5	3	4	5	3		3	4	3
4	I ask most of the questions during class.	4	5	4	3	4	4	4	4	4	4
5	Students pose thought provoking questions during maths.	2	2	3	3	4	3	2	3	3	3
6	Students reflect on their work, progress, and thought processes in maths orally or in writing.	3	4	3	3	4	4		3	3	3
7	I often ask 'How did you arrive at that answer, solution or idea?'	3	5	4	4	5	5	3	4	2	3
8	Students spend time working collaboratively in our maths class.	4	4	4	4	4	4	5	5	4	4
9	Students support their answers in maths with evidence, giving reasons for their thinking.	3	4	3	3	4	5		4	2	3
10	I think that maths questions should be marked as either right or wrong.	3	1	2	3	2	2	4	2	3	3
11	I model thoughtful behaviour in maths.	4	4	3	4	4	5	3		3	3
12	I give adequate time to thinking and reflecting in the maths session.	3	4	2	3	5	4		4	3	3
13	I encourage students to seek alternative ways of approaching problems, interpretations and solutions.	4	4	4	4	5	5		4	3	3
14	Students spontaneously comment on each others responses and ideas.	2	2	3	3	4	3	5	4	2	3
15	We ask questions in class that require complex thought processes.	3	4	3	3	4	4		5	3	3
16	Students confidently and willingly discuss their thinking in maths.	3	3	4	3	3	3		3	2	4
17	Students have the opportunity to use a variety of materials to explore concepts.	5	5	4	3	3	3	4	4	4	4
18	Students respond to my questions with short, one or two-word answers.	4	1	3	3	3	3	4	3	4	3
19	Covering content and CSF II outcomes is one of my major goals.	0	5	3	4	3	3	3	5	3	4
20	I use a wide variety of assessment experiences in maths and use the information to drive my teaching.	5		4	4	4	4	3	4	4	3
21	I am flexible in my lessons, I allow students' questions to divert me from the planned lesson.	4		3	4	5	5	3	2	5	3
22	One of my goals is ensuring that students understand and can apply mathematical concepts to life experienc	4	5	4	4	4	5	5	5	4	3
23	We work to build a community of inquiry in our maths class.	0	0	3	4	3	5		4	3	4
24	We discuss teaching strategies at unit or staff meetings.	5	3	3	4	4	3	1		3	3
25	As a staff we work to reach a consensus on what it means to be an effective maths teacher.	4	4	3	4	5	3		2	2	3

As shown in Table 5.1, all teachers completed the questionnaire. Seven teachers rated all statements 1 = *Hardly ever* to 5 = *Very often*. Teacher 7 had the lowest rating response of the group, not rating 10 of the statements. Statement 3 had the lowest number of ratings with three teachers not rating the statement.

Initially, rather than performing a numerical statistical analysis, I had decided to graph each of the statements against the ratings as column graphs, as the ratings were discrete, and provide commentary. This was to visually present the teachers' ratings to each of the statements, summarising the data and providing a process to look for trends. Figure 5.1 presents the pre intervention data collection for Statement 23.

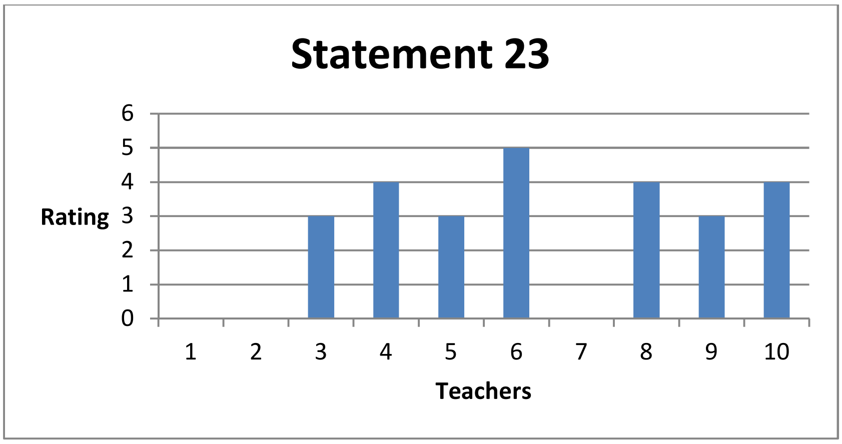

Figure 5.1: Pre intervention data collection Statement 23: We work to build a community of inquiry in our maths class.

Statement 23 had the least number of responses, pre intervention, with three teachers choosing not to rate this statement. In Figure 5.1, three teachers rated the statement 'We work to build a community of inquiry in our maths class' as *sometimes*, three teachers selected the rating *often,* and one *very often*. 'Community of inquiry' (Garrison, Anderson. & Archer, 2010) is a specific phrase, and one possible reason for teachers not responding is they may not be familiar with the term or have an understanding of how this applies to their classroom.

I completed this process of graph and commentary for each of the statements of the pre intervention data collection. This provided a visual representation of the collected data but not a story of what was happening.

5.3 Post Intervention Data Collection

At the end of the professional learning intervention, the same questionnaire was administered on the final day of the professional learning. As with the pre intervention data collection, teachers completed the ratings on a hard copy of the questionnaire. The ratings were collated using Microsoft Excel and a table of the data was created (Table 5.2). Teachers were again provided with the option of not rating some or all of the statements.

Table 5.2: *Post Intervention Data Collection Ratings by Each Teacher Against Each Statement*

		Teacher									
Statement Number	**Statement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	When teaching maths I usually work at or near my desk.	1	1	2	1	3	1	1	1	1	1
2	I display examples of students' work in maths around the room.	5	3	4	3	4	4	5	4	4	3
3	I group students in different ways during my maths class for instructional purposes.	4	5	3	4	4	3	3	4	4	3
4	I ask most of the questions during class.	2	5	3	3	5	4	4	4	3	3
5	Students pose thought provoking questions during maths.	3	4	3	3	4	3	3	3	4	4
6	Students reflect on their work, progress, and thought processes in maths orally or in writing.	5	4	3	4	3	4	3	4	4	4
7	I often ask 'How did you arrive at that answer, solution or idea?'	4	5	4	4	4	5	3	4	3	3
8	Students spend time working collaboratively in our maths class.	4	4	4	4	4	4	4	5	4	4
9	Students support their answers in maths with evidence, giving reasons for their thinking.	4	4	4	4	5	5	3	4	4	4
10	I think that maths questions should be marked as either right or wrong.	3	1	2	2	3	3	3	2	3	2
11	I model thoughtful behaviour in maths.	4	5	4	4	5	4	3	2	4	4
12	I give adequate time to thinking and reflecting in the maths session.	5	4	4	4	4	4	3	4	4	4
13	I encourage students to seek alternative ways of approaching problems, interpretations and solutions.	5	4	4	4	4	4	3	4	4	3
14	Students spontaneously comment on each others responses and ideas.	4	4	3	3	4	4	4	3	4	4
15	We ask questions in class that require complex thought processes.	4	4	4	4	4	4	3	4	3	4
16	Students confidently and willingly discuss their thinking in maths.	4	4	4	3	4	4	3	4	4	4
17	Students have the opportunity to use a variety of materials to explore concepts.	5	5	4	4	4	4	4	4	4	4
18	Students respond to my questions with short, one or two-word answers.	2	2	3	3	3	2	3	2	3	4
19	Covering content and CSF II outcomes is one of my major goals.	4	4	3	3	4	3	3	3	3	4
20	I use a wide variety of assessment experiences in maths and use the information to drive my teaching.	5	3	4	4	4	3	4	3	4	3
21	I am flexible in my lessons, I allow students' questions to divert me from the planned lesson.	3	5	4	4	5	4	4	2	4	4
22	One of my goals is ensuring that students understand and can apply mathematical concepts to life experienc	4	4	5	4	5	5	5	4	5	4
23	We work to build a community of inquiry in our maths class.	4	4	4	4	4	4	4	4	4	3
24	We discuss teaching strategies at unit or staff meetings.	5	4	4	4	4	3	2	3	3	3
25	As a staff we work to reach a consensus on what it means to be an effective maths teacher.	4	4	4	3	4	4	3	3	4	4

All teachers rated all statements in the post intervention data collection, as shown in Table 5.2. Again, I graphed each statement against each rating as a column graph (Figure 5.2) and provided a commentary. Figure 5.2 presents the post intervention data collection for Statement 23.

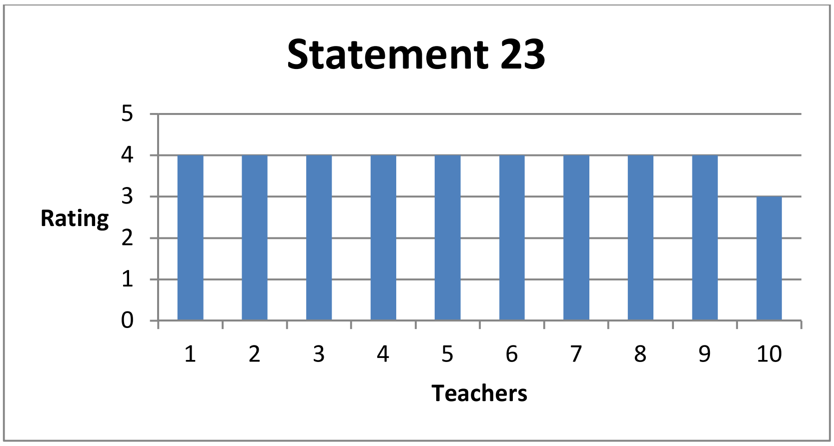

Figure 5.2: Post intervention data collection Statement 23: We work to build a community of inquiry in our maths class.

For Statements 23 all teachers except one rated the statement as *often*, post intervention. One teacher rated this as *sometimes*. This perhaps shows a more consistent understanding across the staff about the phrase ‘community of inquiry’ and how this can be applied to their mathematics classes.

Although the graphs of Figures 5.1 and 5.2 are informative, it is not the individual graphs and commentaries that tell the story, it is when the rating responses to the pre and post intervention data collection are compared that change can be clearly observed. I moved the single graphs to Appendix 4 and decided on a comparative process. I decided to graph each of the statements still using column graphs but placing the pre and post intervention data collection for each of the statements on the same graph, which would allow for comparison to be made.

There are 25 statements in the questionnaire, and I felt that even if a comparison were completed between the pre and post intervention data collection, it would be difficult to investigate whether any change was observed in any single area of teaching such as pedagogical knowledge or content knowledge. I therefore selected a framework by which to group the statements. The framework I selected was Shulman’s (1986b) six key elements of PCK.

The next section of this chapter presents Shulman's (1986b) framework and the comparison process undertaken. The comparison graphs are then presented with commentary. Included with the commentary is any comment about the statement itself, which may have resulted from the initial analysis of the single graphs (Appendix 4).

5.4 Using the Results

The purpose of the questionnaire was to collect teachers' perceptions about their own mathematics teaching. Two analyses are completed on the collected data.

The first analysis used Shulman's (1986b) identified six key elements of PCK (knowledge base) to group the statements. This grouping is shown in Table 5.3. Then, side-by-side column graphs were created presenting the pre and post intervention data collected for each statement. These were analysed, looking for change in the ratings. Changes in the ratings were noted within the context of the statement; whether any change was an increase or decrease was not identified, but this can clearly be seen from the graphs. Using these comments, change was examined across the group. The aim was to seek evidence of change.

The second analysis used side-by-side column graphs to present pre and post intervention data collection ratings for each individual teacher. This was to examine whether all, some, or only one teacher demonstrated change in their ratings from pre to post intervention data collection. Comments were noted for each of the teachers.

In both cases, a change was being looked for rather than an increase or decrease in rating. 'The process of teacher change . . . may be demonstrated in quite different ways by different teachers' (Brown & Renshaw, 2007, p. 99). It could be argued that a decrease in rating may be a positive outcome such as in Statement 1, 'When teaching maths I usually work at or near my desk'. On the other hand, an increase in rating may be an indication of deeper self-awareness as a result of the professional learning intervention. Conversely, with Statement 5, 'Students pose thought-provoking questions during maths', an increase in rating may be seen as a positive outcome, but a decrease in rating may indicate a deeper analysis of the types of questions students were asking during a mathematics class. Thus, a change rather than a direction was being sought in the analyses.

Although the process of comparing collected data is straightforward, there are a number of threats in completing analysis in this manner. The comparison presents a large amount of detail examining teacher ratings to each of the statements and then compares the ratings of each statement for each individual teacher. This can be viewed as both a strength and a weakness. As the data was collected at two different points in time, participants may have changed in different ways, and so any change in ratings may have occurred as a result of the professional learning intervention or for other reasons (Cohen & Manion, 1994). It would be almost impossible to replicate the results in the study or externally at another location due to the design nature of the professional learning intervention and research.

A threat to any study where measures are applied to a nonrandom sample is the statistical phenomenon regression to the mean (Trochim, 2006). In this analysis, it is possible that this occurred, as regression to the mean is a group-based phenomenon and a relative one. In this study, I not only selected my 'success' stories when making comparisons but also included all data for all teachers at the school. I was interested in observing any change, rather than an overall pattern or trend, although these will be mentioned. The process of analysing the comparison graphs was used as one form of evidence in evaluating whether the professional learning intervention led to change in teacher practice.

5.5 Grouped Data Analysis—Statement Analysis

Shulman's (1986b) work identifying six key elements of PCK (knowledge base) was used to group the statements for further analysis. These elements are:

> (1) Knowledge of representations of subject matter (content knowledge);
>
> (2) Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter;
>
> (3) General pedagogical knowledge (or teaching strategies);
>
> (4) Curriculum knowledge;
>
> (5) Knowledge of educational contexts; and
>
> (6) Knowledge of the purposes of education. (Shulman, 1986b, p. 4)

The statements from the questionnaire were grouped by the six element categories as shown in Table 5.3. This was completed by cutting up the questionnaire into individual statements and sorted into groups. These were left for a week then revisited, and some of the statements were moved around. While it is acknowledged this process could have been completed many times with varying combinations of the statements, a set of groupings had to be settled on for this study.

The statement groupings for each element were used to organise the comparison graphs shown in the sub-sections of Section 5.5. Side-by-side column graphs presenting both pre and post intervention data collection ratings for the teachers are used to display the data visually for each of the statements. Commentary is provided for each of the graphs and then further commentary is made for each grouped element. It is acknowledged that a large number of graphs may appear repetitive; however, they have been included to examine any change as a result of the professional learning intervention. I feel that any change is worth noting, and this is done in the context of the professional learning intervention.

Table 5.3: *Grouped Elements Based on Shulman's (1986b) Work Identifying Six Key Elements of Pedagogical Content Knowledge*

Element Number	Element	Statement Number	Statement
1	Knowledge of representations of subject matter (content knowledge)	10	I think that maths questions should be marked as either right or wrong.
2	Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter	3	I group students in different ways during my maths class for instructional purposes.
		5	Students pose thought-provoking questions during maths.
		6	Students reflect on their work, progress, and thought processes in maths orally or in writing.
		7	I often ask 'How did you arrive at that answer, solution, or idea?'
		9	Students support their answers in maths with evidence, giving reasons for their thinking.
		13	I encourage students to seek alternative ways of approaching problems, interpretations, and solutions.

		16	Students confidently and willingly discuss their thinking in maths.
		18	Students respond to my questions with short, one- or two-word answers.
3	General pedagogical knowledge (or teaching strategies)	1	When teaching maths I usually work at or near my desk.
		2	I display examples of students' work in maths around the room.
		4	I ask most of the questions during class.
		8	Students spend time working collaboratively in our maths class.
		11	I model thoughtful behaviour in maths.
		12	I give adequate time to thinking and reflecting in the maths session.
		14	Students spontaneously comment on each other's responses and ideas.
		15	We ask questions in class that require complex thought processes.
		17	Students have the opportunity to use a variety of materials to explore concepts.
		20	I use a wide variety of assessment experiences in maths and use the information to drive my teaching.
		21	I am flexible in my lessons; I allow students' questions to divert me from the planned lesson.
4	Curriculum knowledge	19	Covering content and CSF 11 outcomes is one of my major goals.
5	Knowledge of educational contexts	23	We work to build a community of inquiry in our maths class.
		24	We discuss teaching strategies at unit or staff meetings.
6	Knowledge of the purposes of education	22	One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.
		25	As a staff, we work to reach a consensus on what it means to be an effective maths teacher.

This section now presents each element in order, with the accompanying statement, graph, and commentary.

5.5.1 Element 1: Knowledge of representations of subject matter (content knowledge)

Figure 5.3 presents Statement 10, 'I think that maths questions should be marked as either right or wrong' and it is the only statement included in this element.

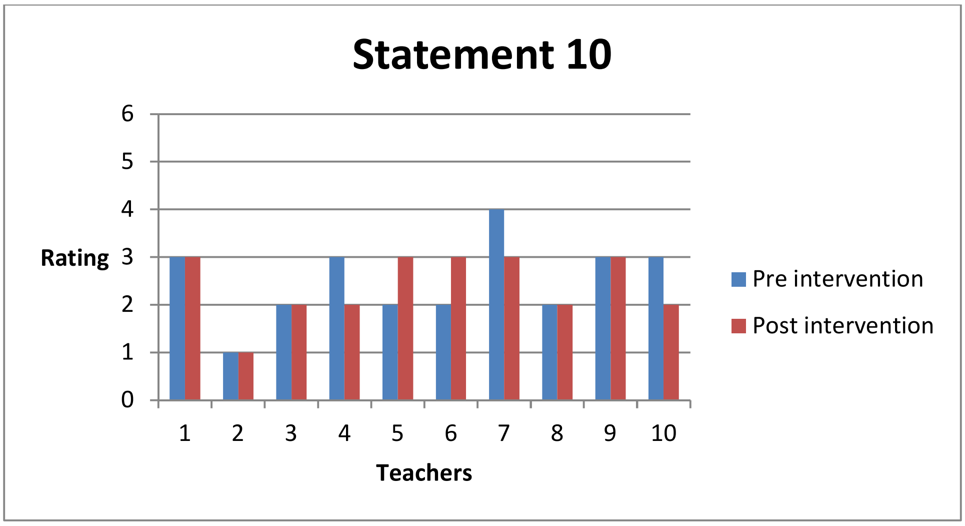

Figure 5.3: Statement 10: I think that maths questions should be marked as either right or wrong.

Pre intervention, the ratings for Statement 10 ranged from *hardly ever* to *often*. Post intervention, the range is *hardly ever* to *sometimes*, a small shift. Change is observed in half the teacher ratings for Statement 10. Five ratings remained the same. Change may have resulted from the discussions within the triads about the value of the answer in mathematics, or the value of process, or even both. Some of the modelled classes included activities that did not arrive at a single answer, placing value on the process and discussion such as a problem-solving task involving football jumpers. This was reinforced during the triads with some teachers focusing on using questions and prompts that may arrive at different responses or encouraging students to explore different processes to arrive at the same answer.

5.5.2 Element 1: Summary

In summary, five teachers changed their ratings, perhaps as a result of the professional learning intervention where different learning tasks were explored and trialled by teachers in the classes of both the modelled lessons and the triad experiences.

5.5.3 Element 2: Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter

Eight statements are included in this element, making it a broader category. Figure 5.4 presents Statement 3: 'I group students in different ways during my maths class for instructional purposes.'

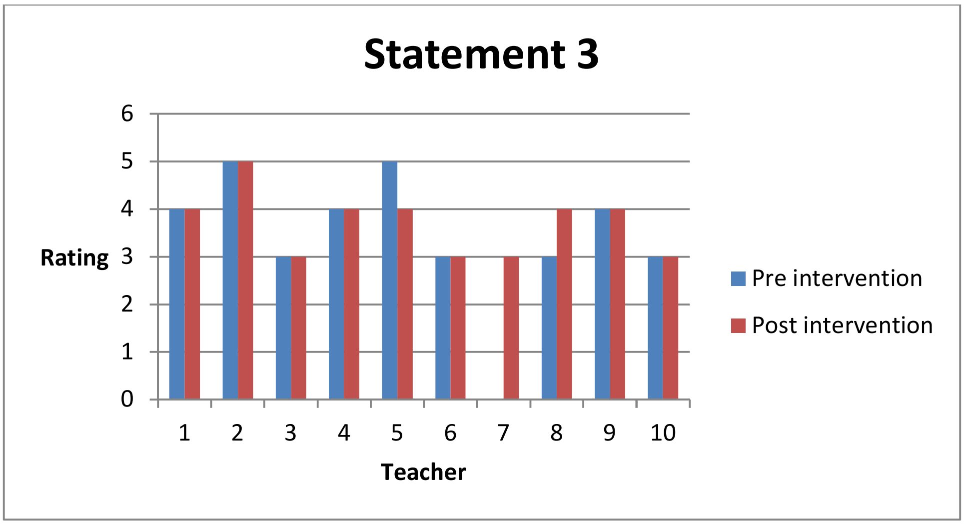

Figure 5.4: Statement 3: I group students in different ways during my maths class for instructional purposes.

Pre intervention, the ratings for Statement 3 ranged from *no response* to *very often.* Post intervention, the range is *sometimes* to *very often*. Change is observed in two of the teacher ratings. The statement itself allows for a varied interpretation by different teachers when considering different ways of grouping. This may include groupings of mixed or like ability, or differently sized groups, or with groups of different focus. The change in the teachers' ratings may have resulted from teachers observing other classes and then trying different ways of grouping in their own classes. In the triads, discussion about different methods for groupings were shared, such as assigning students numbers and then grouping the students with common numbers together, or providing students with parts of a 'jigsaw' shape for them to form that then led to the creation of the group, were among some of the ideas.

Figure 5.5 presents Statement 5: 'Students pose thought-provoking questions during maths.' It is the second statement of Element 2.

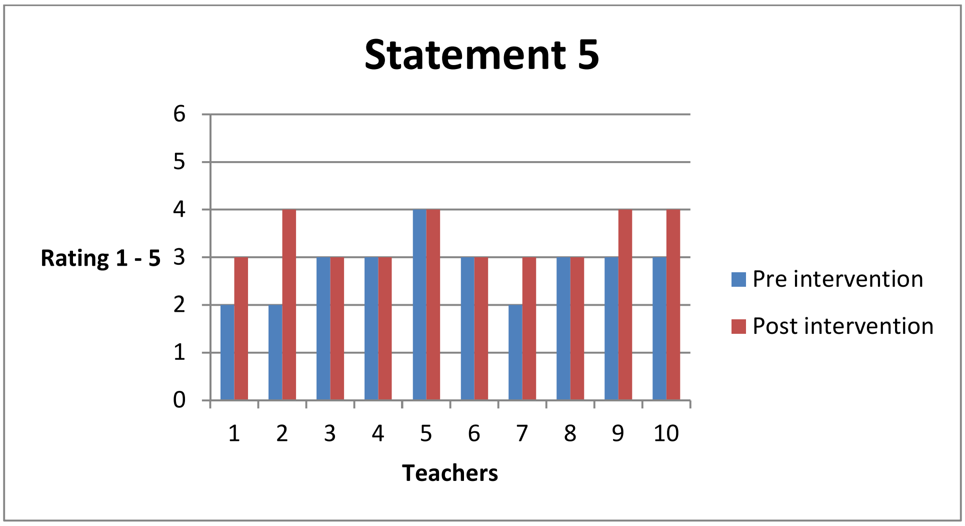

Figure 5.5: Statement 5: Students pose thought-provoking questions during maths.

Pre intervention, ratings for Statement 5 ranged from *seldom* to *often*. Post intervention, the range is *sometimes* or *often.* Half of the teacher ratings changed between the pre and post intervention data collection. One teacher showed a jump across two ratings *seldom* to *often*. Questioning was a focus of the professional learning intervention both at staff and unit meetings, and by individual teachers through their teaching and observation experiences in the triads. This exploration of students asking questions may have led to change. It may have also resulted from teachers analysing the different types of questions students were asking during the triad experiences. It could be argued, as questioning was a focus during the intervention, more change would be expected.

Figure 5.6 presents the third statement of Element 2, Statement 6: 'Students reflect on their work, progress, and thought processes in maths orally or in writing.'

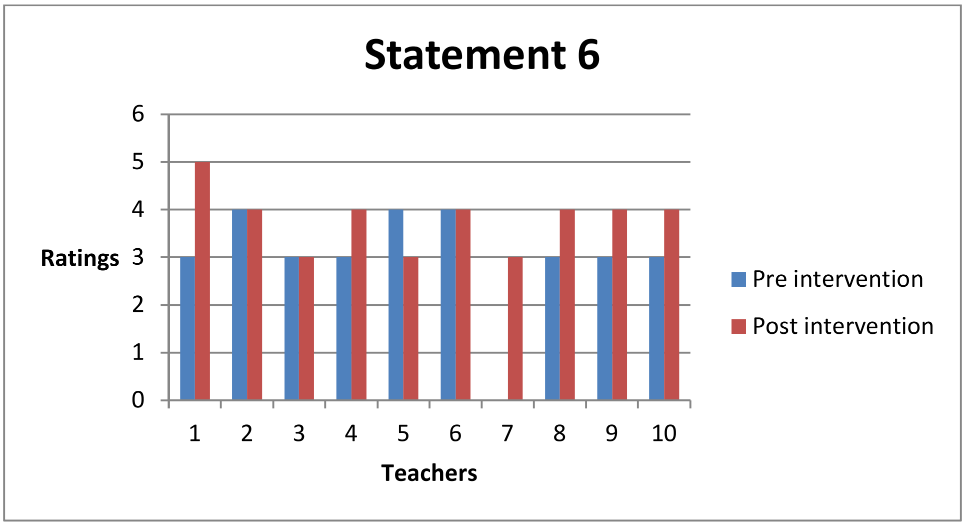

Figure 5.6: Statement 6: Students reflect on their work, progress, and thought processes in maths orally or in writing.

Pre intervention, the ratings for Statement 6 ranged from *no response* to *often.* Post intervention, the range is *sometimes* to *very often* as shown in Figure 5.6. Change is observed in seven of the 10 teacher ratings between the pre and post intervention data collection. More than half the teachers (six) initially indicated they *sometimes* felt students reflected on their work, progress, and thought processes in maths. All these responses except one changed. In Week 3 of the professional learning intervention, there was a focus on reflection at the end of mathematics lessons, and the staff were asked to run, if appropriate, a reflection component in the observed lesson, different to previous observed lessons. A number of teachers had also focused on this as part of the goal setting during the duration of the professional learning intervention. This focus may have led to the change in the ratings between the pre and post intervention data collection. It could also be argued that this is not a significant change in the ratings as this was a school focus, but as mentioned earlier, any change is identified as relevant.

Figure 5.7 presents Statement 7: ‘I often ask ‘How did you arrive at that answer, solution, or idea?’’, the fourth statement of Element 2.

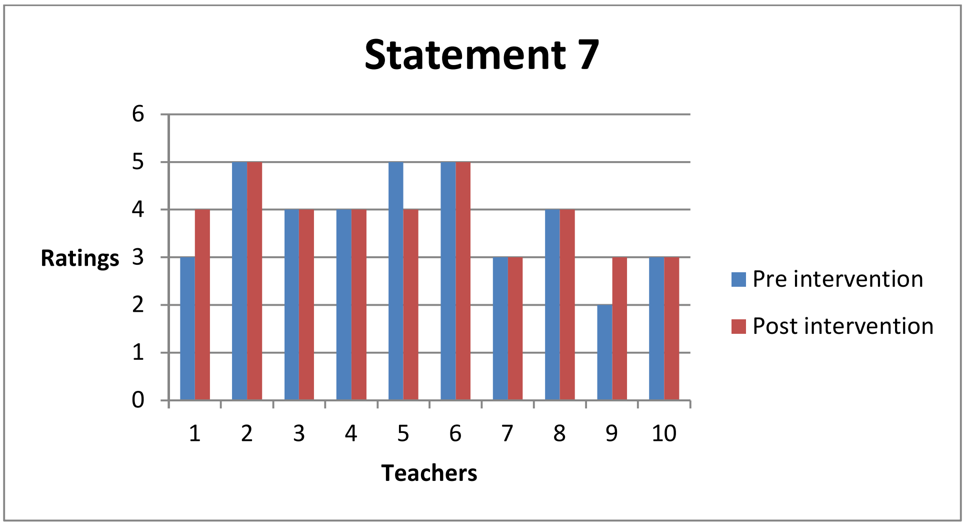

Figure 5.7: Statement 7: I often ask ‘How did you arrive at that answer, solution, or idea?’

Pre intervention, the ratings for Statement 7, ranged from *seldom* to *very often*. Post intervention, the range is *sometimes* to *very often* as shown in Figure 5.7. Change is observed in three of the 10 teacher ratings between the pre and post intervention data collection. This change resulted in a spread of ratings in the post intervention data collection to be either *sometimes*, *often,* or *very often* when considering questioning about how students achieved an answer, solution, or idea. This is a similar spread in post intervention data collection to Figure 5.6: Statement 6, which considered students reflecting on their learning. A small number of teachers focused on questioning during the professional learning intervention. For example, one teacher conducted a graphing lesson with M&Ms, and in the lesson consciously asked students to explain their responses. Other teachers did not focus on this aspect of teaching, and perhaps this is evident in the unchanged responses.

Figure 5.8 presents Statement 9: ‘Students support their answers in maths with evidence, giving reasons for their thinking.’ This is the fifth of the eight statements of Element 2.

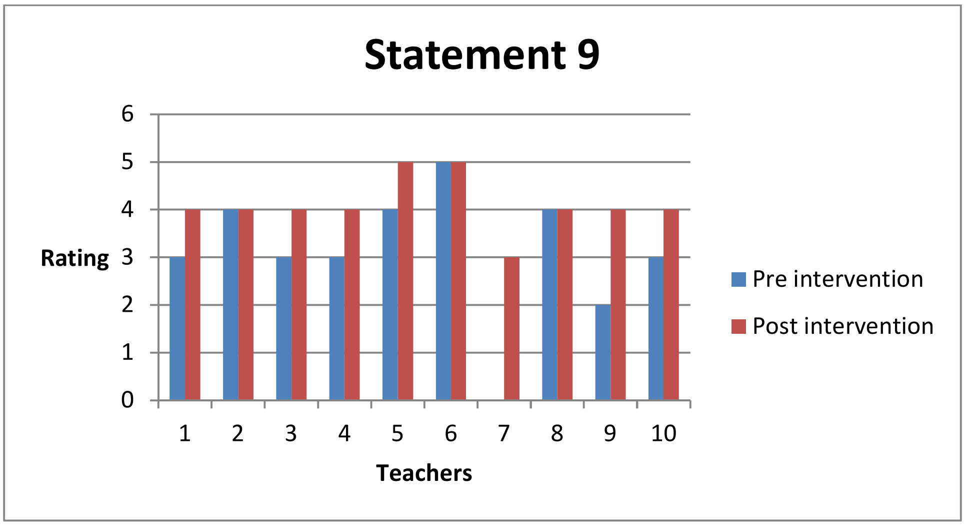

Figure 5.8: Statement 9: Students support their answers in maths with evidence, giving reasons for their thinking.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.8. Change is observed in seven of the 10 teacher ratings between the pre and post intervention data collection. This change resulted in a narrowing of the spread of ratings in the post intervention data collection when considering students supporting their answers in mathematics with evidence and reasoning. It could be argued that this is similar to the spread of ratings of post intervention data collection in Figure 5.6: Statement 6 and Figure 5.7: Statement 7. As mentioned previously, a small number of teachers focused on questioning as part of the personal learning goals during the professional learning intervention. This may have led to the observed changes in the ratings. The discussions in the triads sometimes focused on student thinking and how to identify understanding, so a change in the rating may have been a consequence.

Figure 5.9 presents the sixth statement of Element 2, Statement 9: 'Students support their answers in maths with evidence, giving reasons for their thinking.'

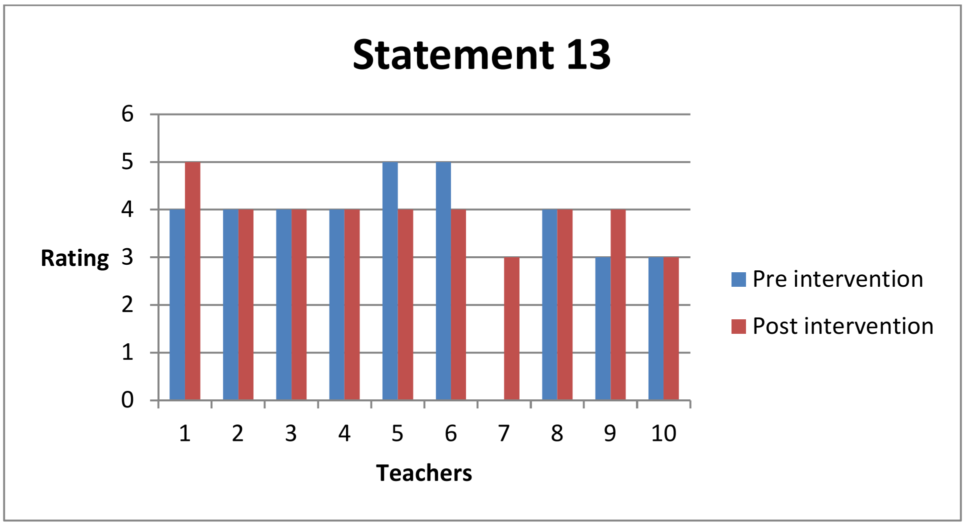

Figure 5.9: Statement 13: I encourage students to seek alternative ways of approaching problems, interpretations, and solutions.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *sometimes* to *very often* as shown in Figure 5.9. Change is observed in half of the teacher ratings. This resulted in a shift in the spread of ratings in the post intervention data collection similar to the previous graphs of this element. During the professional learning intervention, inquiry-based learning was modelled and some teachers developed sessions and trialled them with an inquiry-based approach, such as one on the topic of area. These were observed by the triads. There were also a number of cases where lessons were team taught with the mathematics educator, including a lesson on patterning, where early finishers were encouraged to determine the rules for different patterns. The change in ratings may have occurred due to teachers focusing on attempting inquiry-based learning in their classrooms during the professional learning intervention.

Figure 5.10 presents Statement 16: 'Students confidently and willingly discuss their thinking in maths.' This is the seventh statement of Element 2.

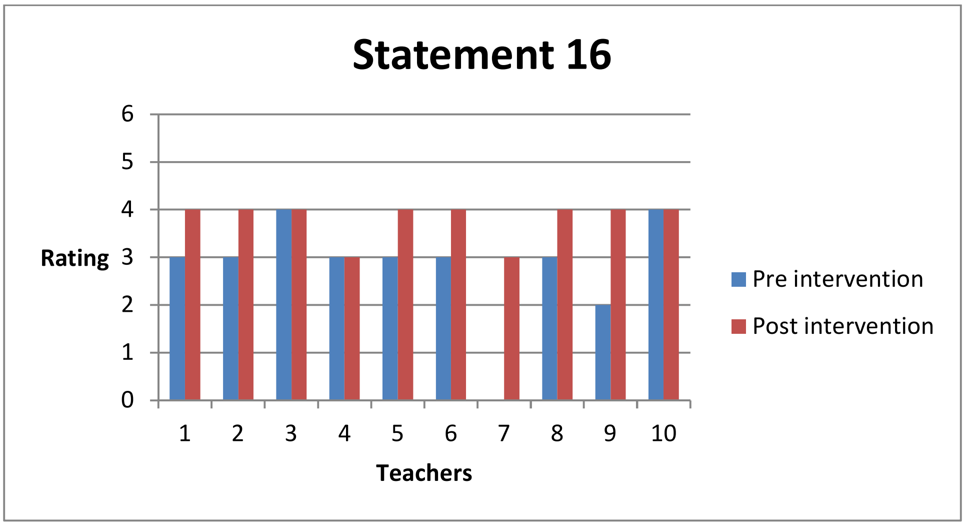

Figure 5.10: Statement 16: Students confidently and willingly discuss their thinking in maths.

Pre intervention, the ratings ranged from *no response* to *often.* Post intervention, the range is *seldom* to *often* as shown in Figure 5.10. Change is observed for seven teachers in their ratings between the pre and post intervention data collection, three teachers remained unchanged when considering the statement about encouraging students to discuss their thinking in mathematics. The post intervention data collection may imply a more consistent staff approach when inviting students to share their thinking in mathematics. These changes are similar to other statements of this element. As part of the professional learning intervention, teachers actively discussed student thinking and how to access this, during both the triad discussions and at unit meetings. This was supported by a focus on reflection on learning in mathematics lessons in Week 3 of the professional learning intervention.

Figure 5.11 presents the final statement of Element 2, Statement 18: 'Students respond to my questions with short, one- or two-word answers.'

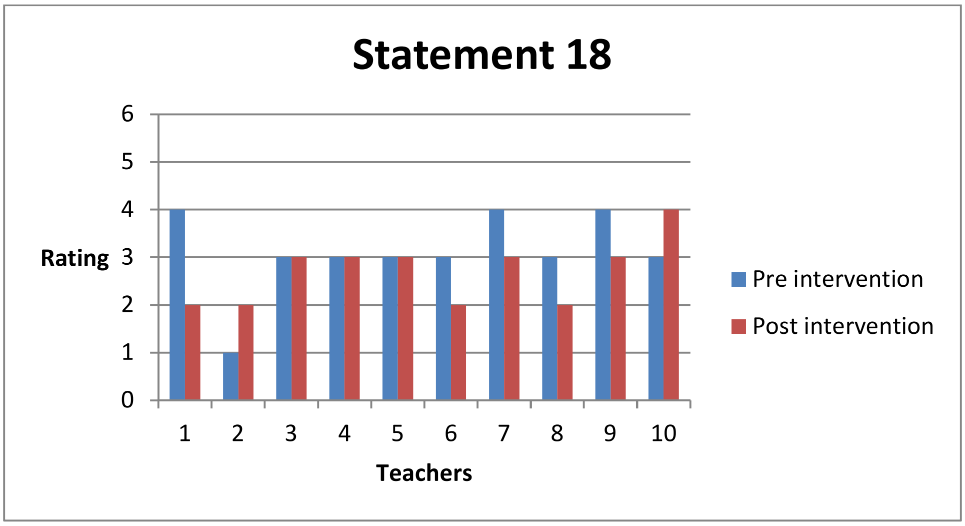

Figure 5.11: Statement 18: Students respond to my questions with short, one- or two-word answers.

Pre intervention the ratings ranged from *hardly ever* to *often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.11. Change is observed in seven of the 10 teacher ratings between the pre and post intervention data collection. A greater change is seen in Teacher 1's ratings of *very often* to *sometimes*, which is a shift of two ratings. During Week 1 of the professional learning intervention, some teachers opted to have their questioning, for example, closed or open, and how their students responded recorded. This was discussed within the triads. One of the observing teachers made the comment, 'I can now see how students are responding to questions' when reflecting after the lesson on their own classes. This analysis and discussion process may have led to some change.

5.5.4 Element 2: Summary

In summary, changes were seen in all seven statements in this element of understanding students' conceptions of the subject and the learning and teaching implications associated with the specific subject matter. The greatest change was seen in the ratings of Statements 6, 9, 16, and 18, which focused on students reflecting about their work and learning, students supporting answers with evidence, students being confident in maths discussions, and how students responded to questioning. All these statements showed at least six changes in teachers' ratings between the pre and post intervention data collection. Statements such as 'Asking probing questions' and 'Encouraging students to seek alternative approaches' showed less change, three and four changes in teachers' ratings, respectively. Statement 3 about grouping students saw the least amount of change in teachers' ratings.

It could be argued that as a number of staff focused on questioning as part of their observed lessons and goals, change could be expected. This change may have been from the observation or discussion component of the triad professional learning model, where teachers could observe questioning in action (Burbank & Kauchak, 2003) and then reflect on this in light of their own situation. It may have also been supported with the multiple triad sessions, which allowed first for data to be collected, then the time between visits allowed for reflection, and subsequent visits provided the opportunity for teachers to target and practice aspects of their teaching. There appears to be some narrowing of the range of ratings in the post intervention data collection, which may indicate a deepening of common understanding across the staff (Atkin, 1996) as they worked together to understand questioning and reflective processes in mathematics.

5.5.5 Element 3: General pedagogical knowledge (or teaching strategies)

This element includes 11 statements, making it the largest category.

Figure 5.12 presents Statement 1: 'When teaching maths, I usually work at or near my desk.'

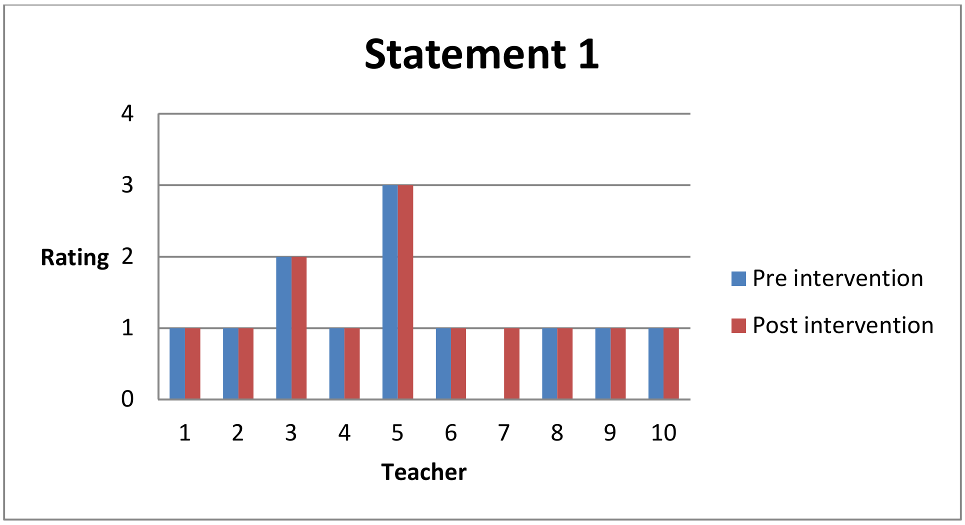

Figure 5.12: Statement 1: When teaching maths, I usually work at or near my desk.

Pre intervention, the ratings ranged from *no response* to *sometimes.* Post intervention, the range is *seldom* to *sometimes* as shown in Figure 5.14. The only change observed in this statement between the pre and post intervention data collection is that one teacher did not initially complete a rating for this statement but for the post intervention data collection indicated that they *hardly ever* worked at or near their desks. All other teachers did not show any change in rating from the pre to the post intervention data collection. Both the *often* and *sometimes* ratings did not change. The location of where a teacher worked in their classroom when teaching mathematics was not explicitly explored during the professional learning intervention. Of the observed lessons, none of the teachers was seen to be sitting at their desk for the duration of the lesson. The statement could be interpreted as 'near' in terms of actual location, and in this school, all teachers' desks were in their classrooms near the front of the room.

Figure 5.13 presents the second statement of Element 3, Statement 2: 'I display examples of students' work in maths around the room.'

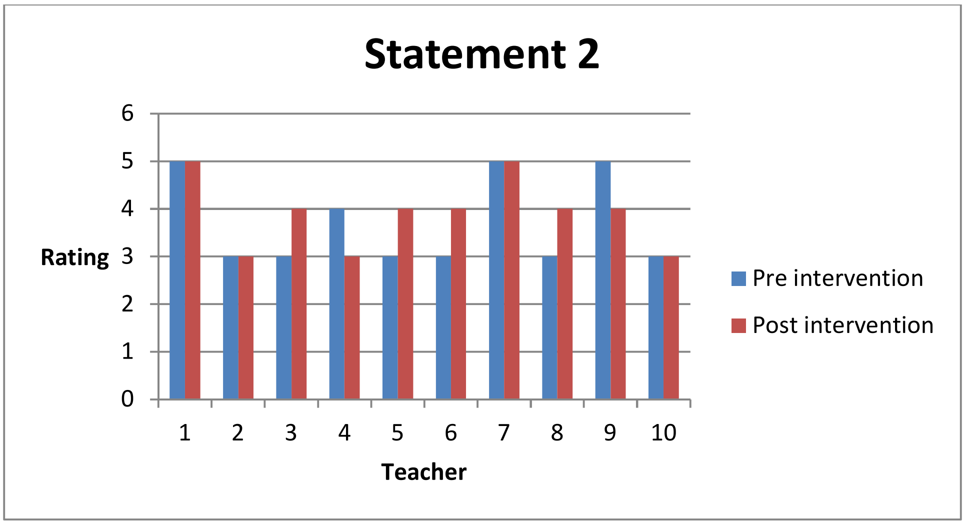

Figure 5.13: Statement 2: I display examples of students' work in maths around the room.

Pre intervention, the ratings ranged from *sometimes* to *very often* and remained the same post intervention as shown in Figure 5.13. Of the 10 initial ratings, six show change between the pre and post intervention data collection in their frequency of displaying students' work in mathematics around the classroom. The importance of displaying students' mathematics work was discussed at one of the staff meetings, as it was noted through observation by the mathematics educator during Week 1 that most classrooms had a large amount of literacy work displayed compared to mathematics. This surprised many of the teachers, and by Week 2 of the professional learning intervention, there was change in the amount of students' mathematics work displayed in a number of the classrooms.

Figure 5.14 presents the third statement of Element 3, Statement 4: 'I ask most of the questions during class.'

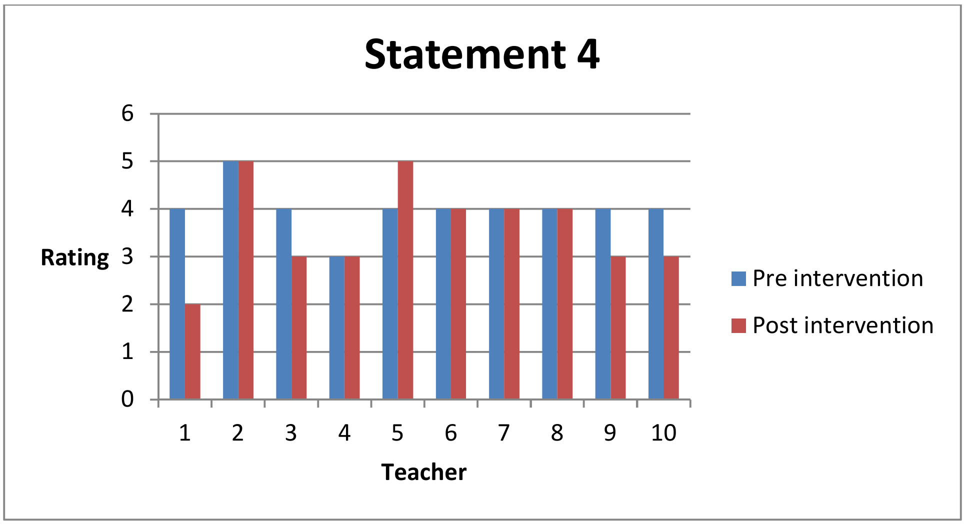

Figure 5.14: Statement 4: I ask most of the questions during class.

Pre intervention, the ratings ranged from *sometimes* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.14. Change is observed in half of the teacher ratings changed between the pre and post intervention data collection when thinking about their own questioning. There is a significant change in Teacher 1's rating from *often* to *seldom*, which is a shift of two ratings. A number of teachers focused on their own questioning as a part of the professional learning intervention, having it as a lesson goal in the peer-reviewed teaching component. Some teachers requested that the observations of the lesson, including recording the types of questioning and who was doing the questioning (teacher or student) during the triad intervention. This was then discussed after the lesson. The time between the visits appeared to allow teachers to reflect on this, and they were then seen attempting different questioning approaches in subsequent professional learning weeks. This increased awareness through peer and mathematical educator feedback may have created the opportunity for teachers to reflect and then change some of their questioning techniques. For some teachers who responded *very often* and *often* initially, no change was observed.

Figure 5.15 presents Statement 8: 'Students spend time working collaboratively in our maths class.' This is the fourth statement of Element 3.

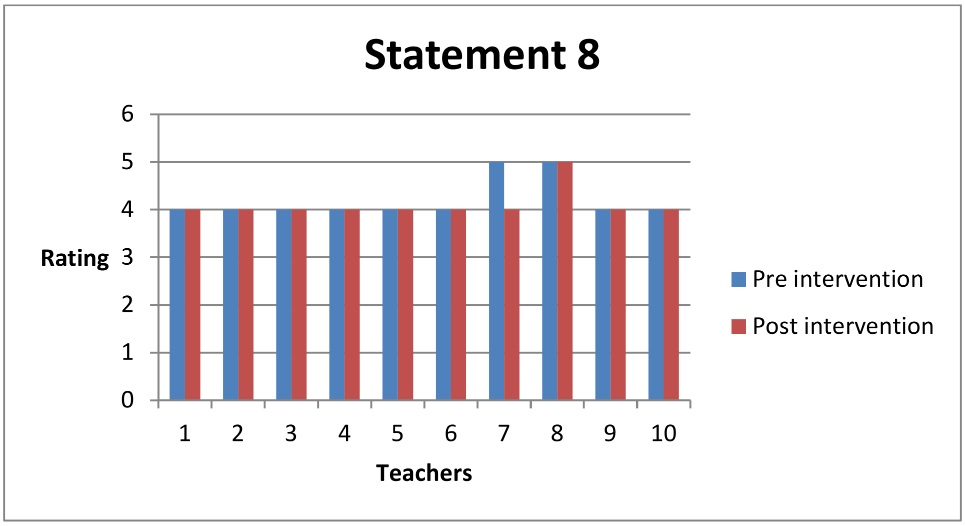

Figure 5.15: Statement 8: Students spend time working collaboratively in our maths class.

Pre intervention, the ratings ranged from *often* to *very often* and remained the same post intervention as shown in Figure 5.15. Only one teacher changed their rating between the pre and post intervention data collection. Prior to the professional learning intervention, the school had a focus on student collaborative learning and it seems teachers had a common understanding of what this is (Atkin, 1996) and how it looks in the classroom. None of the teachers identified this as a personal learning goal for the professional learning intervention, so it could be argued that little change was expected.

Figure 5.16 presents Statement 11: ‘I model thoughtful behaviour in maths.’ This is the fifth statement of Element 3.

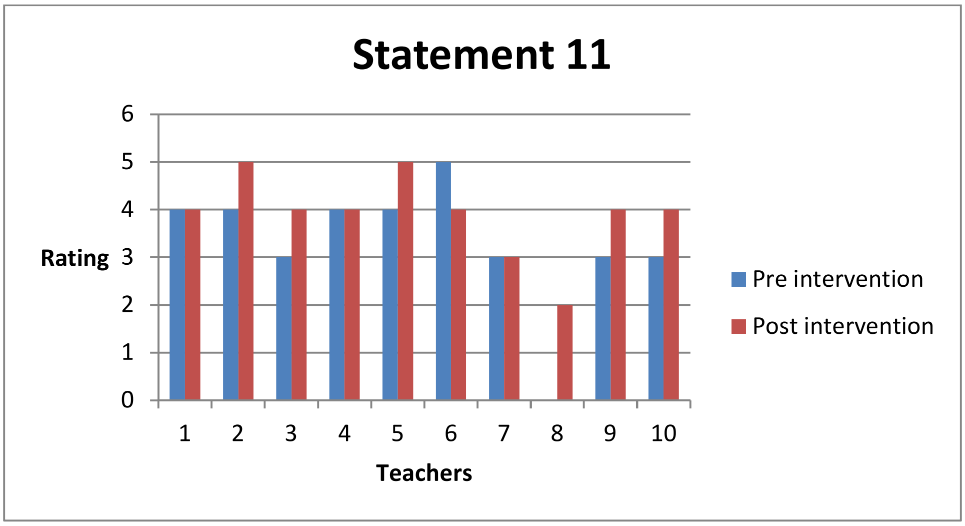

Figure 5.16: Statement 11: I model thoughtful behaviour in maths.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.16. Change is observed in seven of the 10 teacher ratings between the pre and post intervention data collection. There is a spread in the ratings, both pre and post intervention, perhaps indicating the staff do not have a shared understanding of what it means to model thoughtful behaviour in mathematics or what this may look like in the classroom. 'Thoughtful behaviour' many be a term that could have been interpreted in different ways, such as modelling a positive mindset and attitude to mathematics or an openness to solving problems in different ways. If the questionnaire was to be used again, this statement would need clarifying. Although change is seen in the pre and post intervention data collection, it did not lead to a narrower range of ratings in the post intervention data collection.

Figure 5.17 presents the sixth statement of Element 3, Statement 12: 'I give adequate time to thinking and reflecting in the maths session.'

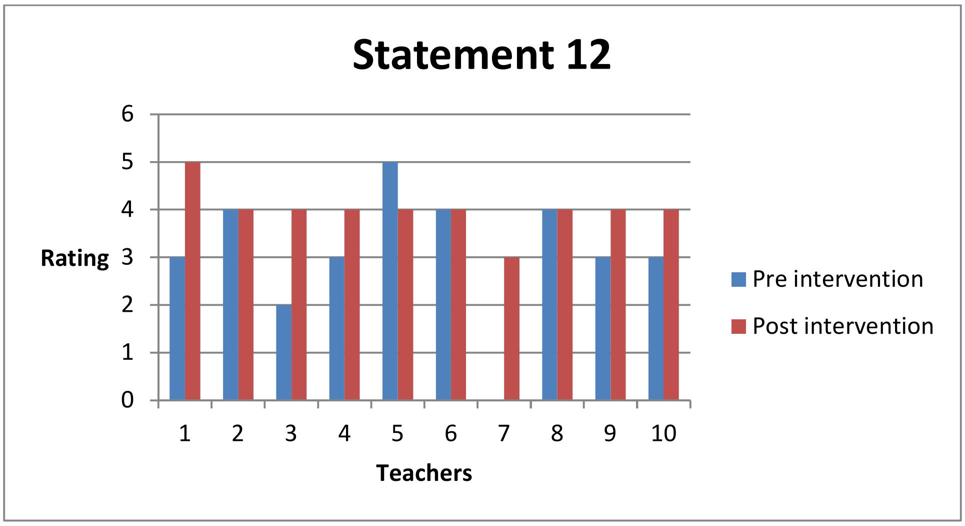

Figure 5.17: Statement 12: I give adequate time to thinking and reflecting in the maths session.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.17. Change is observed in all 10 teacher ratings between the pre and post intervention data collection. The changes result in all except two staff members rating the statement about time for thinking and reflecting as *often*. These ratings are more consistent than the post intervention data collection ratings shown in Figure 5.6: Statement 6, which also considers students reflecting on their work. Thinking time in questioning was a focus for some of the teachers during the professional learning intervention, and one of the teachers actively sought feedback through the triad via the observations. Likewise, reflection and ensuring it was included in mathematics lessons was a focus for the whole staff in Week 3 of the professional learning intervention.

Figure 5.18 presents the seventh statement of Element 3, Statement 14: ‘Students spontaneously comment on each other’s responses and ideas.’

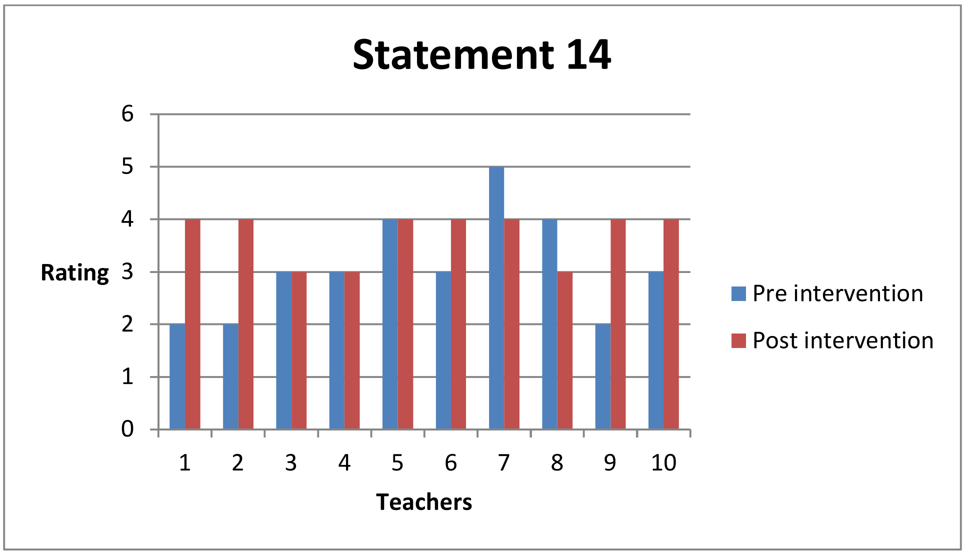

Figure 5.18: Statement 14: Students spontaneously comment on each other's responses and ideas.

Pre intervention, the ratings ranged from *seldom* to *very often.* Post intervention, the range is *sometimes* or *often* as shown in Figure 5.18. Change is not observed in three of the teachers' ratings, but the rest showed change between the pre and post intervention data collection. Three teacher ratings show a movement from *seldom* to *often*, which is across two ratings. As part of the professional learning intervention, teachers were encouraged to try problem-solving activities and implement open-ended tasks. Teachers commented in the triad discussions that students were more engaged and discussing mathematics more readily. This could have been a result of using these types of tasks or teachers making a conscience effort to encourage discussion. This change in students' responses was also noted in one of the triads by the partner teacher, who noticed the difference in students' comments between two of the professional learning weeks. This change and narrowing in the range of ratings of the post intervention data collection may illustrate a common understanding being developed by the staff around this area of teaching and learning, and spontaneous comment on ideas and responses is an acceptable process of learning in the mathematics classroom.

Figure 5.19 presents the eighth statement of Element 3, Statement 15: 'We ask questions in class that require complex thought processes.'

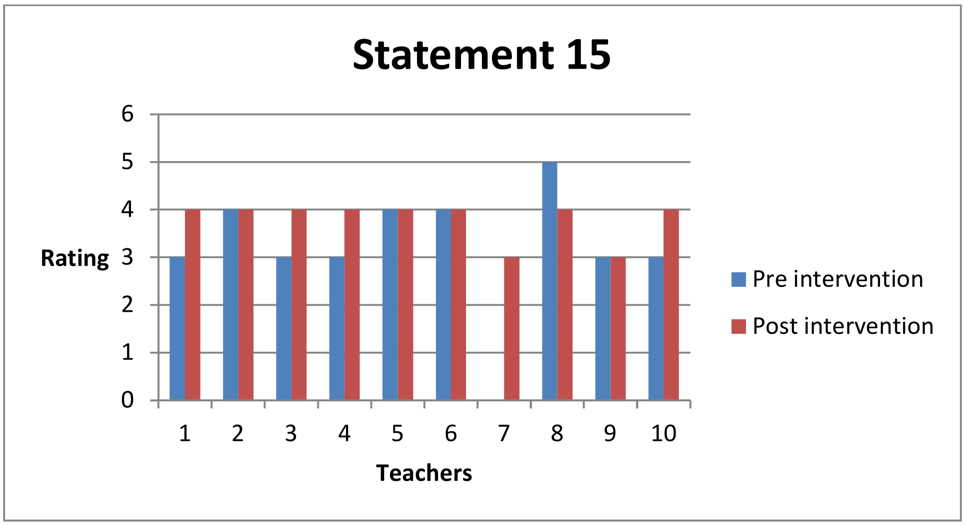

Figure 5.19: Statement 15: We ask questions in class that require complex thought processes.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *sometimes* to *often* as shown in Figure 5.19. Change is observed in six of the 10 teacher ratings changed between the pre and post intervention data collection. The changes resulted in all teachers selecting *sometimes* or *often* for this statement post intervention. This is reflective of the ratings of other statements such as Figure 5.17: Statement 12, which also showed a narrowing of ratings post intervention when considering thinking and reflection in the mathematics classroom. One of the teachers expressed a lack of confidence when using questions that required more complex responses and answering questions they did not know. The teacher found that the professional learning intervention allowed them to observe how other teachers dealt with this in the classroom, and they were later observed using phrases such as 'let's learn together' and 'can we do some research about this?' in subsequent professional learning weeks during the triad sessions.

Figure 5.20 presents Statement 17: 'Students have the opportunity to use a variety of materials to explore concepts.' This is the ninth statement of Element 3.

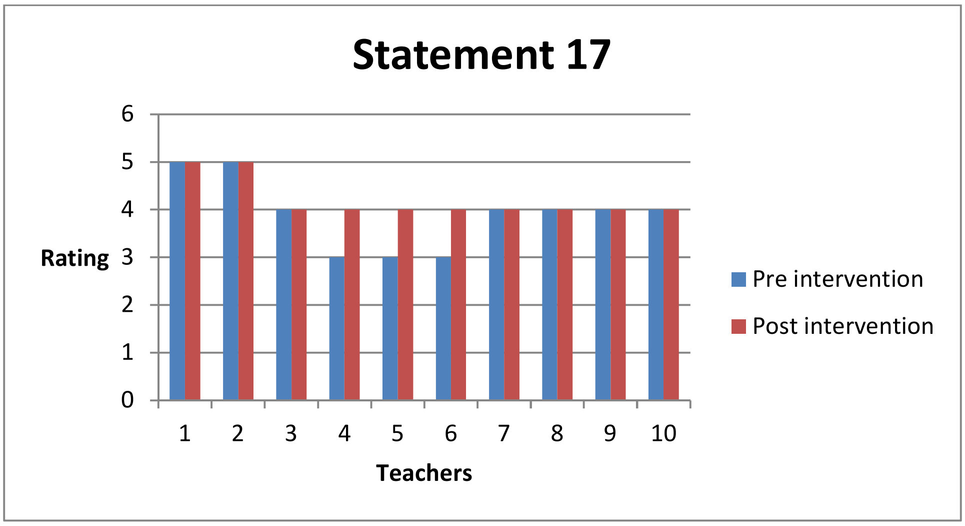

Figure 5.20: Statement 17: Students have the opportunity to use a variety of materials to explore concepts.

Pre intervention, the ratings ranged from *sometimes* to *very often.* Post intervention, the range is *often* to *very often* as shown in Figure 5.20. Change is observed in three of the 10 teacher ratings between the pre and post intervention data collection. This change resulted in all teachers selecting *very often* or *often* post intervention when considering student access to materials when exploring concepts. During the professional learning intervention, teachers were encouraged to use materials and manipulatives when teaching mathematics, as it was observed in the first week by the mathematics educator that this was not happening often in the Years 3, 4, 5, or 6 classrooms. This was particularly encouraged at the senior (Years 5 and 6) levels of the school, which were not observed using materials at all in their lessons during Week 1. Teachers were observed using materials and manipulatives in subsequent visits, and all Years 5 and 6 teachers were surprised with how the students positively responded to using the equipment. This may have led to the observed change in the ratings.

Figure 5.22 presents Statement 20: 'I use a wide variety of assessment experiences in maths and use the information to drive my teaching.' This is the tenth statement of Element 3.

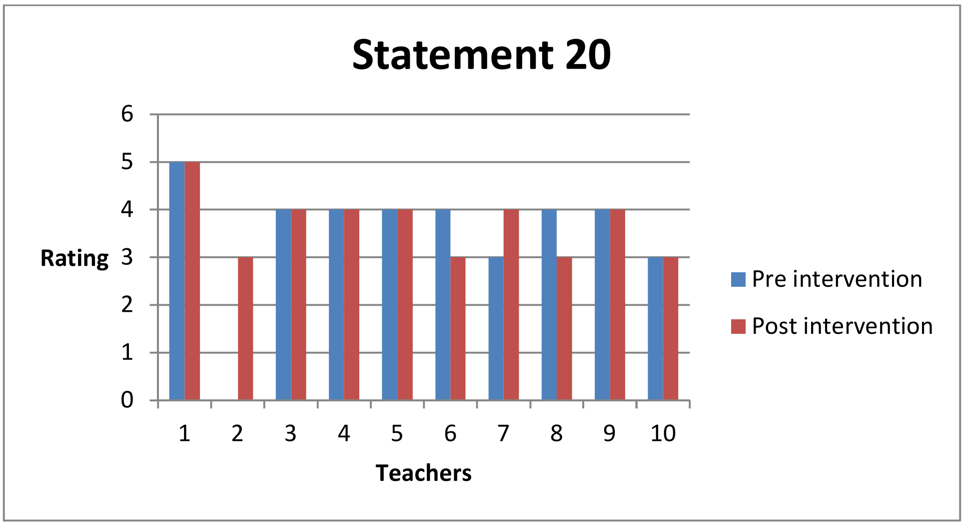

Figure 5.21: Statement 20: I use a wide variety of assessment experiences in maths and use the information to drive my teaching.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *sometimes* to *very often* as shown in Figure 5.21. Change is observed in four of the 10 teacher ratings between the pre and post intervention data collection. Assessment was not a focus of the professional learning intervention; classroom practice was. None of the teachers identified assessment as part of their goals. Discussion was held in the triads, which included assessment. For example, one discussion focused on collecting students' work as artefacts to illustrate student understanding of geometry resulting from an activity based on scale drawing. The observed changes may have resulted from such discussion.

Figure 5.22 presents the final statement of Element 3, Statement 20: 'I am flexible in my lessons; I allow students' questions to divert me from the planned lesson.'

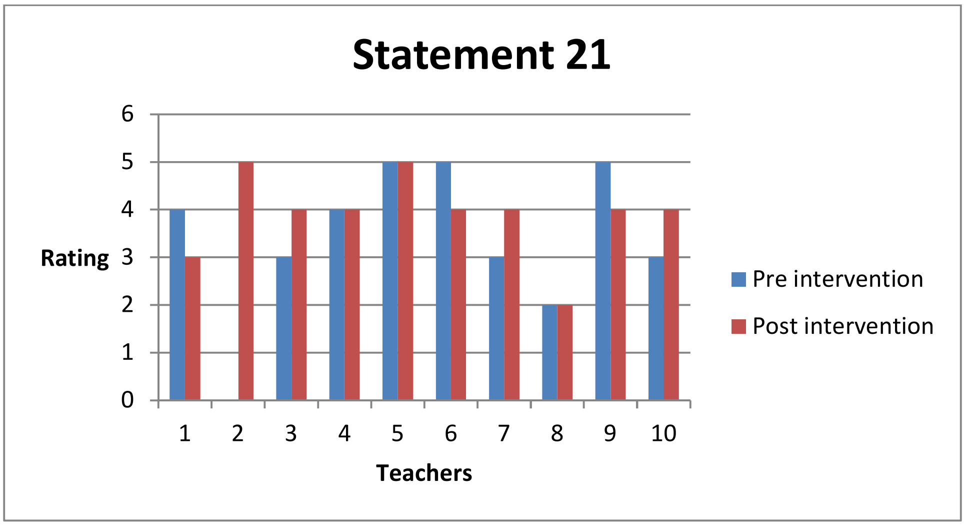

Figure 5.22: Statement 21: I am flexible in my lessons; I allow students' questions to divert me from the planned lesson.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.22. Change is observed in six of the teachers' ratings between the pre to post intervention data collection. There is a range in ratings both pre and post intervention for this statement, perhaps reflecting teachers' personal teaching styles. Changes in ratings may have been as a result of the peer observation component of the triad professional learning model, either via the feedback from an observer, from observations of others, or from the discussion process. Changes in ratings may have also occurred as teachers reflected on their own teaching, developing an understanding of their own practice as a result of the feedback through the triad process. Therefore, there may have been a change of rating, not necessarily a visible change in teacher practice.

5.5.6 Element 3: Summary

Changes were observed in all 11 statements of this element of general pedagogical knowledge (or teaching strategies). The greatest change is seen in response to Figure 5.18: Statement 14, which addressed students spontaneously commenting on each other's work. This included three 'double jumps' in ratings. The least change is seen in response to Figure 5.12: Statement 1, which addressed where the teacher normally works when teaching mathematics, with all cases remaining the same except for one teacher who did not respond pre intervention but did respond to this statement post intervention, so this may still be considered a change.

The amount of change to ratings between the pre and post intervention data collection varied between statements, but in most examples, the changes led to a narrowing in the range of ratings for the statements post intervention. This may indicate a more consistent approach across the staff around language and understanding of general pedagogical knowledge in the mathematics classroom. Questioning and the reflection of mathematics learning were a focus of the professional learning intervention, so change would be expected in this area. However, just because questioning and reflection were a focus does not mean there would be a change in the ratings in the questionnaire or a change in teacher practice. The observation model of the professional learning intervention allowed teachers the opportunity to receive feedback in areas of interest. The time between the visits allowed for reflection on this feedback, and teachers could use this to target particular aspects such as questioning in the next experience to receive further feedback. This created a practice, feedback, reflection loop, allowing teachers to try new things often located in different contexts.

5.5.7 Element 4: Curriculum knowledge

Figure 5.23 presents Statement 19, the only statements of Element 4, 'Covering content and CSF 11 outcomes is one of my major goals' is included in this element.

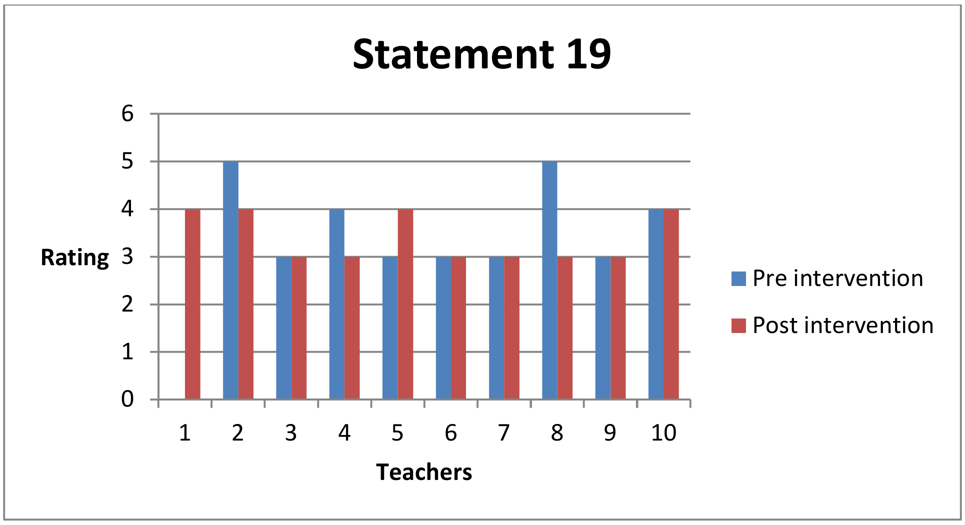

Figure 5.23: Statement 19: Covering content and CSF 11 outcomes is one of my major goals.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *sometimes* to *very often* as shown in Figure 5.23. Change was observed in four of the 10 teacher ratings between the pre and the post intervention data collection. One teacher did not respond pre intervention but did post intervention. One teacher rating shows a movement of two ratings from *very often* to *sometimes*. During the professional learning intervention, discussion was held about curriculum at staff and unit meetings. Two teachers made conscious efforts to use materials that were not part of the teaching programme. They found that they still met the curriculum goals but in different ways and enjoyed the process of researching different materials.

5.5.8 Element 4: Summary

A change was evident for this statement about curriculum knowledge. The change could indicate a decreased focus on covering curriculum goals. It could also indicate an increased focus on mathematics content as the professional learning intervention was focused around the content area of mathematics. Change may have been reflective of teachers becoming more involved in developing the content and the curriculum. The Years 5/6 teachers also explicitly looked at building basic skills in number for their classes during the professional learning intervention, and this may have impacted ratings.

5.5.9 Element 5: Knowledge of educational contexts

Two statements, Statements 23 and 24, are included in this element. Figure 5.2 presents the first statement, Statement 23: 'We work to build a community of inquiry in our maths class.'

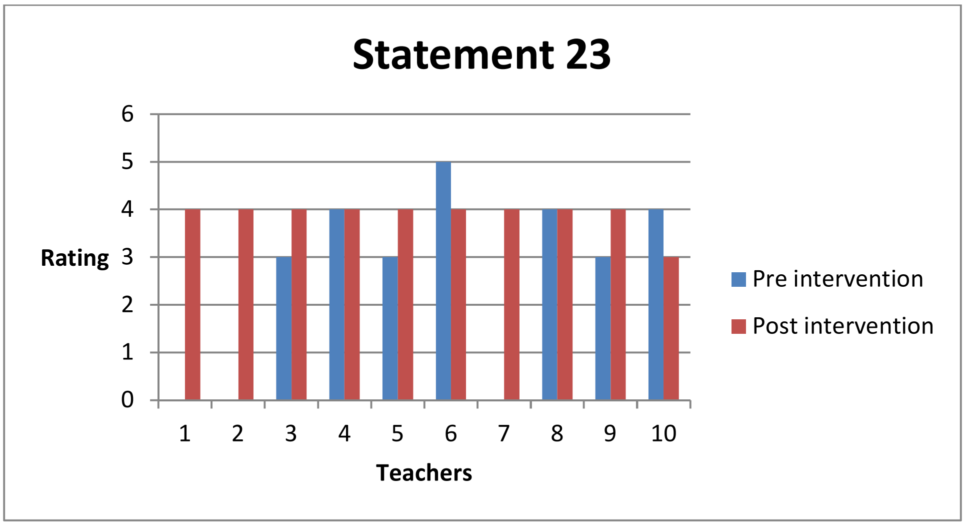

Figure 5.24: Statement 23: We work to build a community of inquiry in our maths class.

Pre intervention, Statement 23 had the least number of responses, with three teachers not responding as shown in Figure 5.24. Pre intervention, the ratings for this statement, ranged from *no response* to *very often.* This may have been due to the statement being unclear, or perhaps teachers were unfamiliar with the phrase 'community of inquiry' and its meaning. Post intervention, the range is *sometimes* or *often* with all teachers responding. Change is observed in ratings to this statement between the pre and post intervention data collection in half the responses. The change resulted in all teachers, except one, selecting a rating of *often* when considering the statement about building a community of inquiry in the classroom.

This consistency in post intervention data collection ratings may reflect the development of a common understanding (Atkin, 1996) across the staff about what community of inquiry means and what it looks like in the mathematics classroom. This is supported in other statements on reflecting, thinking, reasoning, and deeper questioning. As part of the teacher professional learning intervention, there was a focus on open-ended questions in the mathematics class for many of the teachers, which may have resulted in some of the change.

Figure 5.25 presents the second statement of Element 5, Statement 24: 'We discuss teaching strategies at unit or staff meetings.'

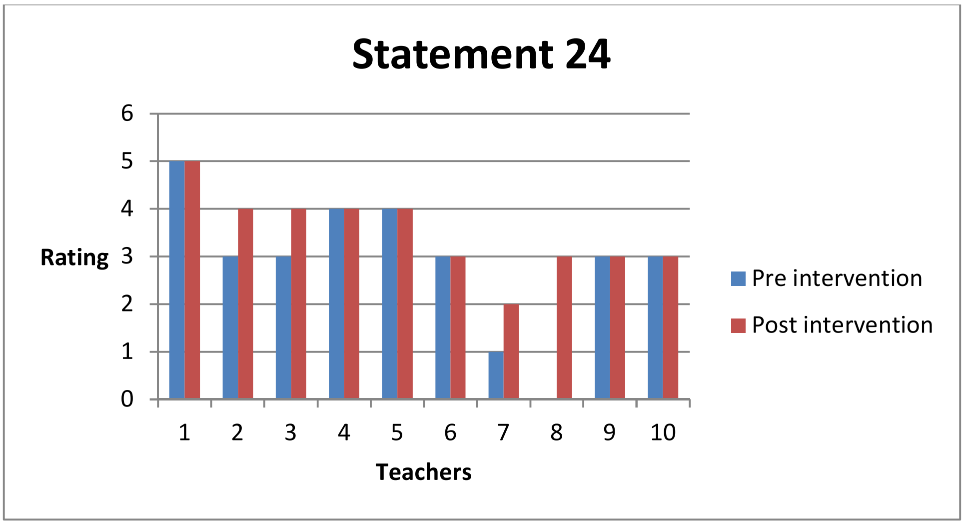

Figure 5.25: Statement 24: We discuss teaching strategies at unit or staff meetings.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention, the range is *seldom* to *very often* as shown in Figure 5.25. Change is observed in the ratings by three teachers between the pre and post intervention data collection. Although change is observed, there is a range of ratings both pre and post intervention. During the teacher professional learning intervention, teaching strategies were discussed at unit and staff meetings when the mathematics educator was present; however, this may not have occurred consistently between visits.

5.5.10 Element 5: Summary

Both sets of ratings to the two statements of the element of knowledge of educational contexts exhibited change to some of the ratings of the statements between the pre and post intervention data collection. For both statements, some teachers did not rate them pre intervention but all teachers made a rating post intervention, which could also be considered a change. Time between visits is generally seen as a strength as it allowed teachers time to reflect on feedback and then try new things and receive further feedback at subsequent visits. Time between visits could also disrupt momentum, such as discussion at staff and unit meetings which were focused on teaching and learning during the week-long professional learning, but they may have reverted to the 'to do' lists between the weeks.

5.5.11 Element 6: Knowledge of the purposes of education

This element has two related statements. Figure 5.26 presents the first statement, Statement 22: 'One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.'

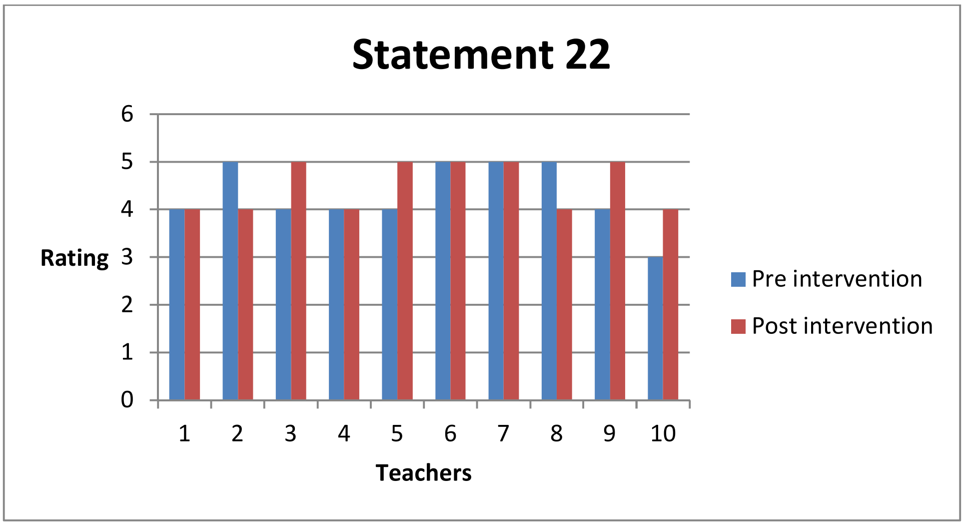

Figure 5.26: Statement 22: One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.

Pre intervention, the ratings ranged from *sometimes* to *very often.* Post intervention, teachers rated the statement as *often* or *very often* as shown in Figure 5.26. Change is observed in six of the 10 teacher ratings between the pre and post intervention data collection. This change resulted in a narrowing of ratings to *often* or *very often* when considering the goals of teaching, understanding, and application of mathematics to life experiences. During the teacher professional learning intervention, one teacher addressed this application to life experiences through an activity of 'solving problems in the building of my new house'. Another activity had students determining the scale to create a scale drawing of their classroom wall. Changes to this statement could have resulted from the conducting and observation of such activities.

Figure 5.27 presents the second statement of Element 6, Statement 25: 'As a staff, we work to reach a consensus on what it means to be an effective maths teacher.'

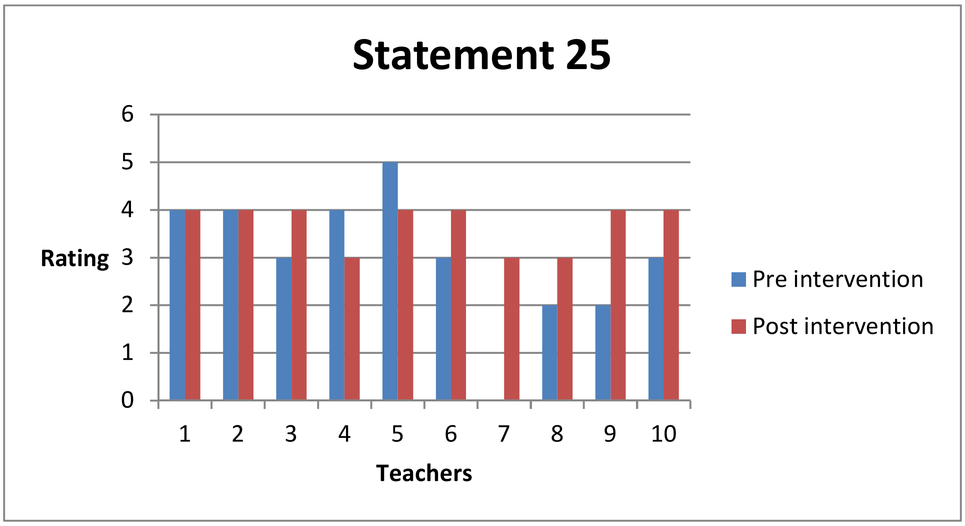

Figure 5.27: Statement 25: As a staff, we work to reach a consensus on what it means to be an effective maths teacher.

Pre intervention, the ratings ranged from *no response* to *very often.* Post intervention teachers rated the statement as *sometimes* or *often* as shown in Figure 5.27. There is a variation in teacher ratings pre intervention, which may be related to the understanding of the phrase 'effective maths teacher'. Change is observed in eight of the 10 teacher ratings between the pre and post intervention data collection. This change resulted in a narrowing of ratings to this statement post intervention, with all teachers selecting either *sometimes* or *often* when considering what it means to be an effective mathematics teacher. This could be expected as a result of the teacher professional learning intervention, with the whole staff involved in the intervention including the principal. This may reflect a movement in the staff to a common understanding of what it means to be an effective mathematics teacher. The changes may have resulted from the discussion element of the triad professional learning model, both individually with the mathematics educator and in the triads following the peer observation lesson and at meetings.

5.5.12 Element 6: Summary

In summary, changes are seen in the two statements of this element of knowledge of the purpose of education. The school's aim for the professional learning intervention included having students understand the application of mathematics concepts to life experiences and the development of teachers as effective mathematics teachers; therefore, change would have been expected. Changes in the ratings of the statements between the pre and post intervention data collection of this element may indicate a developing shared understanding among staff of the purpose of education in the mathematics classroom. Changes could have resulted from the discussion components of the professional learning intervention, particularly in relation to reaching a consensus of what it means to be an effective mathematics teacher.

5.6 Summary of Grouped Data Analysis—Statement Analysis

The aim was to find whether there was change to teachers' ratings to the statements of the pre and post intervention data collection after implementing the professional learning intervention. The graphs were individually analysed in terms of teachers' ratings to each of the statements comparing pre and post intervention data collection. Table 5.4 shows a summary of the data.

An asterisk is placed next to the statements indicating whether one teacher did not make a rating pre intervention but did make a rating post intervention, and this is shown in 14 of the statements. There are three asterisks in Statement 23 as three teachers did not make a rating pre intervention but did make a rating post intervention. It could be suggested that a change is evident if a teacher chose not to rate the statement pre intervention and then did choose to rate it post intervention; however, it is not clear if this could be considered an increase or a decrease in value, or what the motivation was to not respond initially but respond after, so it is noted but not counted in the totals.

Table 5.4 shows in response to every statement, except Statement 1, that at least one teacher changed their rating between the pre intervention data collection and the post intervention data collection. Eight statements show less than half the teachers changed their ratings between the pre and post intervention data collection. These statements are circled in the table. Five statements show exactly half the teachers changed their ratings between the pre and post intervention data collection, shaded on the table. Twelve statements showed more than half the teachers changed their ratings between the pre and post intervention data collection.

Of the 250 rating comparisons, only five ratings showed a ‘double jump’ or shift of more than one rating. This occurred for one teacher in Statements 18 and 19 and for three teachers in Statement 14. Statements 18 and 14 are about students responding to questioning and Statement 19 is about curriculum.

Table 5.4: *Summary Table of Teachers' Ratings for Each Statement*

Statement number	Statement	Number of ratings that showed no change	Number of ratings that showed an increase in value*	Number of ratings that showed a decrease in value	Total number of ratings that showed a change in value
1	When teaching maths I usually work at or near my desk.*	9			0
2	I display examples of students' work in maths around the room.	4	4	2	6
3	I group students in different ways during my maths class for instructional purposes.*	7	1	1	2
4	I ask most of the questions during class.	5	1	4	5
5	Students pose thought-provoking questions during maths.	5	5		5
6	Students reflect on their work, progress, and thought processes in maths orally or in writing.*	3	5	1	6
7	I often ask 'How did you arrive at that answer, solution, or idea?'	7	2	1	3
8	Students spend time working collaboratively in our maths class.	9		1	1
9	Students support their answers in maths with evidence, giving reasons for their thinking.*	3	6		6
10	I think that maths questions should be marked as either right or wrong.	5	2	3	5
11	I model thoughtful behaviour in maths.*	3	5	1	6
12	I give adequate time to thinking and reflecting in the maths session.*	3	5	1	6
13	I encourage students to seek alternative ways of approaching problems, interpretations, and solutions.*	5	2	2	4
14	Students spontaneously comment on each other's responses and ideas.	3	5	2	7
15	We ask questions in class that require complex thought processes.*	4	4	1	5

16	Students confidently and willingly discuss their thinking in maths.*	3	6		6
17	Students have the opportunity to use a variety of materials to explore concepts.	7	3		3
18	Students respond to my questions with short, one- or two-word answers.	3	2	5	7
19	Covering content and CSF 11 outcomes is one of my major goals.*	5	1	3	4
20	I use a wide variety of assessment experiences in maths and use the information to drive my teaching.*	6	1	2	3
21	I am flexible in my lessons; I allow students' questions to divert me form the planned lesson.*	3	3	3	6
22	One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.	4	4	2	6
23	We work to build a community of inquiry in our maths class.***	2	3	2	5
24	We discuss teaching strategies at unit or staff meetings.*	6	3		3
25	As a staff, we work to reach a consensus on what it means to be an effective maths teacher.*	2	5	2	7
Totals	* 17	116	78	39	117

5.6.1 Observations of change

Although increases and decreases are presented in Table 5.4, it was any change that was being sought in the analysis. Overall, 116 of the 250 ratings between the pre intervention data collection and the post intervention data collection showed no change, and 117 of the ratings showed a change, either an increase (78) or a decrease (39), with 17 ratings not recorded across the statements.

As mentioned in Section 5.4, it could be argued that a decrease in rating may be seen as a positive outcome; however, an increase in rating may be an indication of deeper self-awareness as a result of the professional learning intervention. Conversely, an increase in rating may also be seen as a positive outcome depending on the statement, but a decrease in rating may indicate a deeper analysis of practice.

Using Shulman's (1986b) six key elements of PCK (knowledge base), a further summary of change is provided, as shown in Table 5.5.

Table 5.5: *Summary of Changes When Considering Groupings Into Elements of Pedagogical Content Knowledge for Each Statement*

Element number	Element	Number of statements	Number of statements illustrating change	Number of statements not having a pre-intervention data collection rating
1	Knowledge of representations of subject matter (content knowledge)	1	1	
2	Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter	8	8	5 (the same teacher)
3	General pedagogical knowledge (or teaching strategies)	11	10	6 (not the same teacher)
4	Curriculum knowledge	1	1	1
5	Knowledge of educational contexts	2	2	4 (3 teachers on the same statement)
6	Knowledge of the purposes of education	2	2	1

Change is evident between the pre and post intervention data collection in each of the different elements. It is noted in the table when teachers did not respond pre intervention. This was a range of teachers across the questionnaire; however, it is noted that the same teacher opted not to respond to a number of statements pre intervention that fell into Element 2: Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter.

Through the analysis of the graphs, the greatest overall change observed is a narrowing of the range of ratings in post intervention data collection responses. This could be a result of the data regressing to the mean; however, all teachers and all data are included in the analysis, and the main aspect sought was any change in rating. It could be argued that the teacher professional learning intervention allowed teachers to develop common understandings about the teaching and learning of mathematics (Atkin, 1996; Stipek et al., 2001). This could have been facilitated through staff and unit meetings, through the individual discussion sessions before the teaching and learning experiences, or in the rich discussions held after the taught lesson with the triad members. These professional conversations (Britt et al., 2001) and opportunity for collaboration (Opfer & Pedder, 2011) have been shown to be effective elements of professional learning. The use of the mathematics educator in the triads was common across all discussions and all visits throughout the duration of the professional learning intervention, acting as the link to create discussion using a common language for observations and conversations with groups as a whole (Avalos, 2011), which could lead to the development of learning communities.

In the professional learning intervention, teachers took the opportunity to set goals about particular aspects of teaching and learning such as questioning. The teachers then received feedback on this aspect. As there was time between visits, they could reflect on the feedback. The subsequent week-long sessions provided teachers with the opportunity to try different strategies and receive further feedback in the triad situation. This created an action, feedback, reflection loop.

In summary, this section of the chapter presented each of the statements of the pre and post intervention data collection as side-by-side column graphs accompanied with commentary. These were organised by Shulman's (1986b) six key elements of pedagogical content knowledge (knowledge base), and change was seen in all six elements. A summary table (Table 5.4) was also provided.

The next section presents side-by-side column graphs for each of the individual teachers and their ratings to the statements pre and post intervention. These graphs are also accompanied with commentary and a summary table.

5.7 Data Analysis—Individual Teacher Analysis

To show the impact on individual teachers, this section presents side-by-side column graphs for each individual teacher and their ratings to the statements pre and post the intervention. This will examine whether one, some, or all teachers demonstrated change in their ratings, which may not have been observed in the statement analysis of the previous section.

As mentioned in Section 4.8 a calculation of the mean is not strictly correct as the divisions across the scale are not equal. However, the mean has been calculated for the pre and post intervention data collection ratings in an aim to synthesise the data and provide a broad context. Items were not reversed, as change itself—positive, negative, or neutral—was analysed, so although the direction of change is indicated in the summary table (Table 5.6), the change itself is valued.

The statements that had changes to the ratings between the pre and post intervention data collection was analysed in terms of Shulman's (1986b) six key elements of PCK as shown in Table 5.3. This attempted to examine whether there were any particular areas in which change may have occurred for individual teachers. Each graph for each individual teacher is now presented with accompanying commentary.

Figure 5.28 presents Teacher 1's ratings pre and post the intervention.

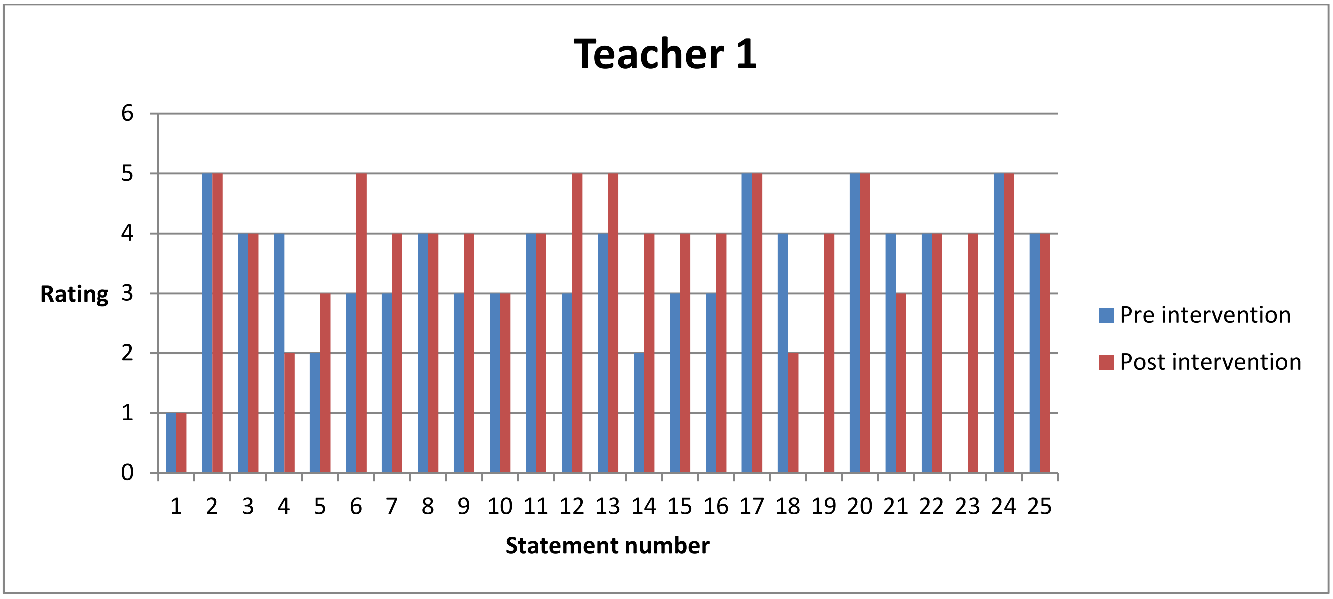

Figure 5.28: Comparison between pre and post intervention data collection for Teacher 1.

Pre intervention the average overall rating for Teacher 1 is 3.28 and post intervention it is 3.88. Pre intervention, this teacher did not respond to two of the statements as shown in Figure 5.28; these were Statement 19 about curriculum and Statement 23 about building a community of inquiry. No change is observed in 11 of the ratings between the pre and post intervention data collection. All statements that had observed changes were in Element 2: Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter and Element 3: General pedagogical knowledge (or teaching strategies) of Shulman's (1986b) six key elements of PCK. These changes could have resulted from the teacher's focus on these two areas during the professional learning intervention. The goal-setting component of the professional learning allowed teachers to maintain a focus on specific areas. The ratings that showed no change could indicate that the teacher had confidence in their understanding of content, curriculum, and broader educational contexts. There were five double jumps (movements across two ratings). These were to Statements 4 and 18 about questioning, Statements 6 and 12 about reflection, and Statement 4 about students commenting on each other's work.

Figure 5.29 presents Teacher 2's ratings pre and post the intervention.

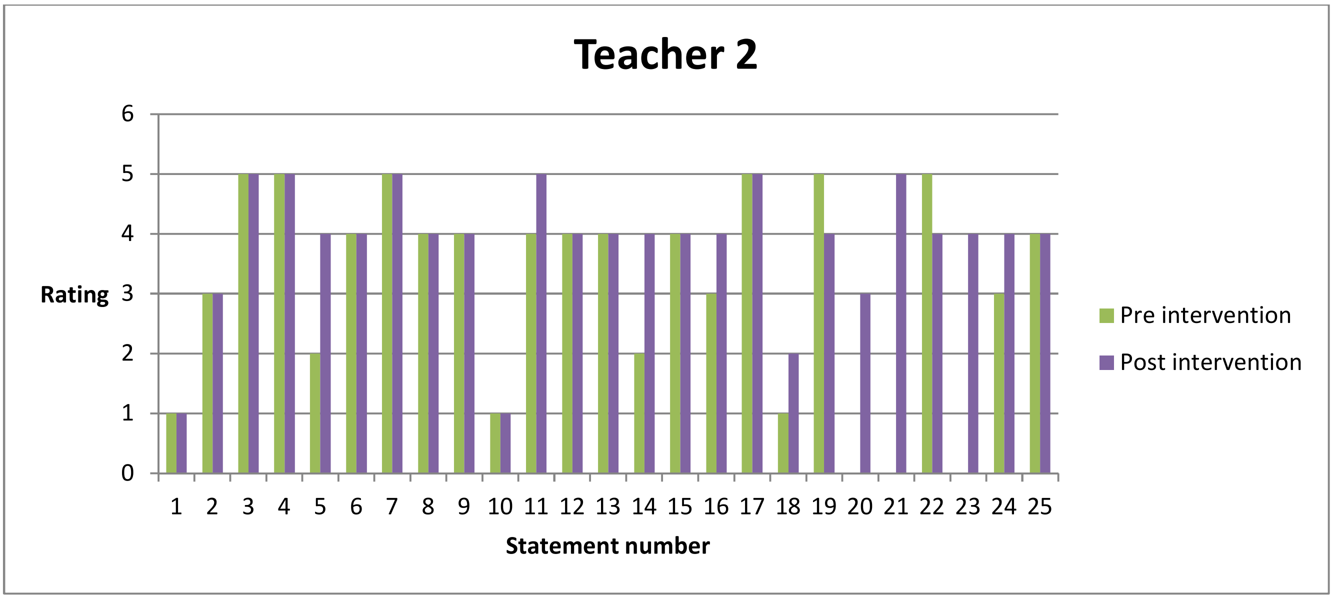

Figure 5.29: Comparison between pre and post intervention data collection for Teacher 2.

Pre intervention the average overall rating for Teacher 2 is 3.55 and post intervention it is 3.84. Pre intervention, this teacher did not respond to three of the statements as shown in Figure 5.29; these were Statement 20 about assessment, Statement 21 about flexibility in lessons, and Statement 23 about building a community of inquiry. No change is observed in 14 of the ratings to the statements. Two unchanged statements that received ratings of *hardly ever* were Statement 1 about working near their desk and Statement 10 about maths questions should be marked either right or wrong, and this is possibly an expected response and is a naturally low value. Change is observed in the ratings to statements across five of the six elements. Element 1: Knowledge of representations of subject matter (content knowledge) did not contain a change. There were two double jumps, one in Element 2 and one in Element 3; these were Statement 5 about questioning and Statement 14 about students commenting on each other's work. The teacher may have focused intentionally on these areas during the professional learning intervention, setting goals. However, as changes are across all of Shulman's (1986b) six elements, this may not have been the case.

Figure 5.30 presents Teacher 3's ratings pre and post the intervention.

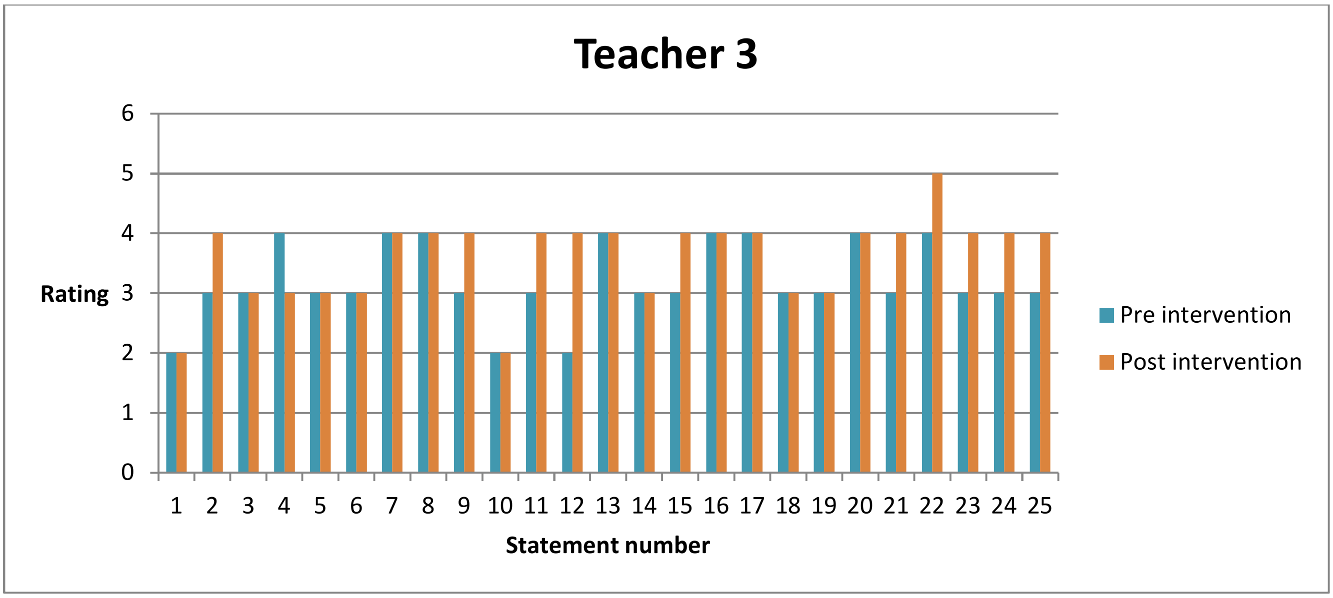

Figure 5.30: Comparison between pre-and post intervention data collection for Teacher 3.

Pre intervention, the average overall rating for Teacher 3 is 3.52 and post intervention, it is 3.6. No change is observed in 14 of the ratings to the statements as shown in Figure 5.30. One change is evident in Element 2: Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter, and change is in all statements of Element 5: Knowledge of educational contexts and Element 6: Knowledge of the purpose of education. The rest of the changes were seen in Element 3: General pedagogical knowledge, with one double jump in the rating of Statement 12 about time provided for thinking and reflecting. It appears some of the changes for this teacher are in the broader educational contexts rather than focused on specific areas such as questioning. This could have resulted from the whole-school focus on mathematics teaching and through the triad discussions.

Figure 5.31 presents Teacher 4's ratings pre and post the intervention.

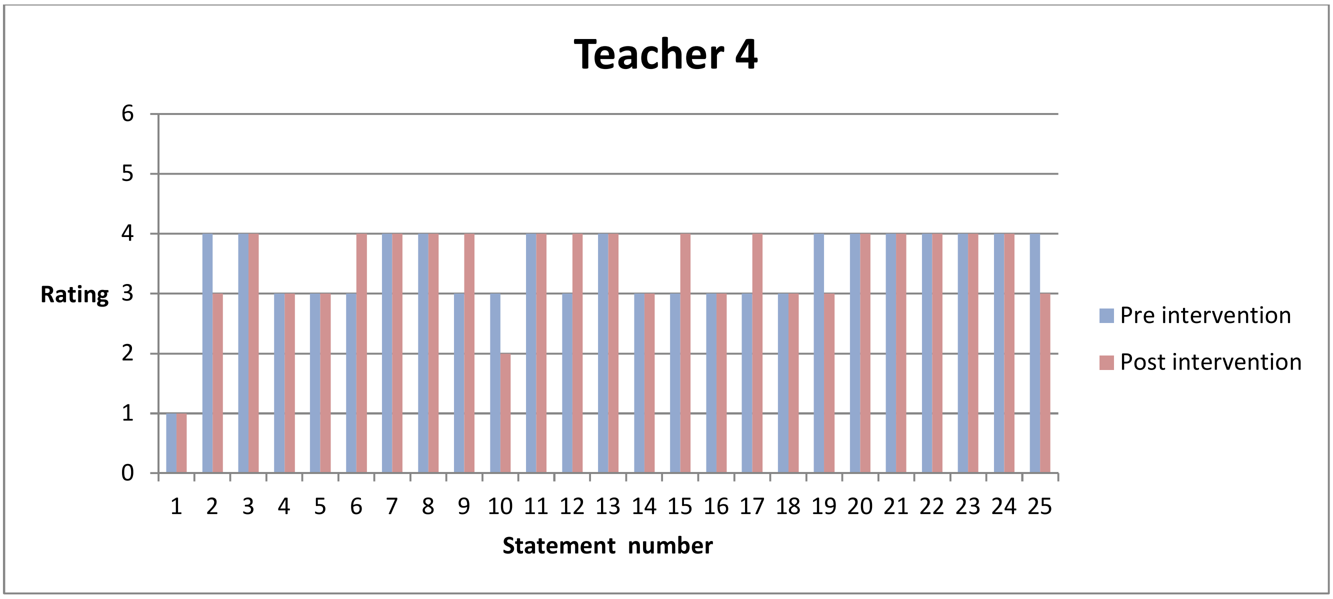

Figure 5.31: Comparison between pre and post intervention data collection for Teacher 4.

Pre intervention, the average overall rating for Teacher 4 is 3.44 and post intervention, it is 3.48. No change is observed in 16 of the ratings to the statements as shown in Figure 5.31. The observed changes in ratings were spread across all elements except Element 5: Knowledge of educational contexts. It appears that the unchanged statements towards the end of the questionnaire were broader educational contexts. Some of the statements that reflected change focused on reflection, the use of materials, and students providing reasoning for their responses. These aspects could have been the focus of the professional intervention for this teacher; hence, the change is evident in specific areas.

Figure 5.32 presents Teacher 5's ratings pre and post the intervention.

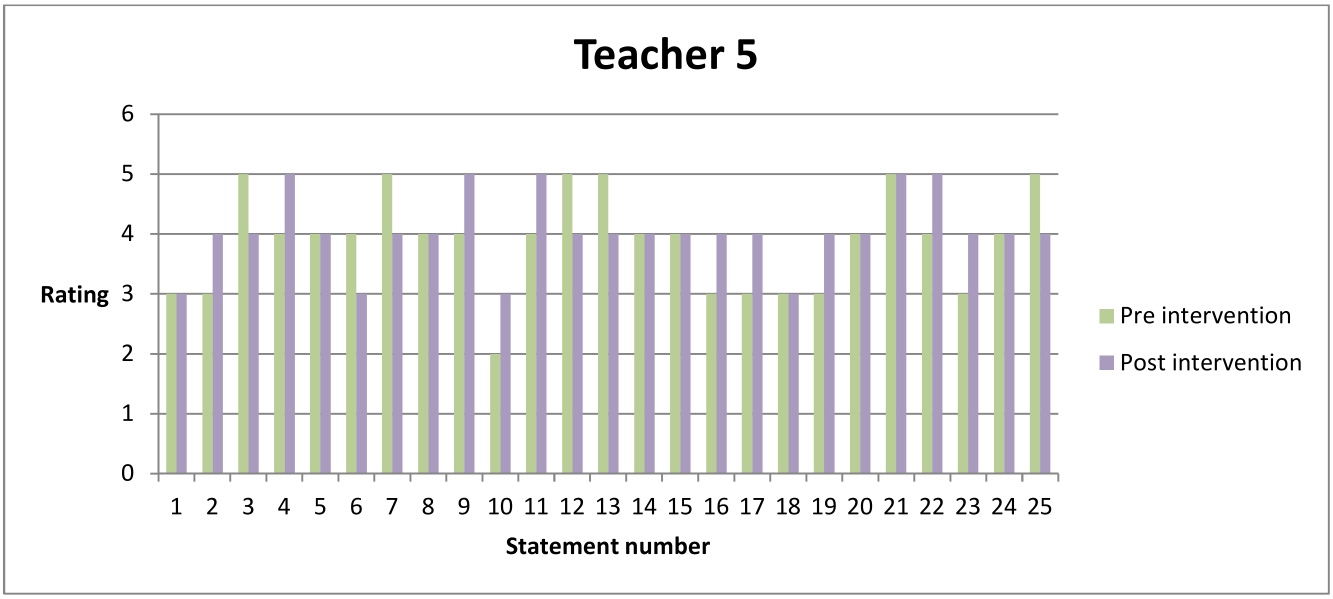

Figure 5.32: Comparison between pre and post intervention data collection for Teacher 5.

Pre intervention, the average overall rating for Teacher 5 is 3.88 and post intervention, it is 4.04. No change is observed in nine of the ratings to the statements as shown in Figure 5.32. The ratings that remained unchanged focused on how students were responding to questioning in the classroom. The observed changes in ratings to statements were spread across all elements. This could have been a reflection of a broader approach to the professional learning experienced by this teacher. This teacher tried a number of different things during the intervention, seeking feedback in a number of areas. It may also illustrate an openness to learning. The changes in ratings were both increases and decreases across different statements, not indicating a pattern but perhaps showing a consideration of different understanding of different situations. This teacher, along with Teacher 9, had the greatest number of changes in the ratings between the pre and post intervention data collection.

Figure 5.33 presents Teacher 6's ratings pre and post the intervention.

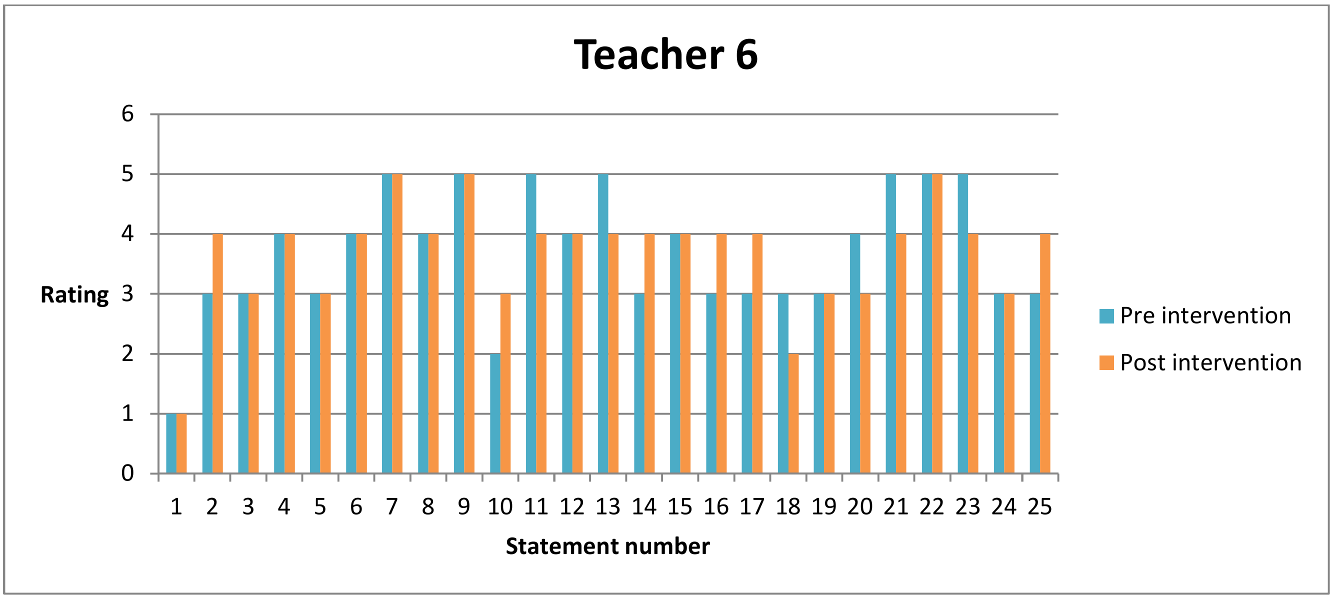

Figure 5.33: Comparison between pre and post intervention data collection for Teacher 6.

Pre intervention and post intervention, the average overall rating for Teacher 6 is 3.68. No change is observed in 13 of the ratings to the statements as shown in Figure 5.33. Changes were evident across all elements. This again may reflect the broader and experimental approach to the professional learning intervention, with the teacher not focusing on one particular area. This may have been supported by the ongoing nature of the professional learning, allowing the teacher to explore different areas of teaching and learning across the three visit weeks.

Figure 5.34 presents Teacher 7's ratings pre and post the intervention.

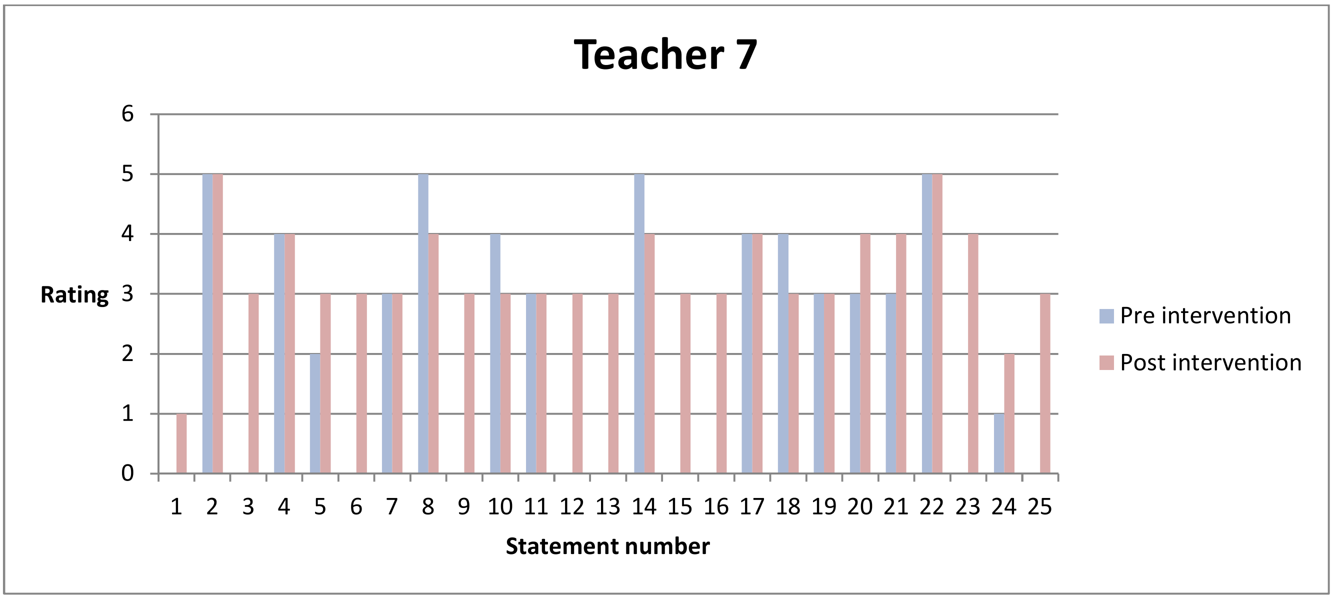

Figure 5.34: Comparison between pre and post intervention data collection for Teacher 7.

Pre intervention, the average overall rating for Teacher 7 is 2.35 and post intervention, it is 3.32. Initially Teacher, 7 did not respond to 10 of the statements in the pre intervention data collection. A number of these statements focused on thinking and reflection. One of the reasons the teacher may have found some of the statements challenging and decided not to respond is that they may have felt the statements were not relevant to their particular context, such as using reflection with foundation level students or using materials and equipment with senior students. It was through involvement in the professional learning intervention that they found these statements applicable, and in the post intervention data collection., all these statements were rated as shown in Figure 5.34. It could be argued that significant change can be seen in this teacher, with a willingness to complete the questionnaire and respond to each statement when initially nearly half the statements were not responded to in the pre intervention data collection. No change is observed in seven of the ratings to the statements as shown in Figure 5.34. The changes observed are evident in all elements except Element 6: Knowledge of the purposes of education.

Figure 5.37 presents Teacher 8's ratings pre and post the intervention.

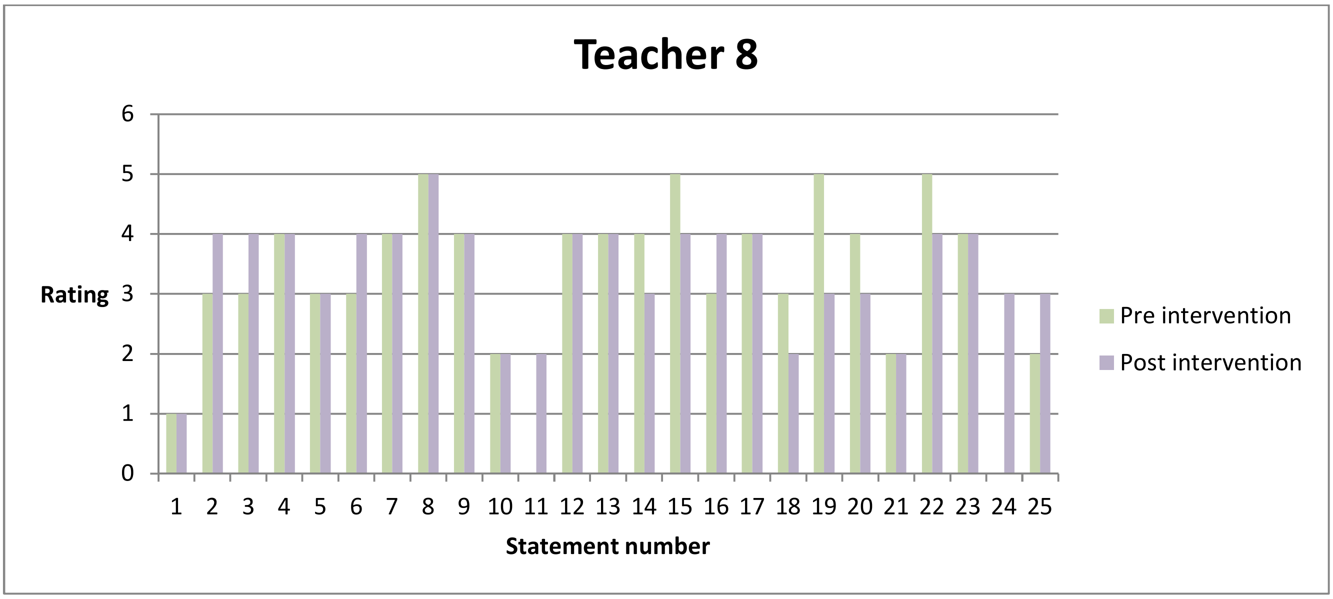

Figure 5.35: Comparison between pre and post intervention data collection for Teacher 8.

Pre intervention, the average overall rating for Teacher 8 is 3.28 and post intervention, it is 3.88. Initially, this teacher did not respond to two of the statements as shown in Figure 5.35; these were Statement 11 about modelling thoughtful behaviour and Statement 24 discussing teaching strategies. Terms such as ‘thoughtful behaviour’ were identified as being potentially problematic and may be one of the reasons for the initial nonresponse. No change is observed in 11 of the ratings to the statements as shown in Figure 5.35. Observed changes were evident in Elements 2, 3, 4, and 6. No change was evident in Element 1: Knowledge of content and Element 5: Knowledge of educational contexts. A double jump was noted in Element 4, Statement 19 covering curriculum. The spread of changes across the different elements may reflect the ongoing nature of the professional learning intervention across a number of months as classroom teaching and learning focuses change in dynamic environments. It should also be acknowledged that changes could also naturally occur outside the professional learning, as students mature during the year and respond to different events both in and outside school.

Figure 5.36 presents Teacher 9’s ratings pre and post the intervention.

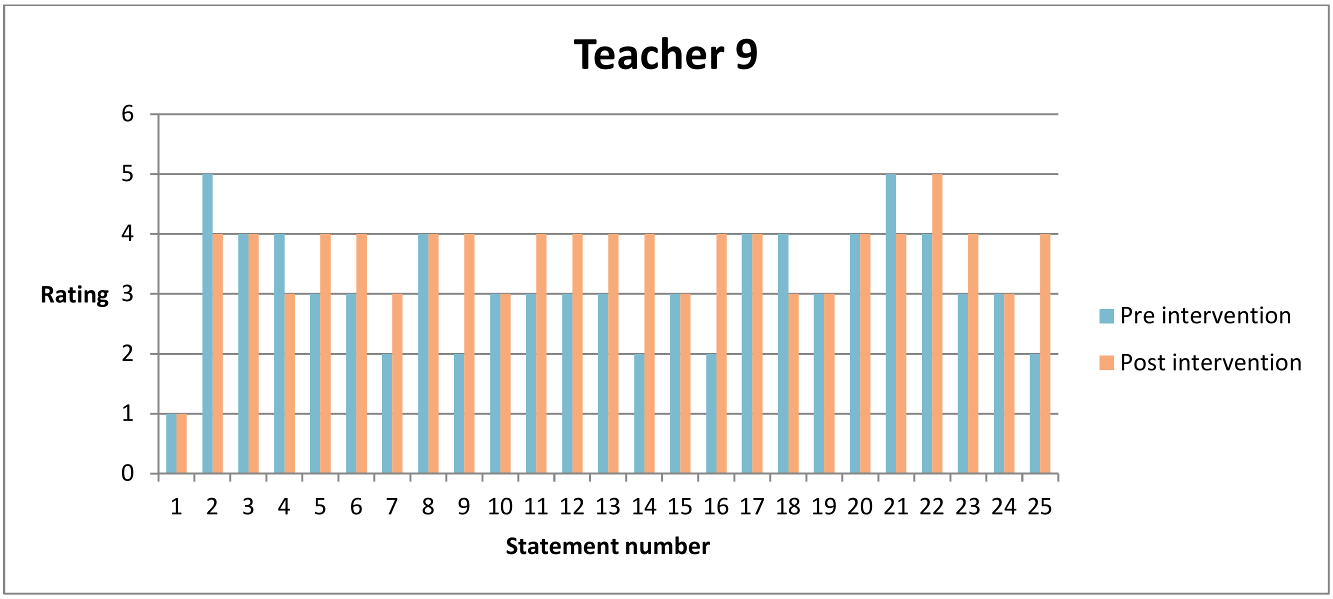

Figure 5.36: Comparison between pre and post intervention data collection for Teacher 9.

Pre intervention, the average overall rating for Teacher 9 is 3.38 and post intervention, it is 3.64. No change is observed in nine of the ratings to the statements as shown in Figure 5.36. Change was observed in seven of the eight statements of Element 2: Understanding of students' conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter. Changes were also observed in Elements 3, 5, and 6. There were four double jumps; these were to Statement 9 about students supporting answers, Statement 14 about students commenting on each other's' responses, Statement 16 discussing students' thinking, and Statement 25 about staff working to reach a consensus about effective mathematics teaching. Three of the statements were about discussing thinking in the mathematic classroom. Changes in the ratings may have been a result of the teacher targeting this area during the professional learning intervention. It could also have resulted from the discussions in the triads, and the change in Statement 25 could indicate that for this teacher, these types of discussions occurred at staff and unit meetings.

Figure 5.37 presents Teacher 10's ratings pre and post the intervention.

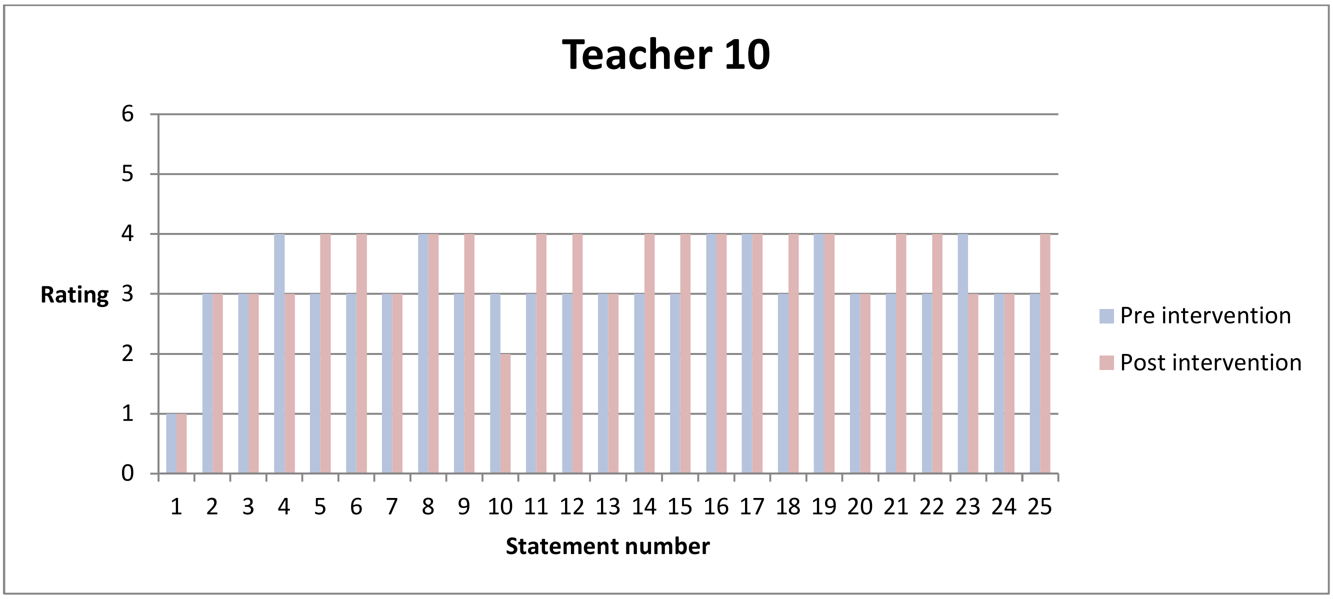

Figure 5.37: Comparison between pre and post intervention data collection for Teacher 10.

Pre intervention, the average overall rating for Teacher 10 is 3.16 and post intervention, it is 3.48. No change is observed in 11 of the ratings to the statements as can be seen in Figure 5.37. Changes were observed across all elements, except Element 4: Curriculum knowledge. These changes across all areas may indicate the ongoing nature of the professional learning, allowing teachers the opportunity to explore different aspects of mathematics teaching and learning.

5.8 Summary Data Analysis—Individual Teacher Analysis

The aim was to find whether there were any changes in teacher ratings to the statements of the questionnaire after teachers were involved in the professional learning intervention.

The graphs were individually analysed in terms of teachers' ratings to each of the statements comparing pre and post intervention data collected. Table 5.6 shows a summary of the data. The table shows that for all teachers, there were changes in some ratings to statements between the pre and post intervention data collection. Four teachers did not rate some of the statements pre intervention, and these are indicated with asterisks in the table. All teachers rated all statements post intervention.

Table 5.6: *Summary Table of Teacher Rating Analysis*

Teacher number	Pre intervention data collection mean	Post intervention data collection mean	Number of statements showing no change	Number of statements showing an increase in rating*	Number of statements showing a decrease in rating	Total number of statements showing any change in rating
1	3.28	↑ 3.88	11 **	9	3	12
2	3.55	↑ 3.84	14 ***	6	2	8
3	3.2	↑ 3.6	14	10	1	11
4	3.44	↑ 3.48	16	5	4	9
5	3.88	↑ 4.04	9	10	6	16
6	3.68	3.68	13	6	6	12
7	2.35	↑ 3.32	7 ***** *****	4	4	8
8	3.28	↑ 3.88	12 **	5	6	11
9	3.38	↑ 3.64	9	12	4	16
10	3.16	↑ 3.48	11	11	3	13

In all cases except one there was an increase in the means of the ratings between the pre intervention data collected prior to the professional learning intervention being implemented and to the post intervention data collected. These are indicated by the symbol ↑ in the table. The one teacher that had no change in the two mean values was Teacher 6 (shaded). As shown in Figure 5.33, there is evidence of change to some of the ratings for the statements, but the amount of change in the ratings to six statements that showed an increase and the amount of change in the ratings to six statements that showed a decrease cancelled each other out, resulting in an unchanged mean.

Although increases and decreases have been recorded in Table 5.6, it was any change that was sought. An increase or decrease in rating could be misleading. For example, a number of the ratings to Statement 1 appear to be low on first inspection of the graphs, such as in Figure 5.12, but Statement 1 is ‘When I teacher maths I usually work at or near my desk’ so a response of *hardly ever* (1) would not be unexpected and an increase in rating may be of concern.

Changes in ratings appear to be grouped when using Shulman’s (1986b) six key elements of PCK for some teachers (Table 5.7), such as Teacher 1, and for other teachers the changes to ratings are more spread. For the grouped changes, this may reflect the focused nature of the goal setting and aims of some teachers in the professional learning intervention. The wider spread of changes may reflect the structure of the professional learning spread over the period of months, with a number of focus weeks of the triad intervention allowing teachers to explore different aspects of teaching. The changes may not reflect the professional learning intervention at all and may be teachers naturally responding to the dynamics of their classroom.

Table 5.7: *Summary of Changes When Considering Groupings Into Elements of Pedagogical Content Knowledge for Individual Teachers*

Element number	**Element**	**Statement number**	**Teacher number**									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Knowledge of representations of subject matter (content knowledge)	10										
2	Understanding of students’ conceptions of the subject and the learning and teaching implications that were associated with the specific subject matter	3							*			
		5										
		6							*			
		7										
		9							*			
		13							*			
		16							*			

		18										
3	General pedagogical knowledge (or teaching strategies)	1							*			
		2										
		4										
		8										
		11								*		
		12							*			
		14										
		15							*			
		17										
		20		*								
		21		*								
4	Curriculum knowledge	19	*									
5	Knowledge of educational contexts	23	*	*					*			
		24								*		
6	Knowledge of the purposes of education	22										
		25							*			

Two teachers were selected to create small teacher stories. The teachers were selected prior to the post intervention data collection being implemented, and reasons for this are provided in Chapter 7. It is useful to discuss at this point that the selected teachers were Teacher 2 and Teacher 4. In the summary table (Table 5.6), these teachers show lower numbers for statements showing change to the ratings between the pre and post intervention data collection. Both teachers displayed changes across most of the elements, not changes focused on one or two elements. It is worth noting that Teacher 7 also had a low number of changes to the ratings but was not selected. However, developing a story for this teacher could have been equally interesting when the number of initial incomplete ratings to completed final ratings were observed.

5.9 Concluding Comments

In summary, this chapter was presented in two main sections using Shulman's (1986b) six key elements of PCK as an organiser.

The first section presented teacher ratings to the pre and post intervention data collection statements as side-by-side column graphs. Table 5.4 shows a summary of the changes to the ratings and showed changes to all statements except Statement 1. The amount of change varied between statements. The greatest consistent change in the data set was the narrowing of the range of ratings in the post intervention data collection. This may be a common statistical phenomenon; however, teachers were working on different aspects of teaching specific to their needs within the overall intervention. It may also be a result of the professional learning intervention, as teachers were beginning to develop a common understanding about teaching mathematics, facilitated by the opportunities for reflection and discussion with a mathematics educator and their peers.

The second section presented each teacher's ratings for each statement in side-by-side column graphs. Table 5.7 showed every teacher had ratings to some of the statements between the pre and post intervention data collection. The composition of these changes varied between teachers, from statements focused on one or two elements to across all elements. Any changes were being sought, rather than an increase or decrease in rating. A change could indicate many things, such as a deepening of understanding around a particular issue or content area or a more detailed analysis of one's own practice. The amount of change was expected to vary from person to person, and it is unrealistic to expect all ratings for each statement to change.

Chapter 7 presents two teacher stories, and in Chapter 8, a personal reflection that helps to contextualise the experience provides two different views when looking for evidence of change taking place in a primary setting as a result of the professional learning intervention.

CHAPTER 6: FINDINGS TEACHER STORIES

Chapter 5 presented comparison ratings of each statement between the pre and post intervention data collection and comparisons of teacher ratings for each pre and post intervention data collection, utilising Shulman's (1986b) six key elements of PCK. I argued that change was seen in ratings to all except one statement, Statement 10, and that all teachers demonstrated change in some of their ratings between the pre and post intervention data collection. I also proposed change was evident in all elements of Shulman's six key elements of PCK.

The previous chapter presented the quantitative data analysis. This chapter presents the qualitative data. Two teacher stories are used to contextualise the data and illustrate the professional learning intervention for those teachers in an attempt to provide detail that the quantitative statement analysis did not.

6.1 Introduction

Two main forms of qualitative data were collected during the professional learning intervention: data from questions and observational data. These data are extensive in nature and described in the next two sections of this chapter. They are then used to create two teacher stories, which feature different elements of the professional learning intervention.

6.2 Set Questions

A set of three questions were provided to all teachers at the beginning of the professional learning intervention, which were presented in Section 5.7.1. A follow-up question was also provided to the teachers after Week 1 of the professional learning intervention.

Written responses to the three questions were collected. Responses to the questions varied from short statements such as 'Okay' and 'It will be useful' in response to 'How do you feel about having a mathematics educator work with you?' through to considered and in-depth responses of one or more paragraphs. The variation in responses may have been a result of teachers not fully understanding what the professional learning intervention encompassed, or they may have found it difficult to articulate how they felt about the intervention, or may have been at ease with the proposed learning intervention. Two teachers indicated they would have preferred to attend external professional learning in response to 'Would you prefer to attend external professional learning?' The variations in responses made it difficult to look for patterns, and as such, these were used to inform the development of the teacher stories.

The follow-up question 'After the first week working with the mathematics educator, how do you feel about the professional learning intervention?' was emailed to teachers after Week 1 of the professional learning intervention. Again, the length of responses varied, but generally, there was more reflection evident, such as 'I valued the opportunity of viewing other teachers' lessons' and 'The discussions allowed me to clarify my ideas around the teaching of graphing with preps'. Some teachers also utilised the opportunity to seek follow-up materials including resources and teaching ideas for activities. The change in the depth of the responses may have been as a result of the teachers understanding and experiencing the professional learning. After meeting the mathematics educator, they may have been more at ease or had a better understanding of the purpose of collecting the data. The apparent anonymity of using email or even the opportunity to consider a response may have facilitated more detailed responses. These data were used to inform the development of the teacher stories due to their varied nature.

Responses to the four questions provided guidance to future designing and more detail was collected from the classroom observations and notes. These are presented in the next section.

6.3 Notes and Observations

Observations and notes were recorded throughout the three week-long professional learning experiences at the school. The observations refer to the notes taken from viewing the taught lessons and the notes refer to the data collected from discussions and records of other interactions such as modelled lessons. These were handwritten and were collected during each of the project-related sessions and interactions with the teachers. These were then reviewed during breaks such as lunchtime, and then typed up at the end of each day.

Notes were collected in the triad sessions before and after the teaching experiences. Notes were also collected when meeting with teachers, after team teaching lessons, after model lessons, and at relevant staff meetings. These were generally handwritten and in dot point format to allow discussions to flow. Again, detail was added after the interactions. The classroom experiences of the triad or extra viewed classes were more detailed as they were used to inform lesson and project goals, and as result, I developed a structure as described in Section 5.7.2 to assist in the recording.

The notes and observations were used in a number of ways. They informed the reports which were provided to the school at the end of each professional learning week. They were a summarised recount of the professional learning activity of the week. These reports were also used to meet funding reporting requirements.

The observation notes were used as a form of feedback that would guide the design of the professional learning. For example, in Week 2 of the professional learning, some observations and comments were made that led to the swapping of the order of the teaching pairs of the lessons. Other changes included having teachers of different year levels view model lessons to allow the teachers to view how classrooms operated across the school. Due to the uniqueness of each individual teacher's experiences, it was difficult to identify trends in the observations and notes, but a couple did become apparent. One was student reflections on their learning, and this became a focus in Week 3 of the professional learning intervention. Another was the exploration of open-ended tasks, which gave a broader focus throughout the project.

The observations and notes were used as a record for the mathematics educator and teachers during the professional learning intervention as they were reviewed and revisited. Teacher lesson goals were reviewed and reflected upon, as were project goals, which may have then been modified. The notes became a source, as the time between visits was a number of months.

The observation notes also became more detailed for two of the teachers who were invited for the teacher stories. These teachers were selected, as they were open to being more extensively interviewed and they appeared to engage with the project and the professional learning intervention. It was felt that any teacher, if approached, would have been prepared to be involved in further studies.

To provide the personal nature and interpretation of the data, and to show how experiences can look substantially different for different teachers involved in the same project, two stories are presented in the next section. The first is Belinda's story and the second is Jack's (teachers 2 and 4 in Chapter 5). The stories are presented to illustrate some of the learnings from the professional learning intervention, and they focus on different aspects. While they are a form of case study, they are illustrative rather than exhaustive and are meant to show some of the changes observed in the classrooms during the intervention and provide the detail that the quantitative analysis may not.

6.4 Story 1: Belinda's Story

Belinda was an experienced teacher who had been teaching in excess of 15 years. She had taught at all primary school levels from Prep to Year 6 and had been a leading teacher and acting principal at different times during her teaching career. She appeared confident and involved in school life as exemplified by her involvement in activities outside the classroom such as another research project. Belinda appeared willing to learn and actively sought opportunity to do so during the professional learning intervention. From observation, she was a quiet and thoughtful member of staff, and was well respected with others seeking her advice.

Belinda's story features four main aspects of the professional learning intervention. It begins with her initial response to the professional learning, leading to some of the ideas she began to explore during the intervention. It then examines her response to the goal setting of the triad model over the three weeks. It concludes with her reflection on the intervention.

6.4.1 Initial response

Belinda's responses to the initial three questions (Section 5.7.1) indicated that she supported the concept of having a mathematics educator work with her at the school and was looking forward to the experience. Belinda wrote:

> A mathematics educator would get to the nitty gritty of what was happening [in my classroom] and what was needed and hopefully real change and progress in both teaching and learning would be attained.

It appears Belinda was open to change in the areas of teaching and learning in the mathematics classroom. Belinda saw the process as being an advantage for the students by having 'an expert on hand', and she was looking forward to 'having someone who could watch the kids with me and help me evaluate both their needs and my teaching practices'. She was not worried about having someone in her classroom viewing her teaching, although she did admit that she would be a 'little uncomfortable, nervous and apprehensive' as she was not as confident in teaching mathematics as other content areas. She was also returning to Year 5/6 after a number of years with younger students and was not as confident in the content at the higher level.

All teachers were asked to respond to the question, 'After the first week of the mathematics educator, how do you feel about the project?' Belinda responded:

> After a week working with [the mathematics educator], I feel extremely positive about the project. Any apprehensions I had re [the mathematics educator] watching my teaching proved false as she always concentrated on the positives and had heaps of suggestions on anything I asked about.

This strategy of focusing on the positive was one that I used to build teacher confidence. It also helped move away from focusing on what needed 'fixing' and instead enabled the building of capacity by identifying teachers' strengths.

The importance of follow up was another way of building trust and building teachers confidence in my (the mathematics educator) abilities and ability to follow through. Belinda wrote 'She also followed up on things immediately and has already emailed suggestions. I have tried several already and can't wait to share them on her return.' By following up, it enabled the work and learning to continue, rather than waiting for the next professional learning session. If things were not followed up, the 'teachable moment' may have been lost or forgotten by the next face-to-face session a number of months later.

The importance of working with the principal and being consistent with the message of the professional learning was also reflected in Belinda's comments: 'She was very insightful about the kids learning and was aware of the direction our school wanted to head, as directed in our charter'. It emphasises the need for leadership to have an understanding of the professional learning being delivered at their school, but also the need for external experts entering schools to have a knowledge of the particular school's direction and focus.

Belinda also discussed aspects of the triad model. She mentioned the importance of allowing teachers to select their own focus for their learning: 'The [mathematics educator] also took the lead from the teachers' concerns and needs. She became very much part of our team during the week, which was appreciated by everyone.' This aspect allowed teachers to focus on what they wanted to learn about at a level that was relevant to their classroom and students. This allowed them to really engage in the learning intervention. Another aspect of the triad model she mentioned was, 'I found it interesting to go into another teacher's classroom, to participate in a lesson as that is not a possibility often afforded to teachers'. This aspect of the learning proved to be very powerful, providing time for teachers to observe and then professionally discuss what they saw, and Belinda commented, 'The discussion from that experience was also valuable for my teaching'. This illustrates that time spent viewing other teachers' classes can be worthwhile.

Belinda's initial feelings of apprehension were dispelled, as she seemed to see the advantages of the professional learning model. The professional learning Belinda had experienced in the form of a full staff development day, as well as the first week of triads, particularly the reflection and discussion component, had illustrated Belinda had already attempted new ideas in her classroom. This experience appeared to be a positive one as Belinda was keen to share her experiences and continue the learning process. In other words, the discussion about practice, the practical ideas and the observations of the other teachers created an apparent openness for Belinda to consider her practice.

6.4.2 Exploring ideas

Throughout the project, Belinda seemed open to ideas and tried many new activities with her class, and some of these are discussed in this section.

Belinda introduced student-focused activities that resulted in students creating multiplication facts partner games and tests themselves. Belinda said, 'They love [multiplication] Bingo. I think they are improving their skills also'. This was a change in Belinda's classroom practice, as she had not allowed students to create their own games before. She had felt previously that the ideas and the activities all had to come from her. This was reflected in her comment, 'Their favourite topic for the term was BODMAS', as Belinda had also allowed students to develop activities around this aspect of mathematics. Belinda recounted that one student wrote, 'It was a whole new thing [BODMAS] for me and I was good at it'.

Belinda's goal for the triads was student attitudes in mathematics. While Belinda had some successes, she noted, 'I still need to work on negative attitude and motivation to mathematics'. Belinda found the goal setting challenging, and although some changes in classroom practice had occurred, Belinda still felt that changes in student outcomes were only developing. She wanted to see greater improvements in student attitudes across the whole class. Belinda had examples of positive change in student attitudes; however, she still felt that overall, student motivation and attitude needed more time and perseverance. This could be seen as a cyclic process, as Belinda sought more ideas and strategies through the professional learning intervention as she set about making changes in her classroom practice in an attempt to improve student attitudes and motivation. Belinda maintained focus on this goal throughout the professional learning. This is reflected in Belinda's evaluations and reflection of her involvement in the project.

6.4.3 Goal setting

Belinda found the goal-setting component of the project helpful. At the beginning of each personal session with the mathematics educator, goals were revisited and Belinda commented, 'It made me think about my teaching by setting goals, talking about why I set them and then putting them into practice'. Goals were also revisited after each triad intervention, and for some teachers these changed and for others they remained consistent throughout the professional learning intervention.

Goal setting was a new experience for many of the teachers in the project as they were asked to set goals about their own learning, and Belinda's was student attitudes in mathematics. She indicated that this was 'still a work in progress' at the end of the project, perhaps indicating that new ideas were continually being tried and the goal would take longer than a couple of months to achieve.

As well as project goals, teachers were also asked to set lesson goals for each of the triad interventions, and Belinda found the lesson goals to be useful as 'I feel I consistently set small goals for each lesson and am achieving them more consistently'. This goal setting was a change in Belinda's practice, as prior to the project, lesson and personal goals were not being set. The project goals gave teachers something large to work towards, and the lesson goals provided teachers with small incremental steps to achieve along the way over the period of the project. The goal-setting component of the project continued to provide aims and direction for teachers, providing them with motivation within the project. It was also hoped goal setting would establish some of the sustainability of the project, adding to teachers' practice and perhaps be seen as a worthwhile tool in teaching.

6.4.4 Reflecting

Belinda's reflection of the professional learning intervention focused on the triad experience, specifically, the aspect of viewing other teachers and classrooms, goal setting, and her own sense of change in her teaching practice.

Belinda explained that the triad model of professional learning 'enabled me to see other teachers in their classrooms, it allowed me to see an expert model lessons at my level and other levels, and most important of all it pushed me to improve my teaching and achieve my goals'. These aspects of learning from other teachers, viewing model lessons, and viewing classrooms of other year levels proved to be of value to Belinda. She mentioned these aspects a number of times throughout the project. Her comment of 'pushed me' may indicate that the changes she implemented perhaps were challenging and required the extra support.

When asked how she improved her teaching, Belinda indicated that she learnt that mathematics needed to be more 'real' and that 'students need to see a purpose in all that they do' in the mathematics classroom. She felt that students 'need to have ownership of the activities' and 'that many activities need to have a 'fun' element'. Belinda's perception about improvements in her teaching may have resulted from experiences in her classroom due to new ideas and changes she made. Belinda felt that she had seen an overall improvement in student attitude and motivation, which was her overall goal for her professional learning. This was supported in feedback from her professional partner viewing Belinda's final triad class. Belinda identified change and noted,

> My own maths teaching is changing in that I try to make activities more real, I involve the students more often in composing and assessing the tasks, I try to include games on a regular basis, I am trying to set more open tasks that students of all levels can tackle and I am becoming more of a facilitator rather than a stand out the front teacher.

When viewed in the first triad teaching session at the beginning of the initiative, Belinda modelled the 'stand out the front' style of teaching where she was asking all the questions. This lesson on patterning felt like a 'one off', and no references were made to previous lessons or prior knowledge or learning. During the last triad teaching experience of the project, Belinda facilitated a lesson on graphing in which previous learning was brought into the lesson. The task of drawing a graph was open ended, and students shared their learning during the session, and at the end of the lesson they completed a self-assessment rubric. Although it could be argued that the final lesson could have been carefully planned to exhibit the 'correct' elements of a lesson, or what Belinda thought was something I (the mathematics educator) was looking for, Belinda did teach her triad lesson at short notice due to a change in the timetable for the week, instead of the pre-organised time. Also, the questions that students asked could have been responded to with single word answers; however, Belinda guided the students to find their own answers by referring to previous lessons in their maths books and looking up information in a 'big book' the class had created. Belinda was exhibiting many of the changes she felt had occurred, such as acting as a facilitator and linking the lessons so that the students could see the purpose of the different lessons within the mathematics classroom.

In summary, Belinda identified some changes in her own practices during her involvement in the teacher professional learning intervention, such as acting as a facilitator. Some of these changes were also seen through the observations of Belinda's lessons, such as referring to previous classes and student learning. Belinda valued the opportunity to set her own goals and work towards them during the intervention. The opportunity to view other teachers' lessons, including modelled lessons, enabled Belinda to reflect on her own teaching practice, which Belinda seemed to find a valuable method for professional learning.

6.5 Story 2: Jack's Story

Jack was a young beginning teacher with two years of teaching experience; he was one of the youngest members of staff. He worked in the junior area of the school. He had spent most of his life in the local geographical area, only going away to university. He had a Year 1/2 composite class during the professional learning intervention and had only taught Year 1/2 previously. Jack appeared to be quiet, thoughtful, and a conscientious member of staff.

Jack's story examines his involvement in the project and his growth throughout the intervention. Jack's story features four main aspects of the professional learning intervention. It begins with his initial response to the professional learning, then discusses the time between the professional learning weeks, the ongoing nature of the learning, and his own development in confidence as he reflected on the professional learning intervention.

6.5.1 Initial responses

Jack's responses to the initial three questions (Section 5.7.1) illustrate hesitation and nervousness about the professional learning intervention. He was one of the few teachers who indicated that he would rather attend an external professional development day, as he was 'unsure what to expect with the mathematics educator program'. His recent university experience of teaching practicum where students are viewed and assessed was reflected in his comment to the question, 'How do you feel about having someone coming to view your teaching?' Jack wrote, 'I didn't want anybody judging the way I taught and thinking I wasn't doing a good job'. Jack was concerned about the experience with the mathematics educator and another staff member observing being judgemental.

During the first full staff professional day, Jack hardly said anything, and then it was only by encouragement or the direct asking of a question. He appeared to be one of the quieter members of staff. Jack was clearly apprehensive about the whole professional learning intervention. For

Jack's first triad learning experience, his partner taught first, and during his time in his professional partner's class, Jack sat and observed and diligently created observation notes. He did not interact easily with the students, and he appeared to distance himself from direct student contact unless it was keeping students on task. In the reflection time after the lesson, it was difficult to draw Jack into the discussion, and he gave the impression that he did not want to or perhaps did not have the skills to provide constructive feedback to his partner.

Jack used his first one-on-one discussion time with the mathematics educator to raise concerns about student behaviour in the mathematics lesson and was unsure why it was such a different experience to the literacy lessons. He commented, 'The students love literacy and listen really well to each other. They will even sit and read each other stories like a teacher would, but they do not do this with maths'. It was an area that concerned Jack and was the focus for his first triad experience. During the time with the mathematics educator, the discussion included lesson structure (whole, part, whole), reflection time, and 'tuning' students in with an activity. Class goal setting and expectations of students listening to each other were also touched on. Jack took an aspect from the discussion and implemented it into his first peer-observed class immediately, which would have been a risk.

In the discussion after the teaching experience, Jack found it difficult to take on feedback. Jack's professional partner had noticed his unease and nervousness of the process, and the comments and discussion were both positive and constructive. Even with the positive nature of the discussion, it was still difficult to encourage Jack to say much, and many of his comments were negative. For example, Jack's professional partner commented, 'I really liked the way you took the opportunity to read the story', and Jack responded with 'It was alright. I wouldn't usually divert from my lesson plan'. This was the aspect that Jack had included from the discussion prior to the lesson.

The discussion focused on the structure of lessons and that sometimes there are teaching opportunities that may arise that were not planned. Jack's professional partner provided a number of examples of this. Towards the end of the discussion, Jack commented, 'I am relieved that I don't have to follow the same model every lesson. I thought that this is what we had to do, as this is the only way we were shown in the training'. It appeared that the discussion before the lesson, the experience of trying something during the peer-observed lesson, and the discussion after the experience, including the partner teacher examples, illustrated to Jack a different way of approaching his teaching.

As a result of the discussion, Jack decided to target one aspect of the teaching of mathematics, attempting new ideas in mathematics lessons. However, to support Jack, this was narrowed to the beginning or end of the lesson to ensure the goal was not too broad. Jack's goal at the end of Week 1 was 'attempting new activities and ideas in the introduction and share time component of maths lessons'.

6.5.2 The time between professional learning weeks

Between Week 1 and Week 2 there was email contact between the mathematics educator and Jack. Activities and ideas were shared. Jack reported he was trying some of the different reflection ideas in his mathematics lessons: 'I am also trying different reflection ideas and am having much more success drawing information out'. This availability of the mathematics educator between the full weeks of professional learning provided Jack with the ongoing support. He was able to share how his learning was going and seek help if required.

Jack's response to the question, 'After the first week of the mathematics educator, how do you feel about the project?' posed after Week 1 of the professional learning intervention indicated that he was feeling more comfortable about the project: 'I am very positive about the project. The week the mathematics educator was here was fantastic and I gained so much from having her around'. It appeared that Jack had seen opportunity in the professional learning intervention and was not as apprehensive about being judged: 'Having her in the room whilst I was teaching turned out to be not as daunting as I thought it would'.

Jack commented on the structure of the program: 'It was great to know that we could ask her for advice at any time during the week. She was very supportive and more than willing to help'. It appears the flexibility in the timetable (see Table 4.1) could be a valuable aspect of the professional learning intervention, allowing time to revisit classrooms or providing time for teachers to seek more assistance as required. Jack completed his comments with, 'The week was very worthwhile and I am very appreciative to be involved in such a project'. It appeared Jack was already engaging with the professional learning intervention, and Jack's response to the question was one of the more detailed ones.

6.5.3 Developing over time

In the discussions during Week 2, Jack was again negative and unconfident in his abilities. Jack's partner commented on how the students appeared more settled and focused in their learning in the triad discussion after the teaching of the lesson. Jack still felt that the students were quite unsettled and not always as productive as they could be. Reassurances were made that it would take time for the students to respond to different teaching strategies, and Jack may not feel difference in the way the students were behaving, as he was involved in the class on a daily basis. Jack's partner commented that 'this particular group of students were always going to be very active, and that Jack should enjoy and build on the students' enthusiasm'. Jack acknowledged that the personalities of this group of students was different to his previous classes. Jack was, however, very proud of the students' improvements in their written work, and after the triad discussion shared a number of samples of work of many of the students in the class. Jack shared the teaching activities that had led to the differences in the work. At the end of the discussion, Jack decided to keep working towards his goal of 'attempting new activities and ideas in the introduction and share time component of maths lessons' at the end of Week 2.

Week 3 was where a more significant change was visible. When Jack came to the half-hour session before the lesson to be taught, he immediately started talking about the strengths of the professional development model, without prompting. Jack talked about how he felt his use of the 'whole, part, whole' model had developed and deepened, particularly in the area of student reflection on their learning. He felt that the content of the reflection time had evolved from just having a student always reporting back to including all the students in some way. This whole-class involvement was working to engage all his students in his class. Some of the introduced strategies that Jack had found effective included group reflection, games, drawing pictures, peer reflection, and taking home reflections to share with parents.

Jack acknowledged that as a result of the initial visit, an aide was provided in the classroom to support a particular student, and this worked very well with the student demonstrating immense progress in numeracy and other learning areas throughout the time of the project. The principal helped facilitate this by organising the testing of the student and funding the relevant aide support, as Jack had not had a classroom aide before and he needed support to learn about the process. The support of the aide helped to alleviate some of the discipline issues of the classroom, as the particular student was supported in their learning. Jack also acknowledged that mathematics was more of a focus in the classroom, with more student work and mathematics-related information being displayed in a specific area for mathematics and numeracy.

Mathematics had also become a focus in Jack's personal learning. Jack took the opportunity of the time and support provided by the project to try new ideas, activities, and strategies. He stated as a direct result of the project that there had been changes in his classroom, including when mathematics was taught during the day, the inclusion of more hands-on activities, the inclusion of more games, and the use of students' enthusiasm and interests to drive the lesson. When asked whether the changes would have occurred if the project was not implemented, he said, 'No, I would have been still struggling on my own'. Jack had engaged with the professional learning intervention, and the support of the mathematics educator, the principal, and the aide were perhaps giving Jack the opportunity to explore different teaching strategies in his classroom.

During the observation of the teaching in the triads, Jack's partner observed a change in the students' reflection time of the lesson. His partner commented that Jack participated more freely in the discussion and was more expressive in his answers. In the discussion, Jack was also more accepting of positive feedback about his questioning technique. During the discussion, the professional partner noted changes in student behaviour and engagement in the mathematics lesson. Jack offered without prompting that he felt the students were also responding to the changes that had been made. Jack indicated that the more relaxed feeling of the students made him feel more relaxed and at ease with his teaching and the class.

Jack adapted his goal of 'attempting new activities and ideas in the introduction and share time component of maths lessons' to include the 'recording of these ideas'. Many of the new ideas and activities that Jack had tried and used, he had not recorded or shared, so he had decided that the first step was to record all these activities he was using. This was discussed in the triad discussion, that this could be the first step leading towards the sharing with the rest of the staff Jack's experiences.

6.5.4 Developing confidence

All staff were asked to think about, write, and bring a personal reflection to the final day of the professional leaning to share. The teachers were provided with some areas to think about and some sentence starters, but they were allowed to digress and develop their own reflections as they preferred. Jack structured his reflection as a number of questions in response to the topic headings, which he wrote and spoke to. Jack on the day shared some of what he had written. The following comments are from both Jack's verbal and written account.

Jack discussed his learning of mathematics. 'I have learnt that maths is not as daunting, I am feeling more comfortable about the course [content], and I find I am enjoying it more'. Jack at the beginning of the professional learning intervention had been challenged in the students' response to the learning of mathematics compared to literacy. His feeling of confidence may have resulted from elements of the professional learning. Jack embraced the experience quickly in Week 1 and engaged with all elements of the intervention, including taking the opportunity to seek help and advice as required.

Jack discussed his learning about his own teaching. He commented, 'I have learnt that I am not that bad at the teaching of maths and my ideas and approaches to teaching the subject are actually pretty good'. During the professional learning intervention, Jack tried many different approaches in his classroom. Some were learnt through the professional discussions held after the peer-teaching experience, some were from the observed classes, and some were sought from the mathematics educator. One aspect that Jack discovered through the professional learning intervention was that 'I have learnt to relax and not to be so worried that I am not following the Early Years Numeracy [model] to the book as it does not always work for every grade'. Jack commented on this aspect of his learning in Week 1 of the professional learning intervention and in his reflection of the project.

Jack learnt about learning and commented, 'I feel as long as I am aware of my students' needs and what they are capable of, making sure I meet them to the best of my abilities, then they are still going to learn'. He became more aware of the different ways students could learn, and this was reflected in the comment made by his professional partner in Week 2 of the professional learning, that classes are different with different combinations of students. It could be argued, as Jack was young in his career, that some of these learnings may have happened anyway. One of the strengths of the professional learning intervention is that Jack could identify and articulate his learning.

Jack commented on the structure of the triad model, commenting that the 'The partner observations were a terrific help'. He indicated that the discussions of the triads were where a lot of his learning was taking place, as ideas and experiences were shared. Both these discussions and observations proved to be useful as Jack commented that 'It gave me the reassurance in the way I was teaching maths was not that different to others more experienced within the school and that I was on the right track'. Jack was learning in a number of ways from other teachers, which helped to reinforce his practice and give him confidence without it being a judgemental process. He also commented on the individual time built into the triad model, that 'The one-to-one talks helped to build my self-confidence and reaffirmed what I was doing was right.' Again, Jack mentioned the aspect of confidence building.

As well as commenting on teaching and learning processes, Jack also discussed goal setting in his reflection. He found that 'setting the personal goals was also a big help as it gave me something to strive towards and become more aware of how to make my teaching more effective'. Jack's initial goal was 'attempting new activities and ideas in the introduction and share time component of maths lessons'. This remained the same during most of the professional learning intervention. He redefined his goal by Week 3 of the professional learning intervention to include 'recording of these ideas', as he found he wanted to record what he was learning. He commented, 'I am working at not being slack with the recording of my ideas and what I did in a lesson, how I may have changed it along the way or a reflection idea we have used, so that I will remember in the future'. Jack's lesson goals were also focused on the same theme throughout the learning intervention. He felt that he had achieved his goal and commented, 'I achieved my goal of getting the children engaged more in the reflection component of the lesson'. Jack had used the goal setting as a focus in the professional learning intervention and felt he had achieved what he had initially aimed to do, but his goals were also developing and evolving.

Jack commented on the overall professional learning intervention stating, 'The way the professional development was done was important as it was approached in a relaxed way and I think it got the best out of me as I felt confident in expressing my beliefs and evidence knowing I would not be judged.' Jack found the model was an effective learning process, as it catered for his own learning style and could enable him to explore his areas of concern or interest. He commented on beliefs, and it appears the discussions involving the mathematics educator and partner teacher were an important aspect. He identified this as one of the strengths of the professional learning intervention, commenting, 'The project was more about bettering yourself and your teaching on a personal level knowing that the advice and information was targeted at you directly'. This element of personalisation within the broader learning intervention gave Jack a sense that the learning was targeted for him and his learning needs.

Jack commented that one of the strengths of the professional learning intervention 'was I could put into practice what had been discussed the following day and continue it knowing that we would have a follow up discussion later on'. Jack valued being able to practice what had been discussed and found the learning relevant to his current practice and could be employed back into the classroom. He also valued the extended learning opportunity as it gave his learning purpose and accountability. He could seek further feedback during the weeks due to the flexibility in the timetable after lunch (see Table 4.1), he could seek feedback via email contact, and follow up was built into the time spent before the next triad experience. This was evident in Jack's further comment: 'Because the project was continual there was a drive to use the knowledge gained as you were going, knowing the problems I encountered along the way could be attended to and the comfort of support was only an email away'. The availability of support reassured Jack, as he knew there was someone he could contact if required.

Jack felt that 'We worked very hard this year attempting new approaches to reflection', and this can be seen in Jack's challenges during the year, and particularly in Week 2, where he felt that student engagement had not improved and he had to persevere with his goal. Jack felt there was change. He commented,

> I can see a big difference from the start of the year where I was dreading a lesson of maths because some students were not being focused or engaged enough to be grasping any of the concepts I was attempting to teach them. I found that there were the same few students answering the questions I asked of them all of the time and I was rushing through and admittedly was on occasion skipping reflection or making a half-hearted attempt because I could not get anything out of the majority (of students).

Jack felt that there had been change, and this feeling had increased his confidence and he continued to persevere trying different ideas and strategies coming from the triad and professional discussions. Jack commented, 'My maths lessons are no longer hard work! I enjoy teaching the subject'. As a result of Jack's experiences, he was developing a more positive approach to the teaching and learning of mathematics. He found elements of the teaching of mathematics more enjoyable and productive: 'Our reflection time is differently approached and not always the same every day. I can get something out of all [the students] a majority of the time, something that was not happening at the beginning of the year with this particular group of students'. Jack felt he was engaging with the students and that they were responding in the mathematics lessons, which was not occurring earlier in the year.

In summary, Jack identified many aspects of his practice that were examined as a result of being involved in the triad teacher professional learning intervention. Changes in Jack's teaching and classroom behaviour were observed by the teacher partner and the mathematics educator. In some ways, Jack needed permission to change his practice so was open to change; however, it was still not an easy process. Some of this affirmation occurred through the discussions, as was through the observations of other classes and teachers. Some of the challenges for Jack included the rate at which the change was occurring. Jack used goal setting to guide his learning and provide the motivation during the professional learning intervention. Jack identified for himself that the strengths of the model were the on-site nature of the learning, the provision of time and support to try new things, and the follow up provided.

This growth in Jack's own learning and teaching was reflected in the behaviour of his students in his mathematics class and in his own personal experiences. Although Jack commented a number of times that it had been a difficult and challenging year, he acknowledged the experience will provide skills in his future years of teaching.

Jack's initial concern was about his students' learning and his current teaching practice; he felt that 'it wasn't working'. The project provided a strong motivation for Jack to review and perhaps revise his practice. It was during this process that the classroom became the context for him to learn. The changes in teaching practices did not result as single incidents but rather as a collection of efforts over a period of time. The break between the mentoring sessions and the observation weeks provided the time for Jack to try different strategies. Through this experimentation, change occurred as Jack worked within his classroom. These changes came about as a result of dilemmas and conflicts. Some of these dilemmas included teaching strategies he had not used in his prior practice. He also had to change his expectations of the students in his current class to those from previous years. He was challenged, as he had to think about different teaching methods to allow students to express themselves in ways that were not what Jack saw as being traditional. He also considered activities that were more active and engaging for the students as the traditional book work was not engaging students in his class.

6.6 Concluding Comments

The two teacher stories illustrate the different experiences of two teachers involved in the professional learning intervention. Each teacher explored different elements of their teaching and responded to different elements of the model. The professional learning path for both teachers was quite different, but this was a strength of the model as it allowed for the individual to set their own goals, within the context of the project, working on issues that would make a different in their classrooms and to their practice. They felt supported within the structure of the triad, and there was strength in the multiple perspectives, providing depth and validity to the discussions. Another strength of the model was that teachers could practice and try new ideas with their own classes and receive instant feedback, and this was complemented with time to reflect about the experience before the next full week of professional learning.

Belinda was an older and more experienced teacher than Jack. Both teachers engaged with the professional learning intervention and found it met their needs in setting and working towards their own goals and the school's broader goal.

Belinda's story presented her initial response to the professional learning intervention, touching on the triads, and visiting other teachers' classrooms. It presented her journey of exploring ideas and the value she found in goal setting to support her learning. Belinda's story concluded with her reflecting on the professional learning intervention.

Jack's story also began with his initial response to the professional learning intervention. It then explored Jack's use of the time between the full weeks of professional learning. Jack's involvement in the intervention over time illustrated his frustrations and perseverance in his learning and attempts at change. It also included details on how he was supported during the experience. Jack's story concluded with an exploration of how his confidence developed as described in his reflection of the professional learning intervention.

The two teacher stories illustrate a number of strengths of the professional learning intervention. Both the questionnaire data analysis of Chapter 5 and the two teacher stories show evidence of change in teacher practice as a result of the professional learning intervention. Chapter 7 will provide my reflections and learnings resulting from my role as the mathematics educator and researcher during the professional learning intervention.

CHAPTER 7: DISCUSSION AND SELF-REFLECTION

Chapters 6 and 7 presented the findings of the study of the professional learning intervention. In Chapter 6, this was the data of the pre and post intervention data collection and the comparison analysis framed by Shulman's (1986b) six key elements of PCK. In Chapter 7, this was the data from the questions and observations collated into two illustrative stories. This chapter describes my reflections on the teacher professional learning intervention. The narrative draws on my research and the different perspectives of the roles that I played during the research, including as the mathematics educator, a co-learner, and a researcher. This chapter is included because the mathematics educator role was one element of the triad central to the professional learning intervention.

7.1 Introduction

My role as the mathematics educator in this study created a case for devoting a section to self-reflection. While the chapters thus far have been based around the professional learning intervention of the teachers, and the data have been used to respond to the research questions, this chapter describes what I have learnt through the experience and the impact it has had on me as an educator and leader of professional learning. This chapter is not technically a self-study as it is not rigorous in its method; it is a process of examining my own learning. This chapter does illustrate the learning that can occur when involved in a small scale intensive study such as this.

This chapter explores my learning through a number of themes. Sections 7.2 and 7.3 provide some background to the learning, creating the context. Section 7.4 presents different elements of the professional learning intervention that have impacted my learning. In Sections 7.5 to 7.7, I consider my learnings within the main identified influences of the professional learning intervention: teacher change, working with leadership, and working with teachers over time. Finally, I reflect on my role as the mathematics educator.

7.2 Research and the Mathematics Educator Role

Each of the research approaches discussed in Chapter 5 have relevance to my role and learning. This includes the study being located on-site at a school and in teachers' classrooms. The research related to each of the teacher's unique situations within the single professional learning intervention (Cohen & Manion, 1994), reflected in my integration as the mathematics educator within each of the triads. The research was collaborative for me as well as for the teachers, with all involved being active members of the triads. I also worked closely with the principal, particularly in the initial phases of planning, selecting and then developing the model, and creating schedules. While the mathematics educator was identified as being a core element of the triads and the professional learning, the actual role initially was not defined, and through my experiences and learnings, it developed over time. The research was also interpretative as I was continually intervening during the professional learning intervention (Erickson, 1986), and while no-one was collecting observations on my work, I did collect my own notes as both recounts and reflections as I taught model lessons and taught with teachers as well as considered my own learning during the mentoring experience. At the beginning of the teacher professional learning intervention, a model was chosen and structure organised; however, what happened within the structure was designed and crafted through the duration of the experience by me and the teachers (Bereiter, 2002). Like the overall professional learning intervention, my role as the mathematics educator was defined by a number of research methods.

7.3 What It Means to Support Teachers

My role as the mathematics educator in the project was to support teachers in the learning process. It was not the role of a teacher's aide, but as a mentor or a coach. Morehouse (2008) identified aspects that make mentoring effective, which include the mentor's ability to answer questions when they arise or have the connections to find out answers if they do not know them. Due to the intensity of the three week-long professional learning interventions, this required me to have the skills and resources at my fingertips. My previous roles at organisations such as the Mathematics Association of Victoria provided me with people and places I could call on. I did find during the weeks that I developed my research skills, as I had to look broadly for some supporting materials and ideas.

I was also involved in teaching model lessons and required experience and knowledge to do this at all primary year levels. This required me to revisit some content at different year levels, and as I had not taught many composite classes, I considered these lessons carefully.

Another aspect of mentoring is to provide constructive and supportive feedback (Morehouse, 2008), which was one of the main functions of the mathematics educator in the triad. The goal-setting component of the professional learning intervention gave the teachers something to work towards, and this is seen in the comments in Jack's story. It also provided a context against which the teacher partner and mathematics educator could provide feedback. Kinlaw (1997) stated that a true coaching conversation is balanced and two-way. The role of mentor requires listening skills, and I employed this skill in the triad components.

Other ways I supported teachers was being available with time and being contactable. Being on-site for the week aided this, as did the structure of the timetable (see Table 4.1), and Jack's story showed that the ability to access the mathematics educator was an important aspect of teachers' learning. I also made myself available between the full week professional learning sessions. The aspect of follow up was important, as illustrated in Belinda's story, as it provided the credibility of the mathematics educator.

7.4 Professional Learning Intervention

This section explores a number of my learning opportunities associated with the professional learning intervention and includes the classroom aspect; the triad model; professional discussions, observations, and reflective practice; building relationships; trust and mathematics confidence; and the importance of stepping back.

7.4.1 In the classroom

This section looks at two aspects of working in the classroom: the location and the use of observations. One of the advantages of having the professional learning at the school was that teachers did not need to travel; I travelled to them. This is worth noting as the school is in a rural location. The research indicates the importance of learning in classrooms, which creates relevance for teachers as learners (Neufeld & Roper, 2003; Opfer & Pedder, 2011); however, it was not until the discussion component of the first triad session that I started to really see its true value. Before the lesson, there were nerves and apprehension of both the teacher and teacher partner, but in the discussion session after, the teachers discussed freely what they saw and how they felt. It was not always that easy; however, teachers liked discussing ideas that were relevant to their day-to-day practice. Classroom environments are dynamic locations and hence, rich environments to examine what both students and teachers are doing and how they are responding and reacting to the interactions around them. It was interesting to watch how the physical location of the teacher could change the dynamic of the classroom, and this was discussed in a number of the triads. Teacher observers noticed different aspects of the classroom environment and interactions to what I observed, and the value of having two observers became apparent.

I had been involved in PST observations through my work in universities in teacher education; however, this project was the first time I had been an observer for teachers, particularly across a whole school. Initially, I took many notes but they were not focused or particularly useful. I quickly developed a template that contained the teacher's goal of the lesson, the timing, and columns for observations against the lesson goal and general observations (see Figure 4.4). Due to the number of observations and conversations, I needed to have a system that would support me. By using the template, this ensured I recorded the teacher's lesson goal prior to the lesson, so I could check back against it. In the first teaching session, I did not record the timings of lesson components, but discovered in the first triad discussion that this could be a useful piece of information, and that is why it was included in the template. As a result of this experience, I now always use a template when observing in any classroom, whether it is the same basic structure as developed for this study or a more detailed one.

The different perspectives of the same class surprised me. In the triad discussions, the teaching teacher tended to be quite negative about their performance with comments such as, 'I didn't like how . . .' and 'I didn't explain . . .' and this was generally counteracted with a positive response from the partner teacher. It was also surprising how different people observing the same aspect of teaching would have quite different interpretations. This showed me that I was not an expert but rather someone who had a different perspective contributing to the conversation, and in fact, my role was a guide who contributed but kept people on task. Fieman-Nemser (2001) stated that the role of conversation is the most important tool of professional development, where teachers as well as experts are doing the talking, thinking, and learning: 'Through critical and thoughtful conversations, teachers develop and refine ways to study teaching and learning' (p. 1042). I needed to remain mindful that because people had different perspectives on observations, they would also have different interpretations on the discussions.

7.4.2 The triad model

When the principal and I sat down to discuss the structure of the professional learning intervention, we examined a number of different models. This included one-to-one mentoring and coaching models, but it quickly became apparent that a triad option could be effective for the school. This was partly because one of the aims was sustainability of the learning, and it was felt that by having three people involved, two of whom were from the school, there was a greater chance of the teacher learning continuing after the end of the intervention. At that point, I did not know this was a triad, but the teacher, partner teacher, and mathematics educator combination was determined, and I researched the model (Haymore Sandholtz, 2000; Kenny, 2009; McIntryre et al., 1996).

I found a number of strengths with the model we settled on. The model allowed teachers to select their own learning focus, as mentioned in both Belinda's and Jack's stories, and this gave them ownership over their learning. It made the learning intervention relevant, not only personally, but also to their daily classroom practice. It allowed the intervention to be targeted at the teachers' needs, as would be completed with students, so the learning became even more relevant and informed by what was observed in the classrooms. It also allowed the teachers to be involved in the development of the professional learning during the intervention (Kaur, 2012). This was a different way for me to examine professional learning, as I had been involved in the 'one-size-fits-all' process previously. It was during the intervention process that I could see teachers progressing at different rates towards their goals. This is illustrated in Jack's story, where in Week 2 of the professional learning, there was a sense of frustration as Jack felt progress was not being made, whereas the partner teacher and I could see some change; it was not until Week 3 that Jack could also see the progress. This teacher learning process taught me that everyone learns differently and at different rates (Masters, 2016).

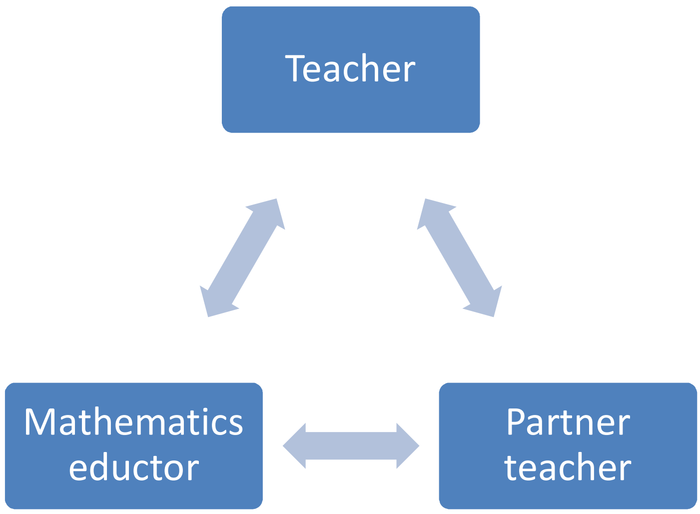

Figure 7.1 Relationship between each person of the triad model.

Another strength of the triad model was that everyone had the possibility of learning from each other (Figure 7.1). There was interaction between the teacher, partner teacher, and the mathematics educator. Hord (1997) presented the concept of 'peers helping peers' (p. 4), whereby teachers regularly visit each other's classes and observe, and then afterwards discuss the lesson. Hord found that this forms an integral part of the development of both the individual teacher and the school's teaching community as a whole. The teacher of the triad was experiencing the lesson, having time with the mathematics educator talking about their own learning goals, being observed, and receiving feedback from the partner teacher and the mathematics educator. This created relevance for them and the partner teacher, as the learning was on-site, in their own environment (Opfer & Pedder, 2011). The partner teacher could view a class in action, which as Belinda's story shows is something she had not often experienced. They also participated and engaged in the discussion. I was surprised by the comments that partner teachers made, as they were insightful and not just recounts of an event. I believe the opportunity to sit and view a class provided time to immediately reflect and interrogate what had been viewed; this allowed for a well-articulated comment when it came to discussion, as this is what I was doing. I was looking for key aspects of the lesson to discuss and target in the discussion session after the triad lesson. I found that my comments were becoming more informed and developed as the professional learning intervention continued.

Hord (1997) highlighted the need for teachers to have 'an environment that values and supports hard work, the acceptance of challenging tasks and risk taking, and the promotion of growth' (p. 4). The development of the triad seemed to provide the teacher with confidence to take risks. I was surprised that Jack, from the very first discussion session, took one of the ideas and applied it to the first peer-observed session. After getting to know Jack, this was a risk he had taken as it was not a method he had really used, especially as he had not taught in the triad before. A number of the teachers took similar risks during the project, which always surprised me, particularly when in the research there was a focus on the challenges of making change, as this takes time and professional involvement (Britt et al., 2001). However, some teachers did just jump in. Other teachers needed more support and to work towards smaller goals in a more consistent approach. This links back to different learners learning at different rates via different experiences.

Within the triad model, the mathematics educator role provided the opportunity to support and mentor a teacher, view a class in action, and be involved in the discussions. It allowed me to be actively involved in the teacher learning process rather than being a pure observer, and I felt this suited my personality. I learnt teaching ideas and had rich discussions with both the teacher and the teacher partner around classroom practice and understandings of teaching and learning. As each teacher could select their own learning focus (Cohen & Manion, 1994) for the professional learning intervention in their own classrooms, it was a challenging role, as I needed to be organised and understand different teachers' needs. I had to learn to work with a range of different personalities and determine who needed more time and who needed less intervention or support. I feel this taught me a lot about people in general and about being more open to differences. The challenge was moving from one classroom to the next, working with different people and taking on different roles, sometimes being the teacher, other times the facilitator or observer. In this sense, it was a mentally tiring role, which I did not expect.

Guskey's (1997) third principle of common professional development elements talks about making small changes guided by a grand vision. The triad model allowed teachers to have lesson goals under the structure of a larger project goal. Goal setting was an important aspect of the professional learning model and features in Jack's story. The small goals allowed teachers to make achievements along the journey, and this helped them to work towards a larger goal. Many of the teachers initially began with a goal such as improving questioning in the classroom. Unpacking this in the discussions, however, I discovered questioning had many elements such as written, verbal, open ended, and closed. This required setting small goals, as the goals were too large and difficult for the teachers to address and the observers to comment on. I learnt that one or two focuses for the taught lesson and an observation is sufficient. This allows the feedback to be targeted and relevant and it allows for clearer learning. This aligns with clear intentions in lesson planning as well. This is an understanding that I use in my teaching and when mentoring PSTs and teachers in classrooms.

As well as the teacher goals, there was the larger aim of the school, which was improving mathematics teaching practice. The process showed that all these goals together worked towards the unified staff goal of 'teachers as learners', and it helped staff with the grand vision. It seemed that the individual experiences of each teacher, which were shared with a peer, made for a much more dynamic and interactive sharing when talking about the project's broader aims. I wondered if the discussions would have been as rich if all teachers were examining the same element of practice in their classrooms. Feist (2003) argued that professional development activities need to match different learning styles, and therefore, participants are more likely to be involved. I felt teachers were more involved as they were genuinely interested in their learning and what they could achieve from the project. In teaching, we cater for different learning styles, so I think this also applies to teacher learning and indeed any learning situations.

There were many strengths to the triad model, but I also learnt that it was extremely intensive and demanding. The format required the mathematics educator to be essentially ‘switched on’ and actively listening, observing, and contributing for essentially five hours straight as the discussions usually ran over time into recess or lunch. I was unable to locate any research that showed the impact on the observer and the maximum length of time they should observe.

7.4.3 Discussions and reflective practice

I felt that the discussion aspects of the professional learning intervention were crucial in teachers' learning. Before each teaching session, I spent half an hour with each teacher. Initially, this was confronting for both the teacher and me. I was conscious of the teachers feeling judged or assessed (Hastings & Squires, 2002), and I addressed this by preparing a small number of questions I could ask if discussion was not flowing, such as ‘What are you currently teaching in mathematics?’ ‘What do you enjoy teaching in mathematics, and why?’ ‘What is your focus in your taught lesson?’ and ‘What have you tried since the last meeting?’ For me, it was the first time I had discussed practice in an intensive way with a number of teachers in one-to-one and small group situations. I was aware of the need to quickly build trust (Timperley, 2008) as we needed to work together over an extended period. This time before the lesson was the teacher's time where they could ask questions and reflect on their experiences; it was also the time they could get to know me and I to know them. The discussion sessions after the observed lesson were equally important.

Possibly as an extension of my own teaching, I always began the discussion with ‘What did you think about the lesson?’ Initially, I did this to take the focus off me; however, I learnt this provided the teacher with the opportunity to debrief, feel valued, and allow them to retain ownership over their lesson. I noticed the observing teachers sometimes found it difficult to provide feedback on elements on the lesson that may have not been effective, as they tended to focus on the positive rather than the negative. As the mathematics educator, I tried to be an impartial observer and talk about aspects of the lesson that worked, aspects that students struggled with, and aspects that could be approached in a different way. I did not know the details of the teacher's backgrounds, the students, or the particular class dynamics, and I tried to comment on the key aspects of the lesson. This changed over time as I worked with the staff and learnt more about the school and the teachers.

All the discussion groups were productive and none of them finished early, with some discussions running into recess or lunchtime. Teachers did find reflective practice challenging (Amulya, 2004), and the discussions in the triads aided in developing this practice. In retrospect, it would have been good to provide staff with some professional learning in this area during the first day of Week 1, as it was an important element of the model. I was pleased to discover in Week 2 that three teachers had written reflections after their teaching experiences (Buczynski & Hansen, 2010). Cooney and Krainer (1996) stated that 'an important component of the reflective process is recording and analysing experiences via the written word' (p. 1174). Jack acknowledged that recording his ideas became important as the professional intervention proceeded. Reading about reflective practice, I learnt that just because the reflection had been completed does not mean it will result in a change in teacher practice, as it needs to be built with action (Clarke & Peter, 1993); I felt the triad model provided both the opportunity to reflect and to act on the reflection.

7.4.4 Building relationships, trust, and confidence

When working with people, communication and the building of relationships are generally at the top of the list; however, when working in an environment where practice is being observed and discussed, trust becomes important, too (Timperley, 2008). The construction of the professional learning intervention using triads provided the time for relationships to develop, and for me, I learnt about the school, teacher concerns, and what they wanted to learn about. I found it a tricky role, balanced between maintaining professionalism, being a researcher, and allowing some of my personality to come through. The teachers needed to feel they could trust me and my skills, and likewise, the principal had to have confidence in my skills in leading the project (Farmer et al., 2005). This did develop over time, and I always made sure I followed up what I said I would do. By doing this, I believe I also created an aspect of accountability from both the teachers and me.

I felt supported by the principal in my role and valued the trust that was placed in me. This was reflected in the support to the staff as well as they were encouraged to try new things, and it was okay to make mistakes during their professional learning (DuFour & Berkley, 1995).

I learnt to value the element of trust in teaching and learning situations through the role of mathematics educator. I applied this in a number of situations as a result of the research, in PST mentoring situations and teacher classroom observations. While working at a university, I implemented a peer observation model with academic and sessional staff members as a form of professional learning.

7.4.5 Building mathematics confidence

The aim of the project was to change teacher practice in the mathematics classroom, and this required mathematical knowledge, pedagogical knowledge and pedagogical content knowledge. It is acknowledged that the teaching of mathematics is different to other content areas. It requires teachers to have deep understandings of the learning of mathematics and strategies of how to move student learning from one point to the next, with its own signature pedagogy (Shulman, 2005). Through the reading, I learnt there appears to be a significant correlation between teacher self-confidence and competence (Stipek et al., 2001). The use of the triads provided opportunity for teachers to receive feedback about their practice in mathematics teaching, and often this was positive or constructive. I felt this added to developing staff confidence. Confidence was also built in the triad sessions, allowing teachers not to feel isolated within their own classrooms and to have discussions around strategies and particular ideas, which is the foundation of communities of learning (Borko et al., 1997). Jack commented about the ability to learn from experienced teachers, which gave him the reassurance that he was on the right track.

Some of the confidence built was around the pedagogy of mathematics, and for some teachers, they just needed permission to do things differently, such as a move away from a particular teaching model if required (Pegg, 1989). In Jack's case, the model did not work naturally as presented in the training sessions and became an uncomfortable formula for teaching mathematics. It required some additions and slight changes to suit the combination of students. Jack just needed 'permission' to do this. This taught me that intervention does not always have to be a big event or a large change, but could be subtle and something that appears to be simple as in Jack's example. This applies to aspects of teaching such as focusing on one lesson learning intention or having one small goal to work towards. I used this understanding as I supported teachers in their experience, looking for small changes or small goals to set. As Belinda's story shows, having smaller goals made the process more manageable.

Many of the teachers showed, through encouragement and support, that they knew more about mathematics and the teaching of mathematics than they thought. The experience showed me how important it was to focus on the strengths of the teachers and be positive about the teaching and learning of mathematics. I found this could be built through observations and discussions, particularly for those teachers lacking confidence in their mathematics ability. I found teachers of all ages were open to learning.

As the project processed, my confidence grew, not only with the development of the professional learning intervention but in my own mathematics education ability, as I was able to support the teacher learning. I learnt how to break down complex situations into smaller pieces that were more manageable for people to examine. I used this strategy during the discussions and found it enabled teachers to work towards how they would approach the problem or challenge. I also learnt how to build people's confidence by focusing on what they could do and then building on those skills.

7.4.6 Stepping back

The following list identified by Hargreaves, et al. (2001) for leaders could apply to all professional learning:

- To support teachers and where necessary, push them to be able to implement appropriate changes that matter;
- To ensure that the changes that teachers make can be sustained over time; and
- To ensure that the changes can be generalised beyond a few enthusiastic teachers. (Hargreaves et al., 2001, p. 157)

The notion of sustainability and generalisation became important in the professional learning intervention. The role of the mathematics educator was to support, mentor, and coach teachers during the professional learning intervention; however, being an expert external to the school, the mathematics educator at some point would have to leave.

The principal and I worked on the triad component of the professional learning intervention, designing it with the view that the mathematics educator would leave at some point and the teacher pairs would continue to operate. A later visit to the school showed that this had occurred and was supported by the learning moving into another subject area. However, sustainability also requires teachers to have enough confidence to try new things within their classrooms and have an increased awareness of where to access support and materials, with the determination to continue the learning and implement the changes.

I learnt about not needing to be the one who has to be in control of the time. Rather, I was there working alongside teachers, intervening if required or requested. The process taught me about the importance of stepping back and allowing the teachers to control their learning. I did find it difficult to step back, as the project was intensive and I wanted to support the teachers, but the role was finite. I enjoyed my time working on the project and was keen to see the learning continue. This learning guided a lot of my work when working in teams. Sometimes I needed to be in charge, but at other times, I had to allow others to facilitate discussions, and I found this helps to build capacity within teams.

7.5 Teacher Change

Through this research, I possibly learnt the most about teacher change. Initially I believed the research was only about the triad model, but through discussions with my supervisor and others, it became apparent that the research was about teacher change as a result of the wider professional learning intervention. I discovered teacher change was a complex thing to measure and identify, through both the readings and the experience. Change in practice seems to be a personal journey, and even when someone might change their beliefs, their practice may not change, or their practice may change but not their beliefs. The ADKAR model (Mulder, 2014) helped me understand more about the change process, about the different stages, and that a desire to change may not be sufficient. My work in the triads, particularly, allowed me to experience change in action with some teachers. Some teachers had a desire to change but felt they did not have the knowledge; others took hesitant steps. Changing practice is a challenging, confronting, tiring, and emotional process (Kaur, 2008), and I observed this for a number of the teachers. The discussions and reflections were part of the process of teacher change (Stipek et al., 2001), but the change had to come from within the teacher.

I also changed as a result of the professional learning intervention. I believe I became more open to different perspectives as my awareness of these developed. I became aware of the complexities of teacher learning, as the experiences for each of the teachers were unique. I learnt that learning in classrooms is a complex process as so many things are happening with multiple people all at once. This was difficult to keep a track of. As a result of this, I altered the way I made observations, took notes, and interacted with the teachers.

My understanding of belief systems changed dramatically. I naively thought everyone learnt in similar ways, but I discovered someone’s belief system is complicated with influences from many directions including their personal experiences, backgrounds, and influences from the work place and the interactions with other people such as students, which are then filtered through their current belief systems (Rashidi & Moghadam, 2015). I found this challenging to understand, initially. I learnt that these beliefs vary dramatically between countries, schools, and even the sexes (OECD, 2009), and there are inconsistencies between classroom practices and beliefs (Raymond, 1997). I also discovered schools can have their own belief systems (Atkin, 1996), but it seems that for it to be effective and supported, it requires a shared understanding by leadership and staff. This was a new idea for me. I found the principal's approach of providing teachers with the information, support, and time for the professional learning intervention created the foundation for the shared understanding of the project.

Previously, I had not had the experience of working with a whole staff on a single project. It was a challenge to bring people along the journey, and communication between the triads and the principal was an important feature. I understand that I was fortunate that everyone involved in the project appeared open to the learning process and accepted me as the mathematics educator. I am aware that some teachers could reject professional learning and not engage. This may be overcome with communication and acknowledging their needs in their learning.

As a result of the research, I have become interested in learning about the aspects of changing beliefs. The aspect of beliefs being a filter (Borko et al., 1997) for professional learning has had an impact on my work, particularly with PSTs. During and after this study, I have had the opportunity to work internationally, and this learning about the complexity of belief systems, around teaching and learning, specifically mathematics, has continued to develop.

7.6 Working with Leadership

The impact of school leadership in any professional leaning is essential (Timperley, 2008). I have been involved in many professional learning activities at schools where the principal does not attend, interact with the facilitator, or know what content is being presented, and this was the first time where I learnt about how a principal could make a difference. In this case, the principal was the instigator of the professional learning. They were also an active learner by being involved as a member of the triad as a teacher and as a partner teacher, and not just a bystander. They also provided support through the provision of extra funds as required.

I worked closely with the principal. This collaboration ensured both the school and I had a clear understanding of the project. During the first professional day, the principal spoke about how the professional learning would fit with the school's goals and improvement plan. This clarity allowed everyone to be involved and to have a shared understanding (Hord, 1994). This was reflected in Belinda's story. Although each individual teacher would have a different experience determined by their needs, the overall goal was a shared one. The principal's involvement in the triads illustrated their personal commitment and belief of the learning process. They completed the teaching with a class, received perspective feedback and set goals for their own teaching and learning. This provided the principal with the opportunity to understand what their staff were experiencing (Timperley, 2008).

This was the first time I had closely worked with a principal, and I learnt about the collaboration that could occur. Both of us had ideas and perspectives to bring to the planning of the professional learning intervention. I found the principal placed trust in the staff and encouraged them to learn and make mistakes along the way. The principal was determined not to have this professional learning about student results, rather to be completely about building teacher confidence and capacity. I learnt the principal's role was pivotal to the professional learning experience of the staff. The principal 'walked the talk', and was a key learning for me: being prepared to do what I ask staff to do. The principal also taught me about balance: being involved, but still allowing people to have some ownership without feeling leadership constrains their learning.

7.7 Working With a School Over a Period of Time

Time is a regularly provided excuse for many things including not being involved in professional learning. It is well evidenced that ongoing professional learning appears to be more successful than single one-off activities (Guskey, 2000; OECD, 2012; Opfer & Pedder, 2011). The use of teacher and mathematics educator time in the professional learning intervention showed me that if a school wants teachers to learn, they will find time. I would have liked to be at the school all the time, but the way the intervention developed proved to be an effective use of time. The week-long professional learning allowed the school to focus on the project intensively. The use of the timetable (see Tables 4.1, 4.2, and 4.3) maximised the use of time while including an element of flexibility within a structure. The timetable was useful as it shared the experience across the staff, and the flexible time after lunch gave me more time to spend with teachers who wanted extra support, so a balance between structure and flexibility was important.

The weeks of professional learning were also spread across a period of three school terms. This proved to be important because as well as the intensive experience of each week, there was time between the triad experiences to allow teachers to reflect, try some new ideas, or refine practice before the next triad experience. Thus, the time between the weeks were an asset. I used this time to follow up with materials and email contact if required, which contributed to individual teacher's learning styles (Feist, 2003), as illustrated in Belinda's story, and enabled the learning to continue between the professional intervention weeks. The teachers could then use the next mentoring session to further discuss what they had discovered. Initially, I was concerned that momentum could be lost in the project and other external factors could impact teachers' experiences, and this made it difficult to research the time impact of the professional learning. However, teachers were aware of subsequent professional learning weeks, and this acted to create a sense of accountability, knowing there would be follow up.

The time between the professional learning intervention weeks provided me with time, enabled me to source and collect materials for the teachers, and reflect about the intervention. It allowed me to refine practices such as note taking and write up fully the observations for the professional learning, as well as look for patterns and plan for the upcoming intensive week.

7.8 Reflection On Being a Mathematics Educator

I enjoyed the role of mathematics educator. I did not realise at the time how important creating the links between the triads would be in the learning intervention (see Figure 7.2), providing support and guidance to the teachers. There is value in having an external expert involved in a professional learning intervention such as this, but there is an onus to ensure that I have an understanding of the overall school direction and reason for the professional learning in the first place. This required me, as the mathematics educator, to work closely with the principal, so that a shared understanding from a leadership point of view was developed. This importance is highlighted in Belinda's story. As I was an external person entering the school, I could observe classes with few preconceived ideas (Timperley, 2008). I learnt quickly to make wider observations rather than just focusing on the teacher, such as what was displayed around the room and student access to materials, which was one of the advantages of being on-site. While the involvement of a mathematics educator or external expert can be valuable, it should not be at the cost of using and building capacity of a school's staff. I feel the relationships and process of discussion and reflection were important components of the professional learning. This cyclic approach to learning allowed teachers to build on their current knowledge.

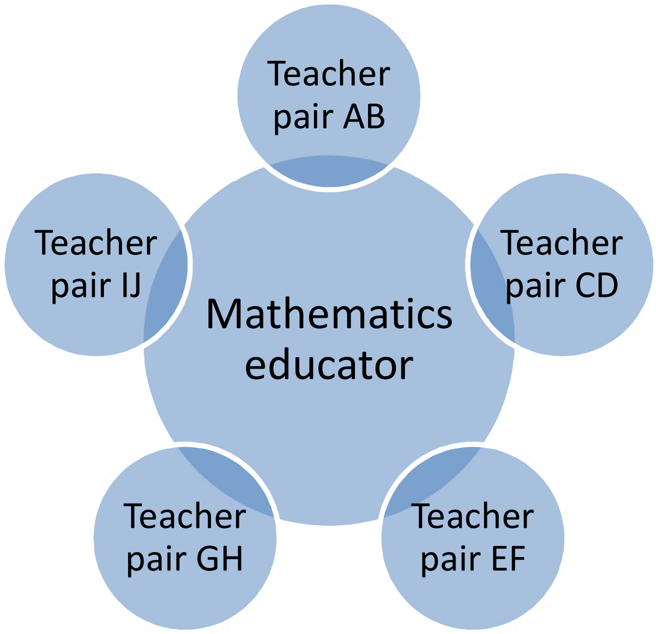

Figure 7.2 Link between the mathematics educator and each of the teacher pairs.

My involvement in the professional learning allowed me to be a participant, a co-learner, a researcher, and a mentor. The diversity of role proved to be challenging, as it required me to move in and out of the different roles during the intervention and each day of working with the teachers. It was a mentally tiring role that required me to draw on a wide range of skills.

Much of my learning from the experience I have used when mentoring PSTs, mentoring teachers in classrooms, conducting professional learning for sessional staff at university, and supporting staff through change processes. I believe my involvement in the intervention helped to develop my own skills in classroom observation and in the way, I provided feedback. I developed recording processes and learnt to break problems, ideas, and goal setting into smaller pieces.

7.9 Concluding Comments

I undervalued my role as the mathematics educator in this professional learning intervention. For me, the teachers were the focus, as they were the ones teaching, being observed, and setting goals for their learning. My role was complex and challenging. As the mathematics educator, I was the facilitator of the programme, I was the mathematics education expert, and I was a member of the triads, a co-learner, and the researcher. I was the link between the triads, the individual teachers, and the principal (see Figure 7.2). Through my experience, I learnt practical skills of recording data, observations, and conversations. I learnt how to break down ideas, focus on single aspects of teaching, and guide teachers in goal setting. I learnt by working with a whole staff and with a principal the importance of letting go to allow others to take charge of their learning. I also learnt about the value of building relationships, trust, and confidence, and that changing one's practice is an emotional experience. Through the intervention experience I changed; I developed leadership skills, and I became open to other people's perspectives and belief systems.

In summary, this chapter examined my personal reflection of the professional learning intervention in a discussion format. The first section considered what it means to support teachers. I then considered different elements of the professional learning intervention including the triad model, learning in the classroom, observation, discussion, and reflective practice, as well as building relationships, mathematics confidence, and the importance of stepping back. The later sections of the chapter examined the three areas of teacher change, working with leadership, and working with a school over a period of time, which are identified as themes in the research and were considered in relation to my learning. I then closed the chapter with my reflections on my role as the mathematics educator.

This chapter identifies with the learning elements of the intervention identified in Figure 4.2 (Chapter 4). These include personalisation through the use of the triad model and working one to one with teachers; collaboration through the triads, with the principal and working with teachers over an extended period of time; targeted teaching and observations which were evident in the triads and the other elements of the intervention such as team teaching; and the use of critique and reflection in the triads, but also during the times between the weeks of the intervention. Although the intervention was targeted at teachers, through my role as the mathematics educator the intervention also provided me with opportunity to learn.

The final chapter of the thesis presents the conclusion. This includes the response to the research questions, important features of the professional learning intervention, and limitations of the research. The implications on practice, policy, and theory are considered as are future directions of the research.

Chapter 8: Conclusion

This chapter begins with introductory comments. Section 8.2 revisits the professional learning intervention. Sections 8.3 to 8.5 address the research questions and identify the important features and influences on the intervention. In Section 8.6, I acknowledge the limitations of the study. Policy, practice, and theory implications and recommendations are made before I conclude with the future directions of the research.

8.1 Introduction

Continual learning is a part of any career, and for teachers its importance is acknowledged in the AITSL standards and teacher registration requirements, such as with the Victorian Institute of Teaching in Australia. Teacher professional learning is a complex process influenced by many factors, regardless of the selected model, as teaching is a dynamic profession taking place in a classroom environment. This small scale intensive study investigated one professional learning intervention set in a rural primary school, involving the entire teaching staff and principal over a period of nine months with the focus on mathematics. The professional learning intervention was funded by the AGQTP.

8.2 The Professional Learning Intervention

The professional learning intervention of this study involved a whole-school teaching staff. The intervention consisted of two main elements. At the heart of the intervention was the use of a triad model, which involved a teacher, partner teacher, and mathematics educator. This sat within a larger professional learning intervention as shown in Figure 4.1.

8.2.1 Components

The components of the professional learning intervention consisted of the use of triads within a broader professional learning programme. All of the teachers at the school were involved in the intervention and selected their own partners; these included the principal who was a member of one of the triads. My role in the intervention was as the mathematics educator.

In the triad, the role of the partner teacher was to peer observe a teacher's class in action and use this observation in a discussion session after the teaching experience. The mathematics educator also observed, but brought mathematics education expertise to the triad. In my role as the mathematics educator, I facilitated the day-to-day running of the programme, I was a member of each of the triads, I reported to the principal, was a co-learner, and a researcher of the intervention. The mathematics educator was the link between each of the triads (see Figure 8.2) and to the principal. As both the mathematics educator role and the teacher professional learning intervention evolved during the project, this study is identified as design research.

The teachers' experience consisted of setting a goal to work towards within the overall school aim of improving teaching in the mathematics classroom. Teachers set lesson goals as well as a project goal and worked towards these throughout the project. This provided the opportunity of personalisation of the learning during the intervention.

8.2.2 Structure

The overall professional learning intervention sat within a structure of one day of professional learning, a series of three professional learning weeks, and concluding with a final day of professional learning (see Figure 4.1).

The professional learning weeks consisted of a structured timetable of classroom triad peer observations and discussion sessions (see Table 4.2) for each of the five triads operating in the school. This involved features of collaboration with staff having one-on-one time with the mathematics educator; staff working in pairs with a partner and peer-reviewed lessons This was complemented with further professional learning, such as extra classroom visits, team teaching, model lessons, and work in staff and unit meetings, which was facilitated within the timetable. These featured aspects of targeted teaching, and elements of critique and reflection.

8.2.3 Data collection

A 25-statement questionnaire, developed in conjunction with the principal based on Barrel's (2001) work, was provided to the teachers on the first day of the professional learning intervention. This same questionnaire was provided at the end of the nine months of the intervention. This was then used to create two comparative studies between the pre and post intervention data collection, one examining the ratings for each individual statement and one examining each individual teacher's ratings. To structure the study, Shulman's (1986b) six key elements of PCK were used as a framework. The collected observation data and notes based on the triad experiences and the broader elements of the professional learning, such as model lessons, were utilised to create two teacher stories to provide detail that the questionnaire analyses could not.

8.3 Research Aims and Questions

The research topic for this study was 'Investigating teacher change through professional learning around the teaching of primary mathematics: The impact of the triad model'.

The research aims and questions for this study were

1. to draw on educational research to understand the importance of influences such as school location and school leadership on teacher professional learning;
2. to identify a teacher professional learning model that could be used as a vehicle for teacher change; and
3. to explore the potential implications of using the selected teacher professional learning model to lead change in teacher practice.

To address these aims, the following three questions when answered may describe the possible teacher change in classroom practice through professional learning in the primary mathematics classroom:

1. What changes are identified in teacher knowledge, beliefs, and practices as the result of a structured collaborative teacher professional learning model in a primary mathematics setting?
2. What factors are identified as influencing teacher professional learning as a result of the structured collaborative teacher professional learning model in a primary mathematics setting?
3. What are the implications for informing mathematics teaching professional learning?

This section examines each of the aims. The first aim was to draw on educational research to understand the importance of influences such as school location and school leadership on teacher professional learning. In Chapter 2, I drew on educational research to understand about the teaching of mathematics. This consisted of mathematics teaching, teacher mathematical knowledge, and teacher pedagogical knowledge. I explored the complexities of teachers' beliefs and the challenges of teacher change. In Chapter 3, I considered professional learning, examining literature which informed parts of my study. I examined elements of professional learning that appeared effective and elements that appeared less effective in informing the design of the professional learning intervention. I explored research about the importance of influences such as school location and school leadership on teacher professional learning interventions.

The second aim of the study was to identify a teacher professional learning model that could be used as a vehicle for teacher change. The literature study and the work I completed with the principal were used to identify a teacher professional learning intervention rather than a model. This consisted of a professional learning intervention, within a structure including a timetable (Table 4.2), with the use of triads associated with the classroom experience. The important feature of the intervention was the ability to allow teachers to select their own learning focus for the experience, which included setting their own goals.

The final aim was to explore the potential implications of using the selected teacher professional learning model to lead change in teacher practice. This is reported in the thesis and is explored in Section 8.3.3 of this chapter, in response to Question 3.

The next three sections respond to each of the research questions.

8.3.1 Question 1

Question 1 of the study was ‘What changes are identified in teacher knowledge, beliefs, and practices as the result of a structured collaborative teacher professional learning model in a primary mathematics setting?’

Data from the comparison analysis of Chapter 5 between the pre and post intervention data collection ratings for each of the 25 statements showed 116 of the 250 ratings between the pre intervention data collection and the post intervention data collection showed no change. A total of 117 of the ratings showed a change, either an increase (78) or a decrease (39), with 17 ratings not recorded across the statements. It could be argued that a decrease in rating may be seen a positive outcome; however, an increase in rating may be an indication of deeper self-awareness as a result of the professional learning intervention. Conversely, an increase in rating may be seen as a positive outcome depending on the statement, but a decrease in rating may indicate a deeper analysis of practice. A nonresponse to the pre intervention data collection and a provided response to the post intervention data collection could also indicate a change, but it is difficult to identify what this may be. Out of the 250 rating comparisons, only five of the ratings showed a double jump or shift of more than one rating, with three double jumps in response to Statement 14, which addressed students commenting on each other’s work.

The amount of change to ratings between the pre and post intervention data collection varied between statements, but in some examples the changes led to a narrowing in the range of ratings for the statements in the post intervention data collection. This may indicate a more consistent approach across the staff around particular aspects of teaching and learning in the mathematics classroom.

A second comparison was completed comparing the pre and post intervention data collection ratings for each of the 10 teachers. This was performed to examine if the changes observed in the first comparison were isolated to one or two teachers or more broadly across the staff. All teachers had changes in some ratings to statements between the pre and post intervention data collection. Four teachers did not rate some of the statements in the pre intervention data collection. All teachers rated all statements in the post intervention data collection. The greatest overall change observed was again a narrowing of the range of ratings in post intervention data collection. This could be as a result of the data regressing to the mean. To address this, all the teachers and all the data were included in the analysis, and the main aspect sought was any change in rating. It could be argued that the teacher professional learning intervention provided teachers with the opportunity to develop common understandings about the teaching and learning of mathematics (Atkin, 1996; Stipek et al., 2001).

The statements were organised according to the framework of Shulman's (1986b) six key elements of PCK. Changes between teachers' ratings of the pre and post intervention data collection were evident in all six key elements. It was found that for some teachers, the changes were grouped in one or two elements, whereas for other teachers it was across all elements. The grouped changes may reflect the focused approach some teachers took in the professional learning, whereas the wider spread of changes may reflect the structure of the professional learning spread over a number of months. Using the questionnaire analyses, some aspects of change could be identified, but the nature of the change was more difficult to identify. This led to the presentation of two teacher stories.

Teachers identified and articulated change in their practice as exemplified with the two teacher stories in Chapter 7. Belinda's comment exemplifies her feelings of change:

> My own maths teaching is changing in that I try to make activities more real, I involve the students more often in composing and assessing the tasks, I try to include games on a regular basis,

> I am trying to set more open tasks that students of all levels can tackle and I am becoming more of a facilitator rather than a stand out the front teacher.

Jack commented, 'The project was more about bettering yourself and your teaching on a personal level'. The partner teachers also made observations about their peers changing, as exemplified in Jack's story. Belinda's story also illustrates her learning was occurring from her experience as the teacher and as a partner teacher, observing other teachers in action.

8.3.2 Question 2

Question 2 of the study was 'What factors are identified as influencing teacher professional learning as a result of the structured collaborative teacher professional learning intervention in a primary mathematics setting?' The next parts of this section will explore some of the factors.

The whole school was involved in the professional learning intervention. This created the opportunity for a whole-school learning focus with an overall goal. The professional learning took place in teachers' own classrooms on-site at the school. The intervention was supported with the construction of a timetable ensuring all teachers had an opportunity to be involved in the triad peer-observed experience, as both a teacher and partner observer. There was flexibility built into the timetable to allow for additional support, model lessons, and team teaching experiences. Therefore, the location of professional learning in teachers' classrooms was as important factor.

The triad component of the professional learning intervention created a structure for the project. The strength of the triad model drew on elements of professional learning that proved to be effective and included the provision of time for the learning and application of the learning to occur (Opfer & Pedder, 2011), the ongoing nature of professional learning (Willis, 2002), being in context at the school in a teacher's own classroom (Neufeld & Roper, 2003), involving collaboration (Joyce & Showers, 1988), and discussion and reflective practice (Pritchard & McDaimid, 2006). The structure allowed for personalisation and flexibility, with teachers selecting their own goals within the triad. The triads had clearly defined roles and a purpose for each of the roles within the intervention, providing multiple perspectives on the viewed lessons. The partner teacher provided support and peer feedback to the learning teacher. The mathematics educator provided support, guidance, and expertise within the model. The triad provided the opportunity for everyone to learn from each other during the teaching experience, via feedback, through the discussions, reflections, and observation. The discussion opportunities were built in prior to the teaching experience and after the teaching experience, and these discussions were rich (Fleming

& Leo, 1999), focusing on teaching and learning and teachers' personal set goals. Thus, the structure and included flexibility of the professional learning intervention was a factor in influencing the professional learning.

The mathematics educator created links between each of the triads and the leadership of the school and had a broader understanding of the project and what each person was doing. The mathematics educator was external to the school, bringing an external perspective as well as resources and connections (Timperley, 2008). The mathematics educator collected the data and, in this study, was the researcher. This role influenced the professional learning intervention, as the research was design based in nature, created and refined as the intervention developed.

The professional learning intervention was separated into three intensive weeks. These weeks had a strong focus on learning, with staff working towards their personal goals and the overall project goal of improving mathematics teaching in the primary classroom. The time in between the weeks provided teachers with the opportunity to reflect on their learning and peer-observed experiences, and to put new ideas into place before the next triad experience (Opfer & Pedder, 2011). This ongoing nature influenced the delivery and frequency of the professional learning intervention.

The principal also influenced the professional learning by providing the opportunity for the learning to take place. The principal worked with the mathematics educator to develop and design the intervention, so there was a common understanding of the process of the learning. The principal was involved in the professional learning days at the commencement and end of the professional learning intervention. The principal was also involved as a member of one of the triads, teaching, peer observing, and participating in the discussions. The principal led by example and supported the teachers' learning by allowing them to mistakes (DuFour & Berkey, 1995) and allowing the intervention to develop and change throughout the nine months.

As the professional learning community developed, it would have been easy for teachers to become similar to each other in style and opinion, but in fact, teachers became more confident in themselves in the classroom and developed confidence to try new things and develop their own learning and identity (as seen through the teacher stories). This provided depth and diversity to the community, with a shared language being created (Wenger, 1998). By developing this community, it was hoped the professional learning would be sustained and a culture of professional learning and sharing of expertise would be created to develop the sustainability. These aspects influenced the professional learning as they provided a community in which the learning could take place.

Teacher mathematical knowledge influenced the professional learning intervention, as initially teachers appeared hesitant to claim their knowledge. As their confidence grew, teachers used their mathematical knowledge more in the classroom. Teachers' pedagogical knowledge developed, and some teachers tried new teaching approaches or structures within their classrooms resulting from the discussions and observations of the triad and other experiences. Teachers' PCK changed as they explored and discussed teaching and learning strategies based around their classrooms.

Teachers' beliefs influenced the professional learning intervention, as these belief systems filtered the information, discussions, and reflections of the experiences and what aspects teachers considered to take on board (Stipek et al., 2001). I learnt that these belief systems are difficult to change and are deep set. Comparison of the pre and post intervention data collections illustrate that it is not possible to change everything (Brown & Renshaw, 2007), and this was not the intent of the learning intervention. The intervention was about teachers identifying areas of knowledge and practice they wished to explore. Teacher beliefs influenced the way they approached the learning intervention and how they considered altering their practice.

Change in teacher practice was the school's main goal for the professional learning. I learnt that any change initiative in teacher practice should not be taken lightly (Hargreaves et al., 2001), as it is a personal experience, which can be emotional. As each teacher's experience in the professional learning was a personal journey, examining elements of their own practice, it is difficult to clearly define which single factor influenced each individual teacher's learning.

The proposed framework of Sullivan et al. (2016) (Figure 2.3) can be used to show the complexity of interactions between each of the described factors of this section. The triad experience relates to the planning intentions node and the opportunities and constraints node of the framework. The opportunities and constraints node is further influenced by the setting, the opportunity to be involved in the intervention, and the principal's influence. The classroom actions node is the activities occurring in the classroom and that where teacher change may be observed. The knowledge of mathematics and pedagogy node is influenced by the involvement in the intervention targeted at primary mathematics classrooms and the combination of all of the experience impacts on teachers' beliefs, values and attitudes.

8.3.3 Question 3

Question 3 of the study was 'What are the implications for informing teaching professional learning?' The next section presents the main findings and recommendations based around the core elements of the professional learning intervention. Then the limitations associated with this are presented before the broader practice, policy, and theory applications and recommendations are presented in Sections 8.7, 8.8, and 8.9 of this chapter.

8.4 Findings and Recommendations

The teacher professional learning intervention proved to be effective for this particular school for a number of reasons. These will be explored in this section and recommendations based around this particular intervention will be made of the important features.

8.4.1 Size of the school/Number of participants involved

Being a small school, the number of staff involved in the study was manageable. It was easy for teachers to pair up to find a teaching partner, and in this case, there were no personality conflicts and people worked together well. Because of the small number of staff involved, it was affordable for the school to employ casual relief teachers to allow teachers to be released from their classes to be involved in the discussion sessions before and after the teaching. The small number of staff also allowed for teachers to work across grade levels if they wished.

Recommendation: To translate this intervention to a larger sized school, this model could be implemented on a smaller scale, perhaps across one area of the school at a time, for example, Foundation to Year 2, then Years 3 to 4, and finally, Years 5 to 6. There is no reason why the model cannot be implemented in secondary schools, but perhaps this could be across single content areas, such as the English department.

8.4.2 Timetable

The model of a half-hour session before the lesson with the mathematics educator and a half-hour session after the lesson with the teaching partner and mathematics educator was suitable for the school as their timetable consisted of two 2-hour sessions 9.00 a.m. to 11.00 a.m., then 11.30 a.m. to 1.30 p.m. (see Table 4.1). This well accommodated the 10-staff involved during the week.

Recommendation: To translate this to a different school, the timetable would have to be examined and the timings altered accordingly. The advantage of running discussions with the teaching partner and the mathematics educator before a break provided a few extra minutes for discussion, if required. It was also found that half an hour was definitely needed for the discussion after the taught lesson. It is recommended that if required, the half-hour discussion before the lesson could be slightly shortened prior to the teaching, but by no less than 20 minutes.

8.4.3 Multiple week-long visits

The multiple week-long visits, spanned over a number of school terms, created the opportunity for multiple teaching and learning experiences in the triad professional learning model. This provided the opportunity for teachers to attempt or trial new ideas and receive feedback, with the time between the full weeks of professional learning allowing teachers to reflect on and implement these ideas in their class for a period of time to embed the learning.

Recommendation: Multiple visit weeks and time between these weeks are required to allow teachers to prepare and trial new ideas in their classes, after the triad professional learning experience. This also provides the time for critical and deep reflection. A minimum of three visit weeks is recommended.

8.4.4 Triad model of professional learning

Having three people rather than two people involved in the professional learning process provided the opportunity for multiple perspectives. There was the teacher (in the moment perspective), a colleague who was familiar with the school, and the mathematics educator. The mathematics educator was a removed observer who was not intimately involved in the school environment, providing an independent perspective. The mathematics educator also created the link between each of the triads, and this link was further strengthened with the mathematics educator's involvement at staff and unit meetings.

Recommendation: The triad of participants format is optimal. By removing the teacher partner, the collegial nature of the process would be eliminated. This person is crucial in creating the links between the experience and the community of learning within the school. By removing the mathematics educator, the independent, nonvested perspective is taken away. It is also assumed that this person would have experience in this field of work, providing the skills and expertise in guiding the discussion, as well as providing the necessary support materials and resources.

8.4.5 Goal setting

Goal setting was key for teachers to be clear about the issue they wanted to explore in the triad professional learning intervention. The advantage of the professional learning model is that it can accommodate different needs within the broader teacher learning context, in this case mathematics. Goals could include examining questioning in the classroom, exploring how to accommodate different learning needs in the classroom, or effective assessment.

Recommendation: Allow teachers to set their own goals within the broader staff learning context. This will allow teachers to have ownership over their learning and the project. If narrower aims for the teacher professional learning are required, a set of goals could be created to allow teachers an element of choice.

8.4.6 Principal's involvement

The principal's (or leadership) role in professional learning is key. Having the principal involved as a teaching member of the triad shows staff their commitment and value of the professional learning intervention. It also provides the principal with insight about the intervention in which the teachers are involved. It is also important for the principal to provide additional support if required, such as money for equipment related to the professional learning.

Recommendation: The principal is actively involved in the professional learning intervention and is a member of one of the triads of the professional learning model.

8.4.7 The use of mathematics educator

The use of an external member as part of the triads brought an external view to the professional learning intervention. A mathematics educator can facilitate the day-to-day running of the intervention and collect data, design the programme to accommodate for teacher learning, and support teachers along their journey. The advantage of having an external person is they do not have other school commitments to draw them away from the focus of the learning, they bring skills and resources that may not be available to the school otherwise, and they provide an objective view to the observations as they are less involved in the school and do not know the students or teachers. The mathematics educator also provides the big picture link between each of the individual triads.

Recommendation: An external expert is included as one of the members of the triads, with expertise in the PCK of the particular content area to promote support within and the connection between each of the triads.

8.5 Limitations

All situations in which data are collected have limitations. Different components are presented in this section and the limitations discussed. Section 5.9 presented limitations of the methods and included a discussion around some of the limitations of the qualitative and quantitative instruments.

8.5.1 The questionnaire

The questionnaire consisting of 25 statements adapted from Barell's (2001) work was rated by teachers with the subject of mathematics in mind. Teachers rated each of the statements on a 5-point Likert scale with 1 representing *hardly ever*, 2 *seldom*, 3 *sometimes*, 4 *often*, and 5 *very often*. Some teachers opted not to respond to some questions for a variety of reasons. The questionnaire was completed prior to the triad professional learning model being implemented and at the end of the study. The aim was to examine whether teachers' ratings had changed over that period of time as a result of the use of the triad professional learning model.

It could be argued that the questionnaire was too subjective and difficult for teachers to rate all statements; three teachers opted not to rate some of the pre intervention data collection statements. In the post intervention data collection, all teachers rated all statements. In some of the commentary, it was noted that teachers may have considered one part of the statement rather than the statement in its entirety. For example, in Statement 20, 'I use a wide variety of assessment experiences in maths and use the information to drive my teaching', teachers may have responded to the assessment component of the statement, the component about using assessment in teaching, or both when rating the statement. Statements like these perhaps should have been simplified, by being split into two statements or rewritten.

8.5.2 Data analysis

The data from the pre and post intervention data collection was collated using Microsoft Excel and column graphs, and side-by-side column graphs were created for comparison purposes. It could be argued that this was too simplistic and that there is little statistical validity in comparing data in such a manner, particularly when the scale is not fixed. The aim was to examine and look for change, not the amount of change, as a result of the triad professional learning model. As the questionnaire itself was simplistic, the survey population was 10, and all teaching staff at the school were utilised, it was felt this method was valid and the study not trivial. If the triad professional learning model was implemented on a wider scale and with larger populations, where a true sample could be taken, more rigorous statistical analysis could be completed.

8.5.3 Summary tables

When analysing the summary tables, it could be argued that a change in rating may not indicate a change in practice or belief, but it could show a deepening of self-awareness in the classroom or an understanding of terms or meanings. As indicated in Chapter 5, what became evident was the range of post intervention data collection ratings narrowed across some statements, which could reflect a more consistent and shared approach across the staff when considering the teaching and learning of mathematics.

The change in 24 of the 25 statements in the summary between the pre and post intervention data collection (see Table 5.4) may not be considered a significant number of changes to illustrate a change in practice or belief, and examining the means of the teacher ratings is not valid. However, it could also be argued that just a single change to the ratings of one of the statements is enough to indicate a change in belief, even though a change in practice may not be observed or conversely, it may indicate a change in practice but a change in belief may not have occurred.

8.5.4 Use of triads

Measuring change in teacher practice in any context is problematic. Although the triads were used at the school for three weeks of professional learning, other aspects of professional learning took place during that time, including the teaching of model lessons, elements of team teaching, professional discussion at staff and unit meetings, and professional readings. All these aspects could have had an impact on an individual's teaching practice, and this is evident in the two teacher stories of Chapter 7. It could be argued that activities such as staff meetings occur at all schools and little change in practice is seen.

It is difficult to isolate whether the change in practice was only attributed to the triad aspect or to the whole intervention of being involved in a project examining teaching and learning of mathematics. If the triads were implemented on a wider scale and with larger populations, then control groups could be used, and some schools could use only triads while others could use the whole intervention to determine whether the model is truly the reason for change in practice.

8.5.5 Limitations on professional learning generally

A number of general impacts and limitations, which could relate to most professional learning interventions, have also been identified:

- Since the completion of the professional learning, a number of the staff have moved on, including the principal, taking the expertise of the professional learning intervention from the school.
- If a particular culture of teaching and learning had been developed at the school around the teaching and learning of mathematics, it would have been helpful to document this and develop a process of inducting new staff into the culture.
- Although the teachers were well engaged during the time of the professional learning, it would be necessary to re-examine the existing teachers to see whether there had been a true change in practice and beliefs, whether they had returned to previous practice, or whether the professional learning intervention structure had been applied to other content areas.

The next three sections will present details of broader policy, practice, and theory implications and recommendations as a result of the study.

8.6 Policy Implications and Recommendations

Four policy implications and recommendations are made in this section.

8.6.1 Importance of professional learning

The relevance of professional learning is indicated in the teaching standards (AITSL, 2015) and is a requirement for maintaining teacher registration (VIT, 2017a). It is more broadly identified at national and international levels as being an expectation that teachers will continue to develop their skills throughout their teaching careers.

This research adds to the body of work on teacher professional learning.

8.6.2 Whole-school professional learning

This study of a professional learning intervention demonstrated that it is possible to conduct professional learning across a whole teaching staff at a school. In this case, this school was identified as small, with a teaching staff of 10, and this was the whole staff. The use of a constructed timetable, which contained both structure and flexibility, showed that it is a feasible process. Having an expert located at the school provided a cost-efficient option for this school in a rural setting. This model could be applied to other content areas.

Recommendation: This professional learning intervention could be utilised in other schools to implement professional learning in any content area.

8.6.3 Ongoing professional learning

This study demonstrated that ongoing professional learning is possible at a school. Having the professional learning isolated to three week-long experiences with a structured timetable minimised the disruption to teaching, as two teachers were involved in the experience per day. The structure also enabled all teachers to be involved. By having the mathematics educator attend the school, it negated the need and additional cost of teachers' travel.

Recommendation: Ongoing professional learning, such as this professional learning intervention, should be utilised in schools.

8.6.4 Principal/leadership role in professional learning

This study illustrated the importance of the involvement of the principal in the professional learning intervention. The principal not only needs to support the professional learning, but also it seems their involvement in the professional learning can have wider impacts, such as understanding teachers' experiences, being involved in the development of the common language of the learning, and having their own learning aims and goals.

Recommendation: Principals/school leaders should be involved in professional learning with their staff.

8.7 Practice Implications and Recommendations

Four practice implications and recommendations are made in this section.

8.7.1 Personalisation of professional learning

The professional learning intervention provided the flexibility within the whole structure for teachers to set their own learning goals. As illustrated in the teacher stories, this was a valued element of the professional learning. It allowed teachers to examine their practice where they felt the need for support was required. This was further supported by the structure of the triad experiences and other elements such as team teaching. This provided learning for the teacher in the area it was required.

Recommendation: When developing professional learning, the aspect of personalisation should be considered.

8.7.2 Staff belief in the professional learning

This study examined teachers' beliefs and the complexities of this when considering change in practice. To do this, teachers need to feel supported and well informed about the professional learning. In this study, the principal and the mathematics educator set the scene for the professional learning, and this was communicated to the staff. The consistency of the basic structure of the learning intervention with the common factor of the mathematics educator in each of the triads created opportunities for trust and working relationships to develop. This fostered a common understanding across the staff about the learning intervention, and they all worked together towards the school goal of improving mathematics teaching in the classroom.

A staff understanding and belief in the professional learning is required.

8.7.3 Principal influence

This study illustrated the role of the principal in the professional learning. The principal can provide the support and leadership of the learning. They need to allow the learners (teachers) to make mistakes along the journey and provide time for the learning to occur. They need to demonstrate belief in the external expert in this form of professional learning.

The principal/school leader should be aware of their influence on teacher professional learning.

8.7.4 Wider application of this professional learning intervention

This study was completed in a primary school setting which could be translated into a secondary setting or a larger school setting. This intervention model has the potential to also be applied to academic situations. For example, in a tertiary academic setting the external expert could be an industry expert, the teacher an academic, and the partner teacher could be another academic or sessional staff member. This model has the potential to create an academic and industry relationship.

Recommendation: Exploration of this professional learning intervention model in a tertiary setting such as a university.

8.8 Theory Implications and Recommendations

Five theory implications and recommendations are made in this section.

8.8.1 The use of triads in professional learning

This professional learning intervention utilised triads in the classroom observations and discussions. While there is research around the use of triads in professional learning (Kenny, 2009), this is not a common model used in schools and with professional learning interventions.

This research adds to the body of work on the use of triads in professional learning.

8.8.2 Teacher change

Attempting to change teacher practice is acknowledged as being a challenging process (Timperley, 2008), complicated by teachers' knowledge, skills, and belief systems. Placing these changes into practice is even more complex. This study examined the potential for changing teacher practice as the result of a particular intervention. While it can be argued that some change occurred, the amount and degree of change was difficult to measure. As each teacher's experience during the professional learning was a personal one over a period of time, this added to the difficulty of measurement. Some change was found through the questionnaire analysis and teacher stories and contributes to the work in this area.

This research adds to the body of work on teacher change.

8.8.3 Principal influence

The influence of the principal throughout the study is important. While the research shows that principals need to support, fund, and devote time in the school schedule for professional learning to occur, the role of the principal as a participant leader is important. The principal in this study was fully involved as a participant in the professional learning intervention, illustrating the value they placed on the learning and allowing them to experience the learning their staff was involved in. The principal's role also included the collaborative work with the mathematics educator, which aided to create a clear understanding of the intervention for all involved.

Recommendation: Further work to continue in researching the role of the principal/school leader in professional learning interventions.

8.8.4 Self-involvement in research

My role in this study was as the mathematics educator. It was shown that this role was complex and consisted of many facets, one of which was as the researcher. There are strengths and weakness in being the researcher while being involved in designing and delivering a professional learning intervention. The insight by being immersed in the intervention provided a unique perspective that would not be possible as a pure observer. It allowed for the examination reflection on the experience as a participant and observer.

Recommendation: Research should include opportunities for self-involvement.

8.8.5 Developing trust

Change in practice is an emotional process (Hargreaves et al., 2001) and should be valued and people's journeys acknowledged, as any change in practice should not be taken lightly. Trust and relationships were important elements of this professional learning intervention. It was found that as teachers were challenged to examine their practice and travel a personal path when considering change in their practice, trust had to exist in those who were supporting them on their journey. They had to feel supported by the principal, and they had to trust their partner teacher and the mathematics educator. They had to trust that the feedback was not going to be judgemental but constructive and supportive and that their opinions and perspectives would be valued.

Recommendation: This research adds to the body of work on trust in teacher professional learning and change in teacher practice.

8.9 Future Research

There is potential for a range of research stemming from this study as shown in Figure 8.1.

The teacher professional learning intervention could be separated. The triad component could be isolated from other aspects of the professional learning and studied. This would attempt to identify the true impact of the triads on teacher learning.

The experience of the partner teacher and the mathematics educator could be further explored. This could be completed as a perspectives analysis, making direct comparison between the observation sessions. Alternatively, the role of the mathematics educator and the partner teacher could be examined across a number of triads to tease out the impact of learning on each of these roles.

A comparison study could be completed by providing a set of teacher educators with the questionnaire to complete and then make comparisons between expected and actual data of the teacher questionnaires.

The school and teachers could be revisited. The questionnaire could be reapplied to teachers involved in this study and the teachers of the stories further interviewed if the staff were still at the school. The new intervention data could be combined with the existing data to examine whether the ratings had changed or remained similar to the post intervention data.

A comparison study could also be performed between rural/regional and metropolitan schools using a similar professional learning intervention, analysing whether the impact was similar or different.

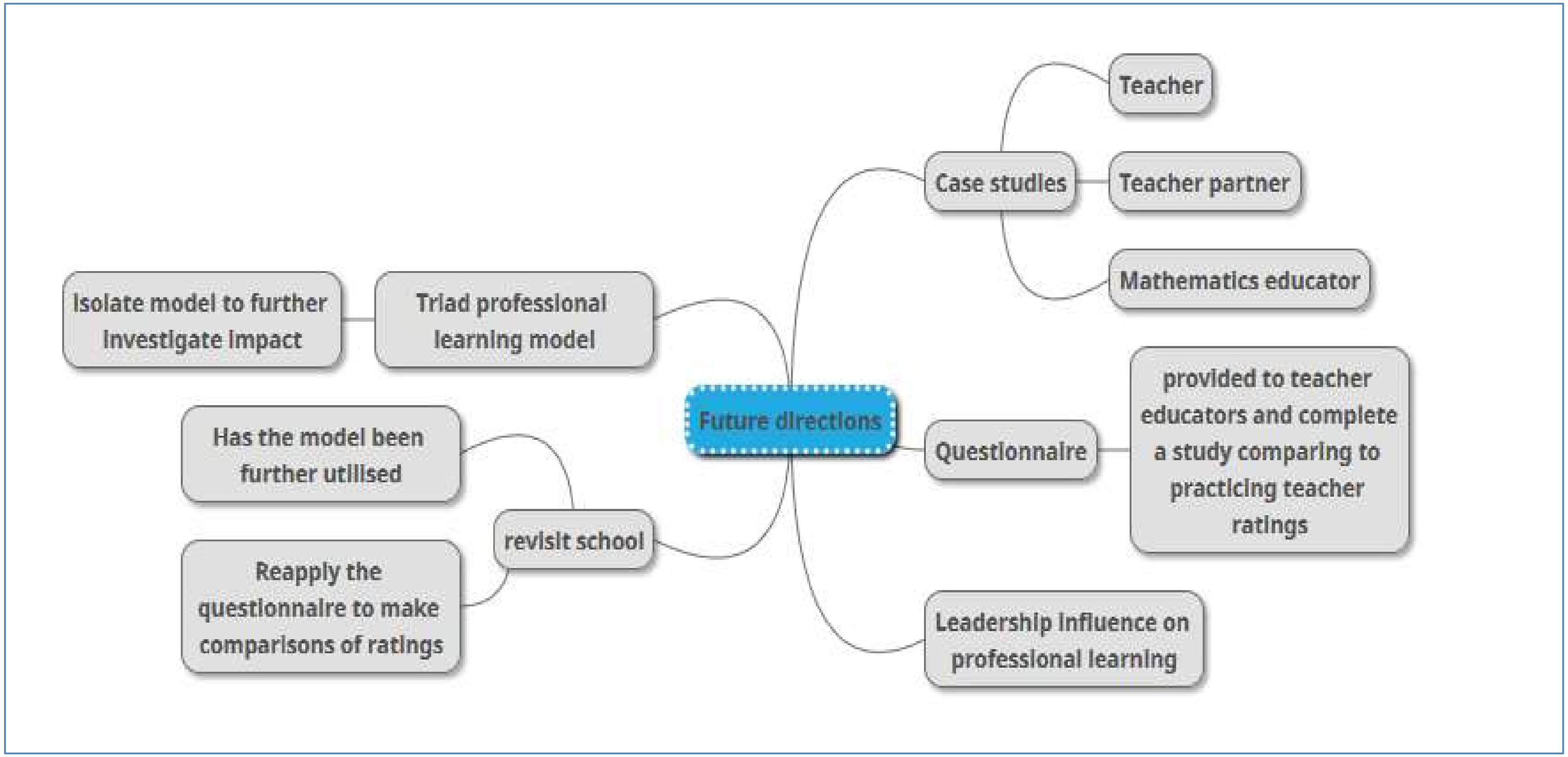

Figure 8.1: Ideas for future research.

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Appendices

Appendix 1: Ethics letter

LA TROBE UNIVERSITY

Faculty of Education

3 July 2006

Ms Pauline Rogers
14 Princes Street
Berry 2535

FILE COPY

Dear Pauline

RE: YOUR APPLICATION FOR ETHICS APPROVAL
FHEC No: R043/06
Project/Activity Title: Teachers as learners in a professional development case study model
Supervisor Professor Peter Sullivan

Thank you for submitting your project for consideration by the Education Faculty Human Ethics Committee. The proposal has now been considered by the Committee and has been granted approval till **31/12/2007.**

If you wish to discuss any aspect of your project, please contact your supervisor (if you are a student) in the first instance, the Secretary Ms Joan Freeman, (j.freeman@latrobe.edu.au) or the Chairperson Dr Wan Ng (w. ng@latrobe.edu.au).

The following standard conditions apply to your project:

• Complaints - If any complaints are received or ethical issues arise during the course of the project, researchers should advise the Secretary of the Education FHEC.

• Limit of Approval - Approval is limited strictly to the research proposal as submitted in your application while taking into account the conditions and approval dates advised by the FHEC.

• Variation to Approval - As a consequence of the previous conditions, any subsequent variations or modifications you wish to make to your project must be notified formally to the FEHC. This can be done using the 'Application for Approval of Modification to Research project' which is available at http://www.latrobe.edu.au/rgso/ethics/.

• Progress Reports - You are required to submit a Progress Report form annually (if your project continues for more that 12 months) and also at the conclusion of your project. If the project is approved for less than 12 months the report is due at the end of the approval period, as notified above. Your Reports will be due on 29/6/06 & 31/12/07. The form is available from http://www.latrobe.edu.au/rgso/ethics/.

Please note that your application has been reviewed by a sub-committee of the FHEC in the interest of facilitating a decision before the next committee meeting. The decision will require ratification by the full Human Ethics Committee and, as a consequence, approval may be withdrawn or conditions of the approval altered. However, you may commence your project prior to ratification of the approval decision and you will be notified if the approval status is altered.

On behalf of the Committee, best wishes with the success of your project.

Yours sincerely,

[redacted]

Joan Freeman
Executive Secretary, Education Faculty Human Ethics Committee.

cc: Chair: Dr W. Ng
Supervisor/s: Professor Peter Sullivan

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ABN 64 804 735 113

Appendix 2: Letter of request to research to school and teachers

6 April 2006

Principal

Dear,

Further to our discussions, I am writing to seek your approval for the school and staff to participate in a research project to be conducted at … in 2006.

The title of the project is **Teachers as learners in a professional development model case study**

I am the principal researcher. My contact details are:

Pauline Rogers
Tel:
Mobile:
Email:

My principal supervisor is: Professor Peter Sullivan and his contact details are:

Professor Peter Sullivan
Faculty of Education
Monash University
Wellington Road Clayton VIC 3800
Mobile:
Email:

The research will investigate the learning and experiences of teachers. The professional development model to be implemented will be examined for its benefits, strengths, disadvantages and weaknesses. I would like to find out more about this professional development model for teachers.

The project will involve all staff completing surveys; answering questions and reflecting on practices. I attach a more detailed description of the project.

Confidentiality of the staff and school will be maintained at all times. Reports of the project may be published in professional journals and in other publications. No publication will identify the school or you. Data will be stored in my office in locked cabinets.

Participation is voluntary and anyone may withdraw consent at any time without adverse consequences.

I have also written to the Department of Education and Training, requesting to conduct research in your school (copy attached).

If you have any questions please do not hesitate to contact me. If you approve can you please acknowledge this in writing.

I look forward to working with your staff and school.

Yours sincerely

Pauline Rogers

6 April 2006

Dear Sir/Madam,

I am writing to seek your approval to participate in a research project to be conducted at …. in 2006.

The title of the project is **Teachers as learners in a professional development model case study**

I am the principal researcher. My contact details are:

Pauline Rogers
Tel:
Mobile:
Email:

My principal supervisor is: Professor Peter Sullivan and his contact details are:

Professor Peter Sullivan
Faculty of Education
Monash University
Wellington Road Clayton VIC 3800
Mobile:
Email:

The research will investigate the learning and experiences of teachers. The professional development model to be implemented will be examined for its benefits, strengths, disadvantages and weaknesses. I would like to find out more about this professional development model for teachers.

The project will involve all staff completing a survey, answering questions and reflecting on practices. It will comprise of week long visits to the school a number of times during the year working one-to-one with you in your classrooms. Data collected will include the surveys, written reflective pieces and observational notes.

I attach a more detailed description of the project.

Your confidentiality will be maintained at all times. Reports of the project may be published in professional journals and in other publications. No publication will identify the school or you. Data will be stored in my office in locked cabinets.

Participation is voluntary and you may withdraw consent at any time without adverse consequences.

If you have any questions regarding this project please feel free to contact me on.

This project has received ethics approval from the Human Research Ethics Committee of La Trobe University. If you have any questions that have not been answered, or any complaint about the way you have been treated during the project, please write to:

Ethics Liaison Officer
Human Ethics Committee
La Trobe University
Bundoora Vic 3086

Alternatively: Tel. 9479 1443, or email: humanethics@latrobe.edu.au

If you agree to participate in the project, please complete the attached form, keep one copy and return the other to the principal.

Yours sincerely

Pauline Rogers

Appendix 3: Plain language statement

Teachers as learners in a professional development case study model

Summary of proposed research project
by Pauline Rogers

The proposed *project aims* to examine a teacher professional development model and its effectiveness in the area of mathematics. This model is of an on-going nature based on week long visits to the school a number of times during the year working one-to-one with staff in their classrooms.

The *focus* of the research will be teacher professional development, and specifically teacher learning. This teacher professional development initiative is centered on a 'mathematician' in residence (MIR) conducting professional development, visiting classes, observing specific mathematics lessons, teaching model mathematics lessons and team teaching with staff as required over week long periods. In this study mathematics will be the focus. A timetable will be developed and teachers will be paired into professional partners. For each teacher, a half hour will be spent with the MIR prior to each observed lesson, discussing the lesson and any other concerns or interests regarding the teaching of mathematics. Then a lesson of approximately one hour will be taught, with the MIR and professional partner viewing and participating as appropriate. After the lesson, a half hour (or more) will be spent reflecting on the lesson with the MIR and professional partner. During each visit teachers will be encouraged to set their own personal goals. For the final teaching week, teachers will be asked to develop a lesson goal which was reflected upon during the half hour after the lesson. Goal setting will be important for the project as they will provide teachers with aims, direction and motivation for the project.

Teacher learning and reflection on their current practices are the focus, and staff will be encouraged to attempt new ideas, models and skills such as rich assessment tasks and the teaching of open ended strategies in the area of Numeracy. All teachers at the school will be invited to participate.

The *research* will be presented as a case study and will examine the benefits, strengths, disadvantages and weaknesses of the professional development model, as well as comparing it to other forms of professional development. The work will look at the teacher, rather than the student, learner. Teachers will be asked to examine what they learnt, how they learnt and why the learning was significant.

The *findings* will be shared with the staff, through full staff professional development days, feedback throughout the work and via reports with the principal.

Teachers will be given the opportunity to develop as thinkers and learners. Consequently will hopefully lead to a change and improvement in teaching, and hence student learning.

Appendix 4: Single graph analysis

4.1 Pre intervention data collection

This section presents the pre intervention data collection. Each statement has a column graph created of the teachers' ratings to the statement, some commentary is made following each graph.

Figure A4.1.1 presents Statement 1, 'When teaching maths, I usually work at or near my desk.'

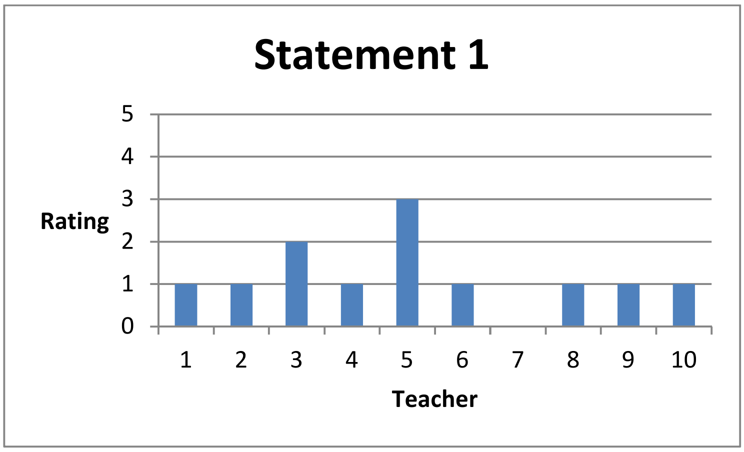

Figure A4.1.1: Statement 1: When teaching maths, I usually work at or near my desk.

One teacher did not complete a rating for this statement as shown in Figure A4.1.1. All teachers indicated they *hardly ever* 'usually' worked at or near their desks except for two teachers, one who selected *seldom* and the other who selected *sometimes*. It could be argued these ratings would be deemed expected by the teaching population, as work at a desk is not always seen as effective teaching practice.

Figure A4.1.2 presents Statement 2, 'I display examples of students' work in maths around the room.'

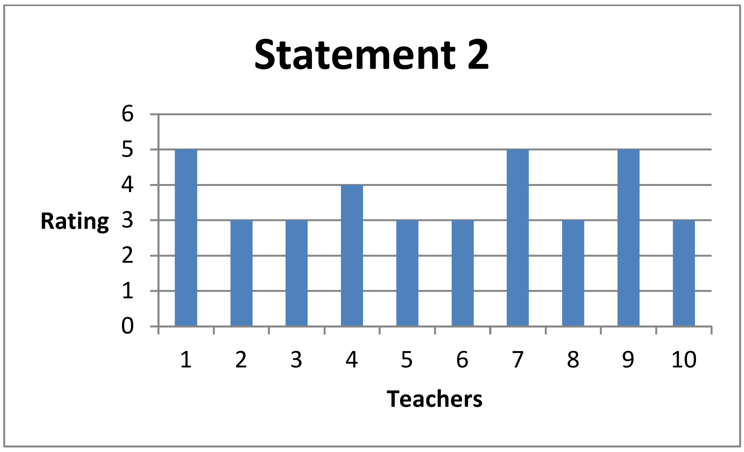

Figure A4.1.2: Statement 2: I display examples of students' work in maths around the room.

All teachers selected ratings of *sometimes*, *often* or *very often* for displaying students' work in maths around the classroom in Figure A4.1.2. Three teachers selected the rating *very often* of displaying examples of students' work and one rated the statement *often*. This is reflective of what is seen in classrooms with different teachers displaying varying amounts of student work,

Figure A4.1.3 presents Statement 3, 'I group students in different ways during my maths class for instructional purposes.'

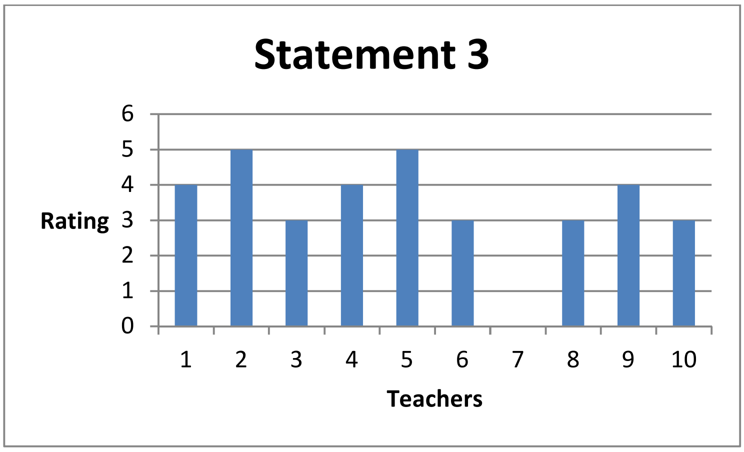

Figure A4.1.3: Statement 3: I group students in different ways during my maths class for instructional purposes.

One teacher did not respond to this statement. All other teachers rated this question as *sometimes*, *often* or *very often* for grouping students in maths for instructional purposes as shown in Figure

A4.1.3. Grouping of students is a common practice in primary settings and would be expected, although groupings may not always be targeted in teaching.

Figure A4.1.4 presents Statement 4, 'I ask most of the questions during class.'

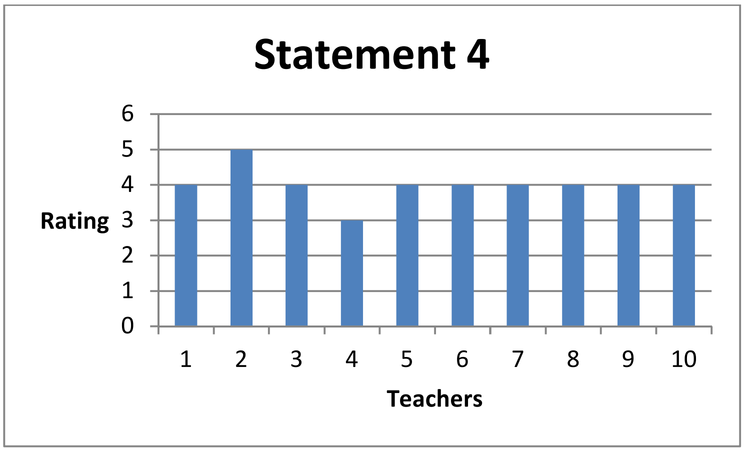

Figure A4.1.4: Statement 4: I ask most of the questions during class.

Eight of the ten teachers selected the rating *often* in response to who asked most of the questions during class, as shown in Figure A4.1.4. One teacher indicated they *very often* asked most of the questions. Only one teacher of the group indicated they *sometimes* asked most of the questions during class. The ratings in response to the teacher asking most of the questions may appear high and perhaps is reflective of the whole, part, whole model of teaching being used at the school and may indicate the inquiry based models are not being used as frequently.

Figure A4.1.5 presents Statement 5, 'Students pose thought-provoking questions during maths.

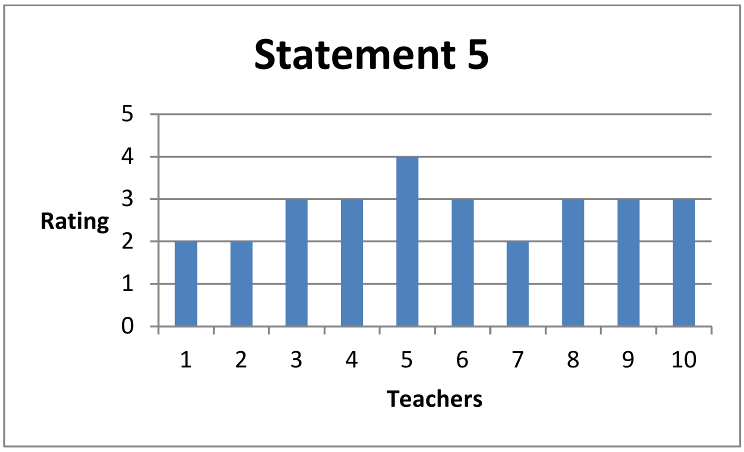

Figure A4.1.5: Statement 5: Students pose thought-provoking questions during maths.

One teacher indicated students *often* posed thought-provoking questions during maths as shown in Figure A4.1.5. Half the teachers selected the rating *sometimes*, while three of the teachers rated this as *seldom*. This relates to Figure A4.1.4, Statement 4, where teachers indicated they tended to ask questions more frequently, the ratings to this statement are not unexpected.

Figure A4.1.6 presents Statement 6, 'Students reflect on their work, progress, and thought processes in maths orally or in writing.'

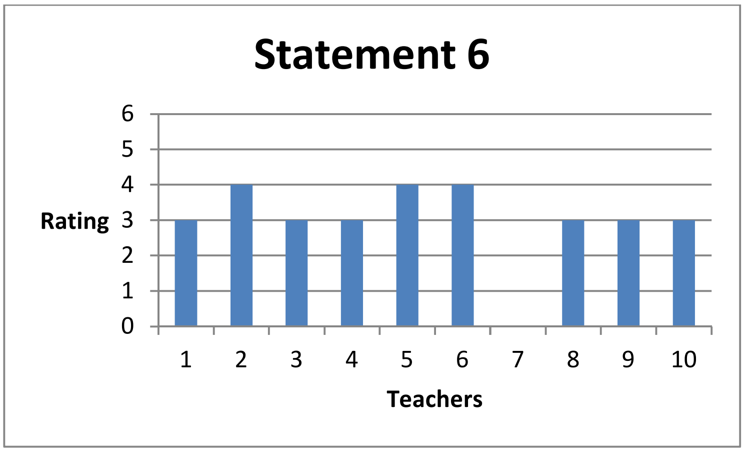

Figure A4.1.6: Statement 6: Students reflect on their work, progress, and thought processes in maths orally or in writing.

More than half the teachers (six) indicated they felt students reflected on their work, progress and thought processes in maths *sometimes* as shown in Figure A4.1.6. Three of the teachers rated this statement as *often* and one teacher did not respond. The spread of ratings may not be unexpected as students reflecting on their learning in mathematics in writing, is not a common practice, it does tend to be orally often via questioning.

Figure A4.1.7 presents Statement 7, 'I often ask "How did you arrive at that answer, solution or idea?"'

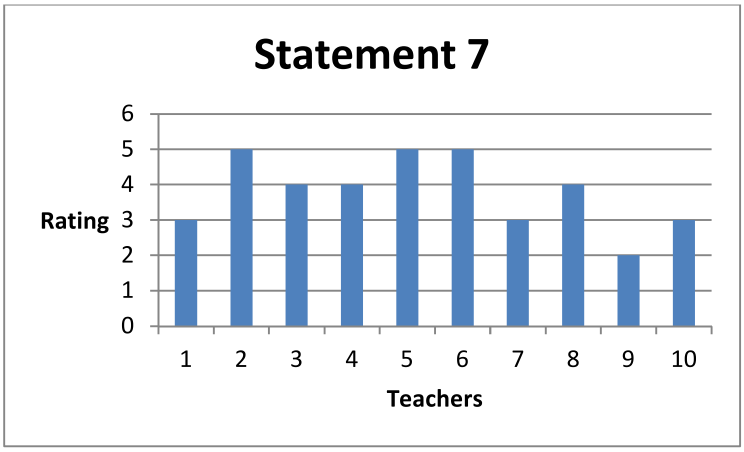

Figure A4.1.7: Statement 7: I often ask "How did you arrive at that answer, solution or idea?"

A range of responses are presented for this statement in Figure A4.1.7. One teacher selected *seldom*, three selected *sometimes*, three selected *often* and three selected *very often* as ratings to how often they ask the question 'How did you arrive at that answer, solution or idea?' Ratings to this statement are varied and may reflect teacher confidence in unpacking the mathematical understanding behind a response to a mathematical question or problem.

Figure A4.1.8 presents Statement 8, 'Students spend time working collaboratively in our maths class.'

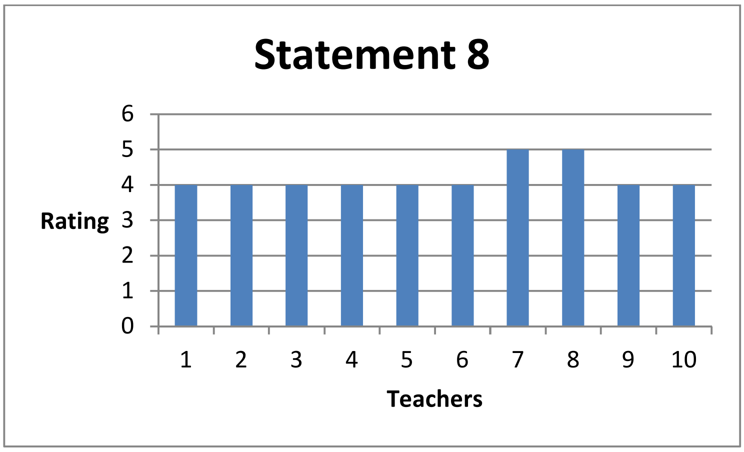

Figure A4.1.8: Statement 8: Students spend time working collaboratively in our maths class.

Eight of the ten teachers rated the statement in Figure A4.1.8 that students *often* spent time working collaboratively in the maths class. The remaining teachers selected the rating *very often*. These ratings of *often* and *very often* reflective the collaborative nature of both the teaching and learning at the school, and the whole school approach taken.

Figure A4.1.9 presents Statement 9, 'Students support their answers in maths with evidence, giving reasons for their thinking.'

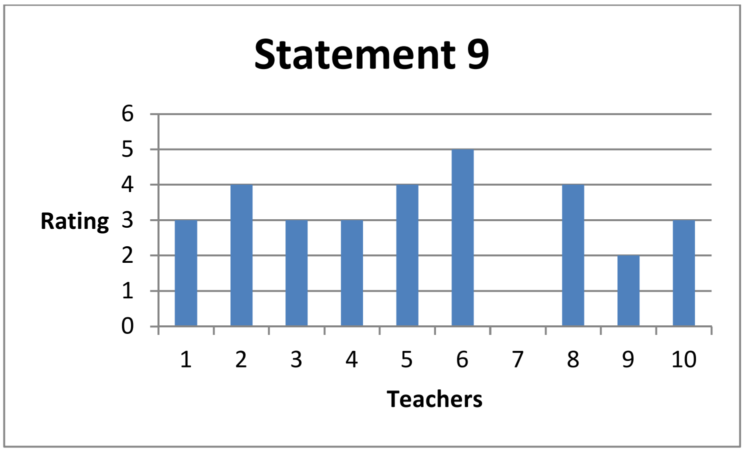

Figure A4.1.9: Statement 9: Students support their answers in maths with evidence, giving reasons for their thinking.

One teacher indicated that students *seldom* supported their answers in maths with evidence, giving reasons for their thinking. Four teachers rated this as *sometimes*, three teachers rated this as *often* and one teacher rated this as *very often* in Figure A4.1.9. One teacher did not respond to the statement. The ratings by teachers for this statement are widely spread. This statement relates to Figure A4.1.7, Statement 7, although the spread of responses is wider in Figure A4.1.9. This may be because represented in Figure A4.1.7, teachers indicate they are asking the 'how' question, but represented in Figure A4.1.9, the ratings are lower with teachers indicating that don't feel students are supporting their thinking with evidence or reasoning.

Figure A4.1.10 presents Statement 10, 'I think that maths questions should be marked as either right or wrong.'

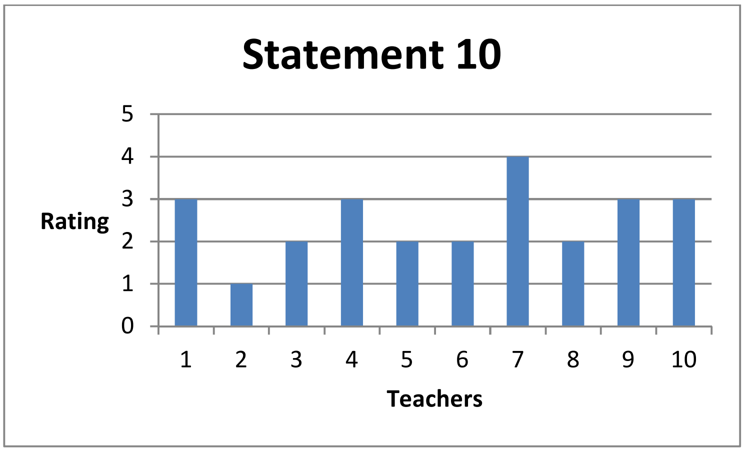

Figure A4.1.10: Statement 10: I think that maths questions should be marked as either right or wrong.

One teacher indicated that they *hardly ever* thought maths questions should be marked as either right or wrong. Four teachers rated the statement as *seldom*, four teachers rated *sometimes* and one teacher rated the statement as they *often think* that maths questions should be marked as either right or wrong as shown in Figure A4.1.10. This range of ratings may reflect teacher's personal beliefs about the nature of mathematics. With a staff of individuals, a range in responses is to be expected.

Figure A4.1.11 presents Statement 11, 'I model thoughtful behaviour in maths..'

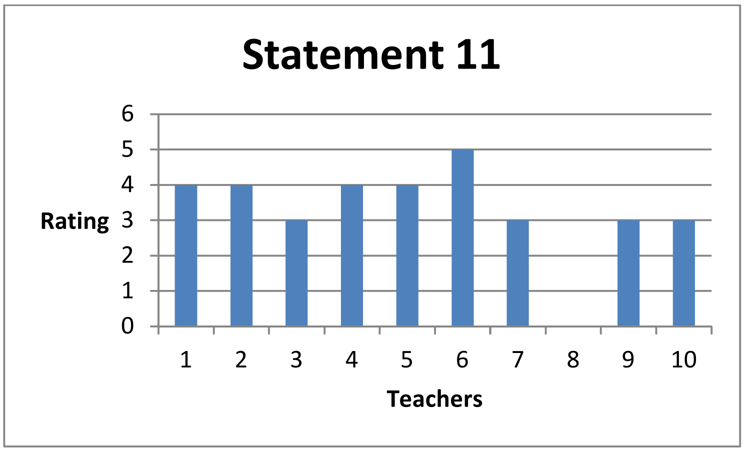

Figure A4.1.11: Statement 11: I model thoughtful behaviour in maths.

Four teachers responded with they *sometimes* model thoughtful behaviour in maths. Four teachers rated the statement as *often* and one teacher rated the statement *very often* they modelled this behaviour. One teacher did not respond to the statement as shown in Figure A4.1.11. Only one teacher responded with very often to the statement. This may reflect teachers critically reviewing their behaviour and identifying that behaviour does vary in response to different aspects of teaching.

Figure A4.1.12 presents Statement 12, 'I give adequate time to thinking and reflecting in the maths session.'

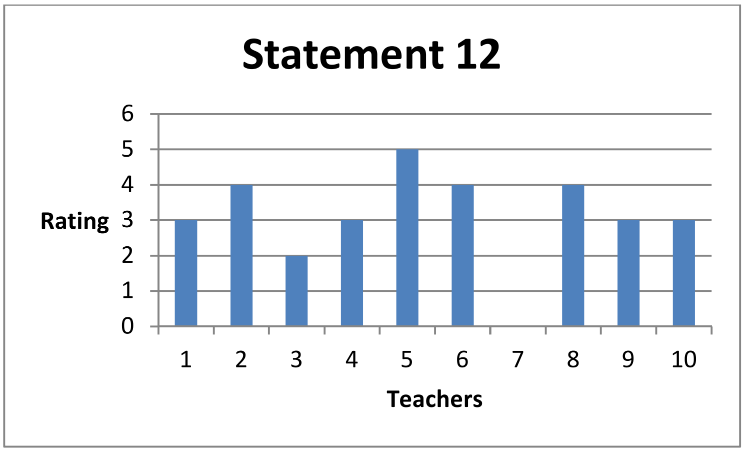

Figure A4.1.12: Statement 12: I give adequate time to thinking and reflecting in the maths session.

One teacher rated the statement that they *seldom* gave adequate time to thinking and reflecting in the maths session. Four teachers rated the statement as *sometimes*, three teachers rated *often* and one teacher rated the statement as they *very often* gave adequate time to thinking and reflecting in the maths session. One teacher did not respond to the statement as shown in Figure A4.1.12. As with ratings to Figure A4.1.9: Statement 9 and Figure A4.1.7: Statement 7 there is a spread of ratings when considering the thinking and reflection components to lessons.

Figure A4.1.13 presents Statement 13, 'I encourage students to seek alternative ways of approaching problems, interpretations and solutions.'

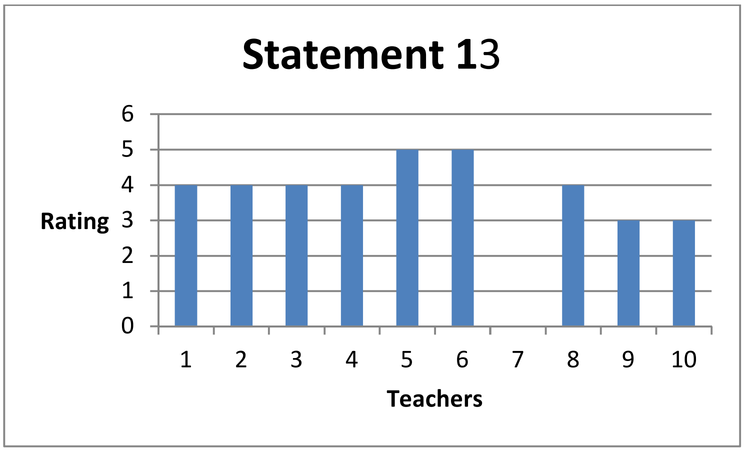

Figure A4.1.13: Statement 13: I encourage students to seek alternative ways of approaching problems, interpretations and solutions.

Half of the teachers indicated with a rating that they *often* encourage students to seek alternative ways of approaching problems, interpretations and solutions. Two teachers rated this as *very often* and two as *sometimes*. One of the teachers did not respond to the statement as shown in Figure A4.1.13. The ratings to this statement is more in line with the ratings in Figure A4.1.8: Statement 8 which examines collaborative work. This reflects another area of teaching and learning which has been a focus at the school.

Figure A4.1.14 presents Statement 14, 'Students spontaneously comment on each other's responses and ideas.'

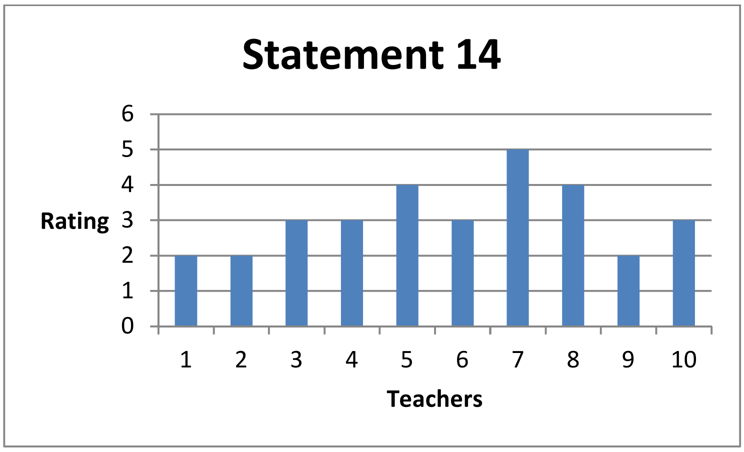

Figure A4.1.14: Statement 14: Students spontaneously comment on each other's responses and ideas.

Three of the teachers rated the statement that students *seldom* spontaneously commented on each other's responses and ideas as shown in Figure A4.1.14. Four teachers rated this as *sometimes*, two *often* and one rated that statement as *very often* to students spontaneously commenting on each other's responses and ideas. Again, a spread of ratings is seen when considering how students are reacting to their own (Figure A4.1.7: Statement 7) and others' ideas and responses (Figure A4.1.14: Statement 14) in the classroom.

Figure A4.1.15 presents Statement 15, 'We ask questions in class that require complex thought processes.'

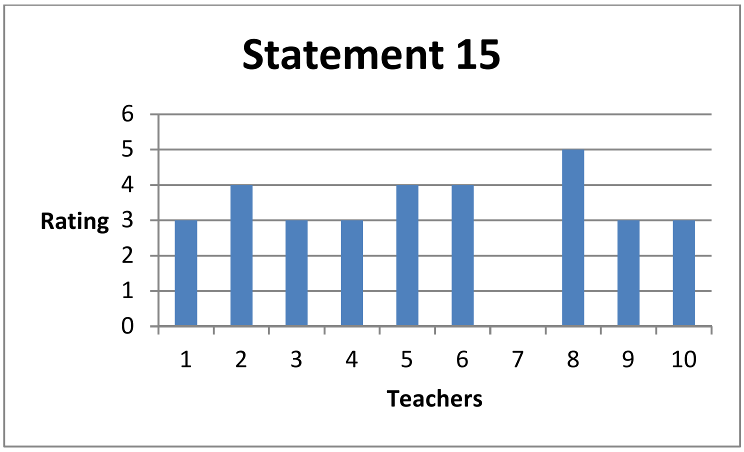

Figure A4.1.15: Statement 15: We ask questions in class that require complex thought processes.

Half of the teachers rated the statement as they *sometimes* asked questions in class that required complex thought processes as shown in Figure A4.1.15. Three teachers rated this as *often* and one *very often* for higher order questioning. One teacher did not respond to this statement. A range of ratings is seen in response to this statement about questioning in comparison to Figure A4.1.4: Statement 4, as teachers may have interpreted the statements from two different perspectives, that of themselves or that as a collective class.

Figure A4.1.16 presents Statement 16, 'Students confidently and willingly discuss their thinking in maths.'

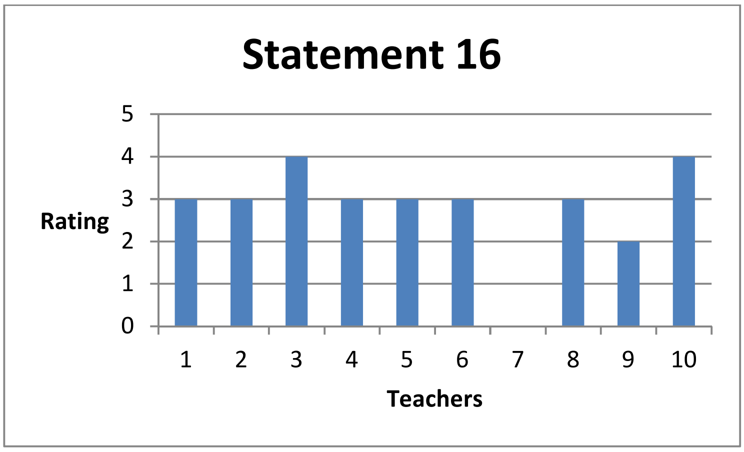

Figure A4.1.16: Statement 16: Students confidently and willingly discuss their thinking in maths.

More the half of the teachers (6) rated the statement *sometimes* students confidently and willingly discussed their thinking in maths as shown in Figure A4.1.16. One teacher rated this as *seldom* and two teachers rated this as *often*. One teacher did not respond to this statement. The range of ratings is not as spread as has been in previous responses, to other statements such as Figure A4.1.9: Statement 9, about students discussing and sharing their thinking.

Figure A4.1.17 presents Statement 17, 'Students have the opportunity to use a variety of materials to explore concepts.'

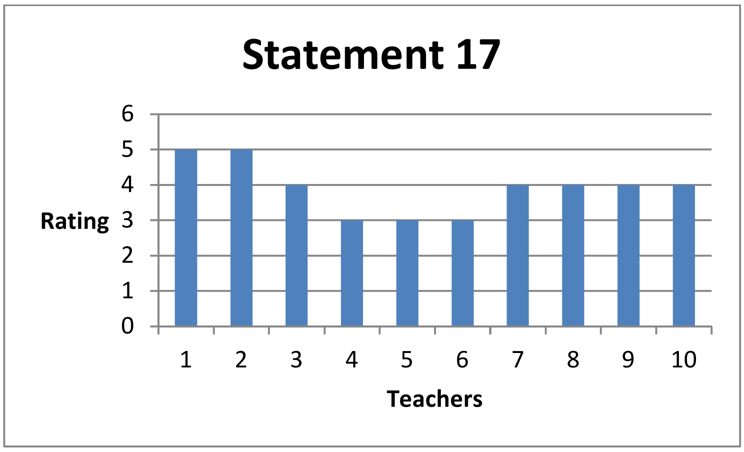

Figure A4.1.17: Statement 17: Students have the opportunity to use a variety of materials to explore concepts.

All of the teachers had a rating of 3 (*sometimes*) or above for students having the opportunity to use a variety of materials to explore concepts as shown in Figure A4.1.17. Half of the teachers rated this statement as *often* and two as *very often*. The ratings in response to this statement are more consistent than ratings of statements around students questioning and thinking. This may be because teachers are more conscious of using hands on materials in the classroom, and also may be a reflection of the more hands on teaching approach with primary students.

Figure A4.1.18 presents Statement 18, 'Students respond to my questions with short, one or two-word answers.'

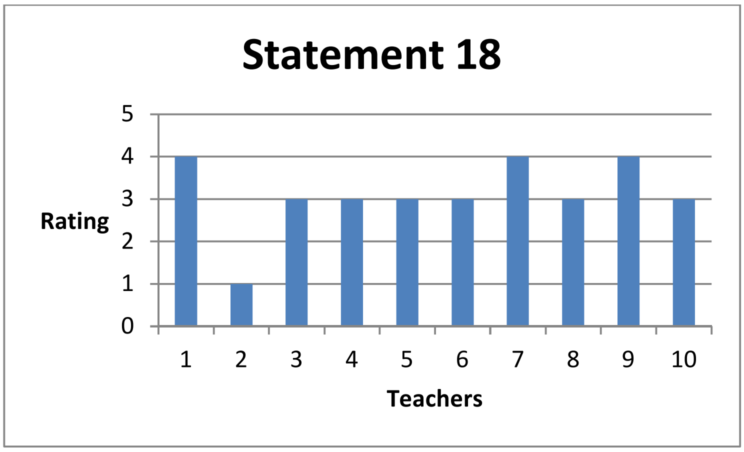

Figure A4.1.18: Statement 18: Students respond to my questions with short, one or two-word answers.

One teacher rated the statement as *hardly ever* for students responding to questioning with short, one or two-word answers. More than half (six) teachers rated this statement as *sometimes* and three teachers rated this as *often* as shown in Figure A4.1.18. The ratings are more consistent than responses to statements about in-depth questioning or providing reasoning around thinking, as in Figure A4.1.9: Statement 9 so it appears students provide short answers but don't expand on responses to questions.

Figure A4.1.19 presents Statement 19, 'Covering content and CSF 11 outcomes is one of my major goals.'

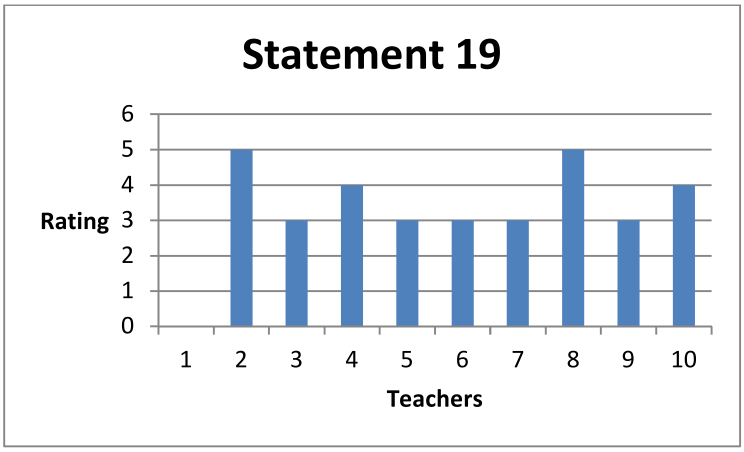

Figure A4.1.19: Statement 19: Covering content and CSF 11 outcomes is one of my major goals.

Half of the teachers rated the statement that *sometimes* covering content and curriculum was one of their major goals. Two teachers rated this statement as *often* and two teachers rated it as *very often*. One teacher did not respond to this statement as shown in Figure A4.1.19. These ratings may be a reflection of the emphasis of the need to meet curriculum outcomes placed on staff by leadership, or could be level related, e.g. more emphasis is placed on covering curriculum at Years 5 and 6.

Figure A4.1.20 presents Statement 20, 'I use a wide variety of assessment experiences in maths and use the information to drive my teaching.'

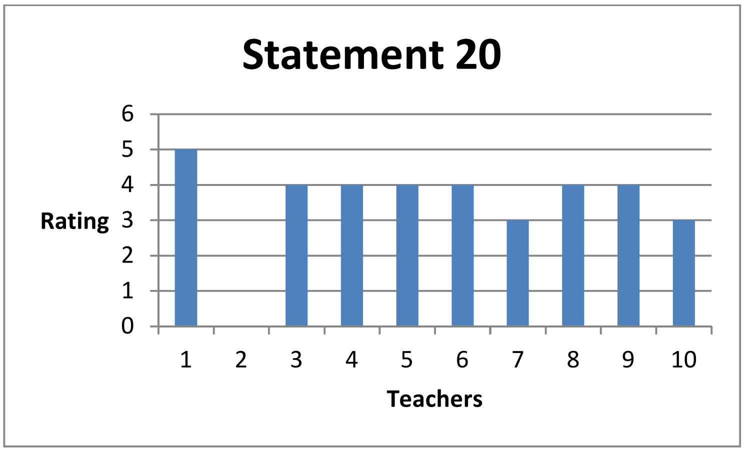

Figure A4.1.20: Statement 20: I use a wide variety of assessment experiences in maths and use the information to drive my teaching.

More than half (six) of the teachers rated the statement as *often* they used a wide variety of assessment experiences in maths and then used the information to inform their teaching. Two teachers rated the statement as *sometimes* and one teacher rated this as *very often* as shown in Figure A4.1.20. One teacher did not respond to this statement. This is a strong set of ratings and may be a reflection of a whole school focus considering assessment experiences. This could also be seen as a negative, as teachers may be using an inconsistent set of assessment materials or alternatively teachers may have placed a stronger emphasis on the second part of the statement of using assessment to drive their teaching.

Figure A4.1.21 presents Statement 21, ‘I am flexible in my lessons, I allow students’ questions to divert me form the planned lesson.’

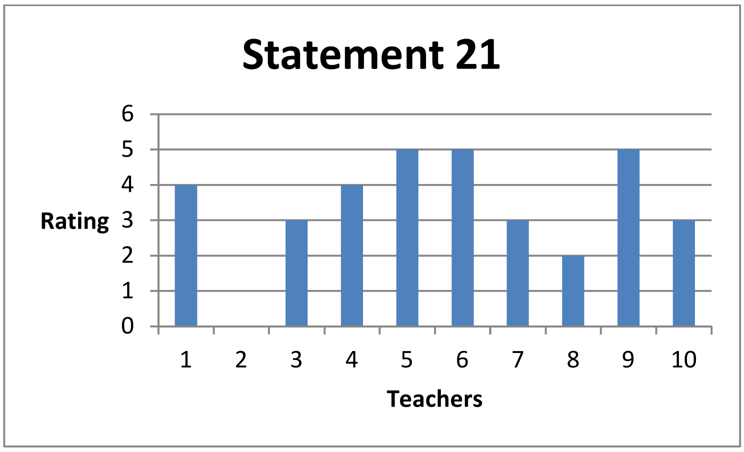

Figure A4.1.21: Statement 21: I am flexible in my lessons, I allow students' questions to divert me form the planned lesson.

One teacher rated that statement as *seldom* they were flexible in their lessons, allowing students' questions to divert them from the planned lesson. Three teachers rated this statement as *sometimes*, two teachers rated the statement as *often* and three teachers as *very often* as shown in Figure A4.1.21. One teacher did not respond to this statement. This variation in responses is to be expected as teachers may have rated the flexible nature of the statement or may have responded to the second part, of diverting from planned lessons. This can be seen as having pros and cons, as it may be good for teachers to respond to 'teachable moments' but conversely there may be too much diversion occurring.

Figure A4.1.22 presents Statement 22, 'One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.'

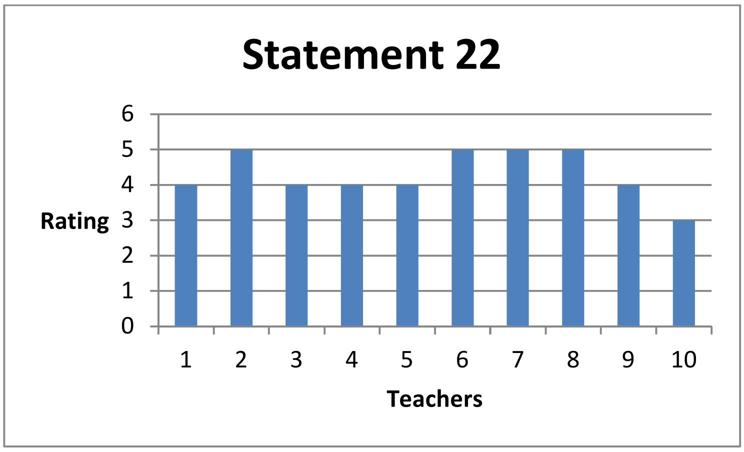

Figure A4.1.22: Statement 22: One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.

All, except one teacher, rated that statement as *often* or *very often* as shown in Figure A4.1.22, to one of their teaching goals is ensuring students understand and can apply mathematical concepts to life experiences. One teacher rated this statement as *sometimes* this was their goal. This is minimal spread in the ratings to this statement, reflecting a whole school focus on the value of mathematics and the application to real life situations.

Figure A4.1.23 presents Statement 23, 'We work to build a community of inquiry in our maths class.'

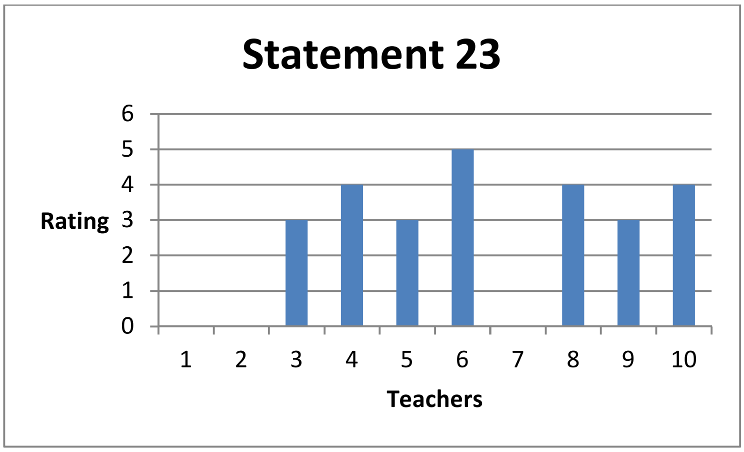

Figure A4.1.23: Statement 23: We work to build a community of inquiry in our maths class.

This statement had the least number of responses, with three teachers choosing not to rate this statement. Three teachers rated the statement as *sometimes* they work to build a community of inquiry in the maths class, three teachers selected the rating *often* and one *very often* as shown in Figure A4.1.23. ‘Community of inquiry’ (Garrison, Anderson & Archer, 2010) is a specific term, and one possibility for teachers not responding is they may not be familiar with the term, or what this ‘looks like’ in a maths classroom.

Figure A4.1.24 presents Statement 24, ‘We discuss teaching strategies at unit or staff meetings.’

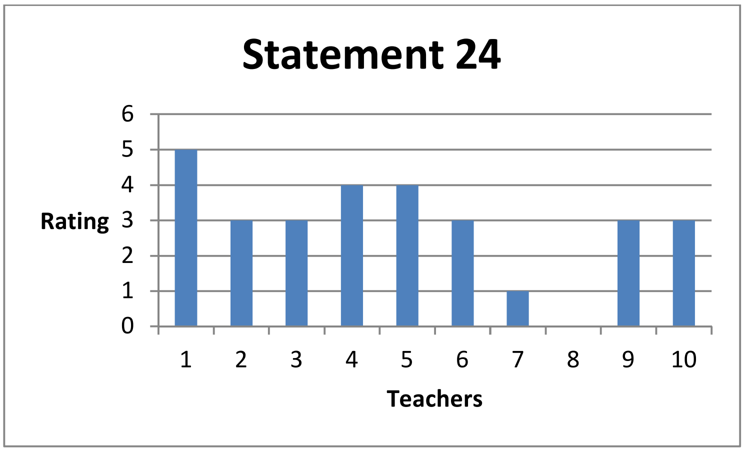

Figure A4.1.24: Statement 24: We discuss teaching strategies at unit or staff meetings.

One teacher rated the statement as *hardly ever* teaching strategies were discussed at unit or staff meetings. Half of the teachers indicated *sometimes*, two teachers selected *often* and one teacher selected *very often*. One teacher did not respond to this statement as shown in Figure A4.1.24. The results are surprisingly varied when considering ratings of other statements that reflect aspects that have been a focus of the school such as Figure A4.1.22: Statement 22 considering mathematics related to life experiences and students working collectively. It raises the question, where messages about teaching strategies are being discussed and shared.

Figure A4.1.25 presents Statement 25, ‘As a staff, we work to reach a consensus on what it means to be an effective maths teacher.’

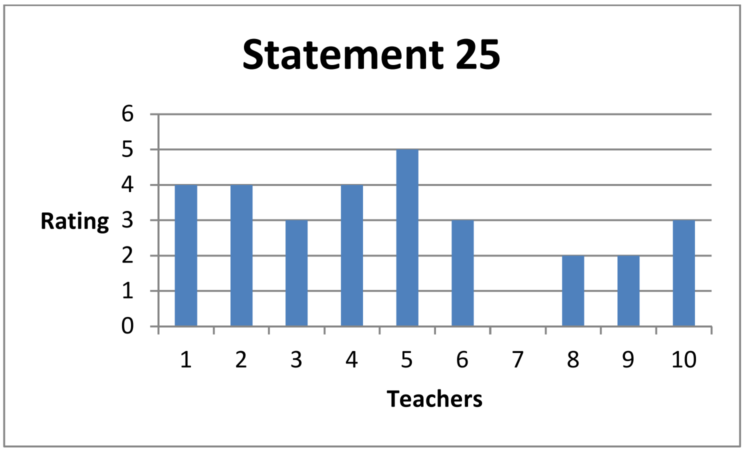

Figure A4.1.25: Statement 25: As a staff, we work to reach a consensus on what it means to be an effective maths teacher.

One teacher rated the statement that they were working to reach a consensus on what it means to be an effective maths teacher (Shellard and Moyer, 2002) as *very often*. Three teachers rated this as *often*, three *sometimes*, and two *seldom* as shown in Figure A4.1.25. One teacher did not respond to the statement. As in Figure A4.1.24: Statement 24, ratings are varied and are perhaps reflecting a focus in staff and unit meetings on the practical aspects of teaching rather than the big ideas of teaching.

5.2 Post intervention data collection

This section presents the post intervention data collection. Each statement has a column graph created of the teachers' ratings to the statement, some brief commentary is made following each graph.

Figure A4.2.1 presents Statement 1, 'When teaching maths, I usually work at or near my desk.'

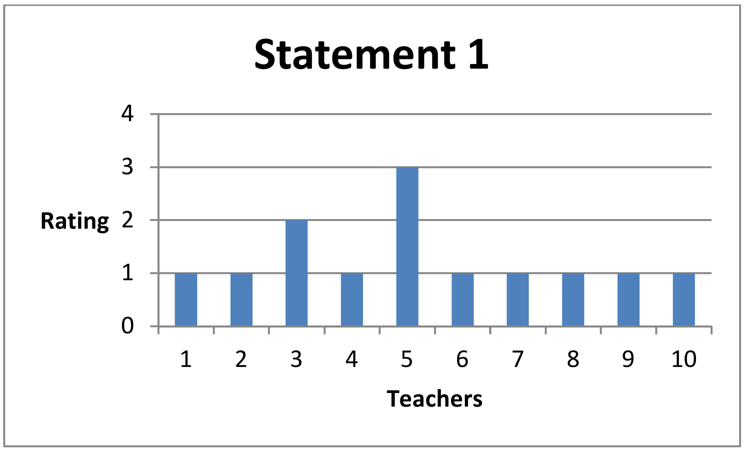

Figure A4.2.1: Statement 1: When teaching maths I usually work at or near my desk.

All except two of the teachers rated the statement that they were working at or near their desk as *hardly ever*. One teacher rated this as *seldom* and the other *sometimes* as shown in Figure A4.2.1.

Figure A4.2.2 presents Statement 2, 'I display examples of students' work in maths around the room.'

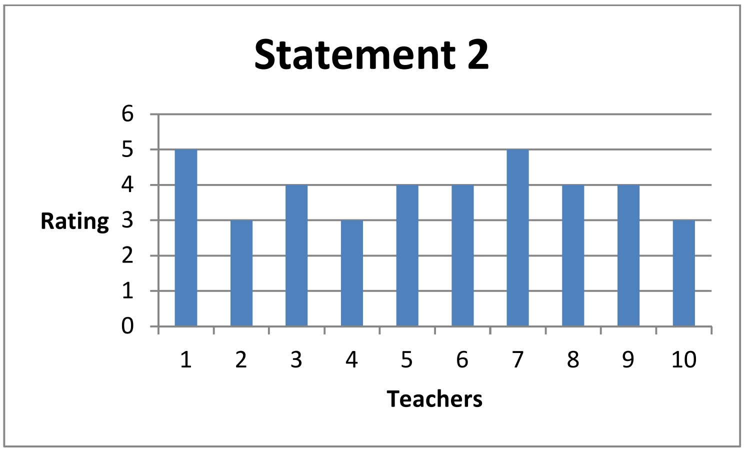

Figure A4.2.2: Statement 2: I display examples of students' work in maths around the room.

Half of the teachers rated the statement they displayed examples of students' work in maths around the room *as often*. Three teachers rated this as *sometimes* and two rated this as *very often* as shown in Figure A4.2.2. These ratings are fairly narrow in range, and a difference would be expected as individuals have personal taste about the amount of materials displayed in a classroom.

Figure A4.2.3 presents Statement 3, 'I group students in different ways during my maths class for instructional purposes.'

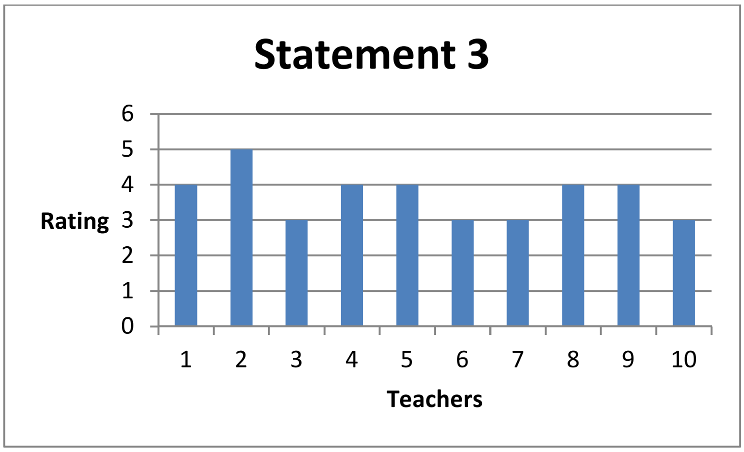

Figure A4.2.3: Statement 3: I group students in different ways during my maths class for instructional purposes.

One teacher rated the statement they grouped students in different ways during maths classes for instructional purposes as *very often*. Half of the teachers rated this statement as *often*, four teachers rated this as *sometimes* as shown in Figure A4.2.3. There is not a large spread of ratings for this statement, and grouping is a common teaching technique used in classrooms.

Figure A4.2.4 presents Statement 4, ‘I ask most of the questions during class.’

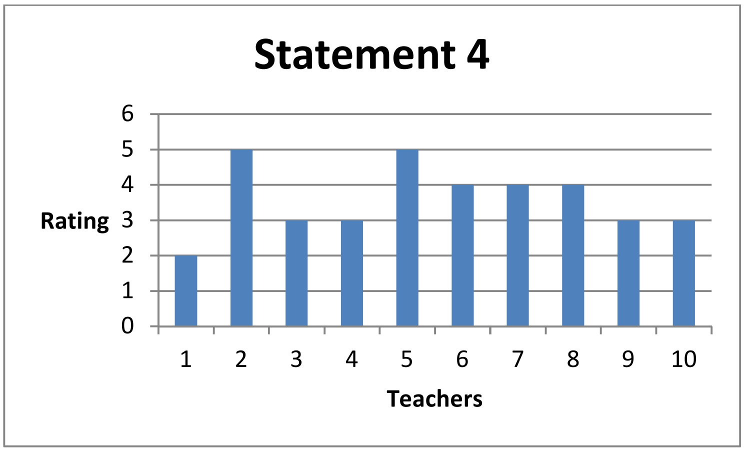

Figure A4.2.4: Statement 4: I ask most of the questions during class.

Two teachers rated the statement they asked most of the questions during class as *very often*, as shown in Figure A4.2.4. Three of the teachers rated this statement as *often*, while half of the teachers rated this as *sometimes* or even *seldom*. There is a spread of ratings of teachers asking most of the questions during class, which may be due to teaching styles or a desire for students to ask more questions.

Figure A4.2.5 presents Statement 5, ‘Students pose thought-provoking questions during maths.’

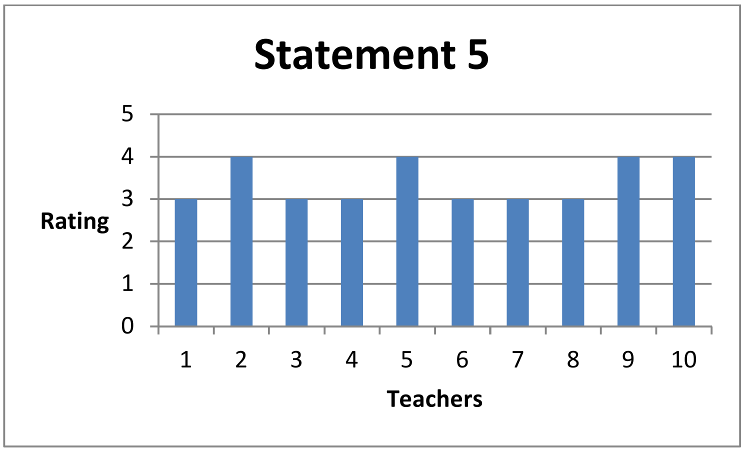

Figure A4.2.5: Statement 5: Students pose thought-provoking questions during maths.

Most of the teachers rated this statement students posed thought provoking questions during maths as *sometimes*, while four of the teachers rated it as *often* as shown in Figure A4.2.5. This is a narrow spread of ratings of sometimes and often to this statement compared to the previous Figure A4.2.4: Statement 4, when considering teacher questioning and deeper students questioning.

Figure A4.2.6 presents Statement 6, 'Students reflect on their work, progress, and thought processes in maths orally or in writing.'

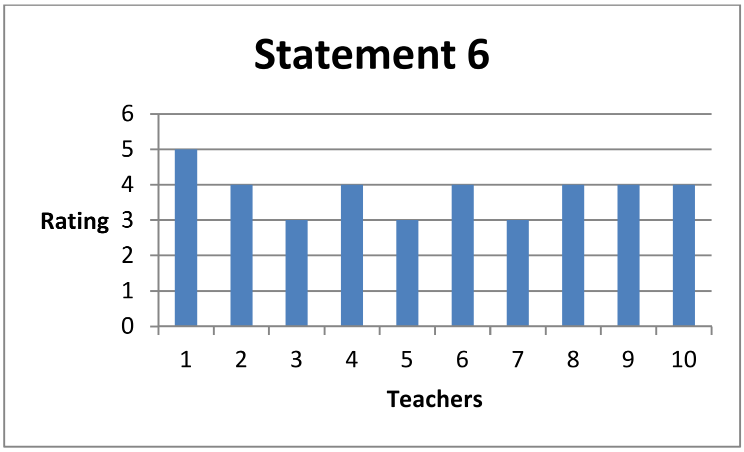

Figure A4.2.6: Statement 6: Students reflect on their work, progress, and thought processes in maths orally or in writing.

One teacher rated the statement students reflected on their work, progress, and thought processes in in maths as *very often*. Most (six) of the teachers rated this as *often*, and three teachers rated this statement as *sometimes* as shown in Figure A4.2.6. The spread of ratings is not unexpected as students reflecting on their learning in mathematics in writing, is not a common practice, it does tend to be orally often via questioning.

Figure A4.2.7 presents Statement 7, ‘I often ask “How did you arrive at that answer, solution or idea?”’

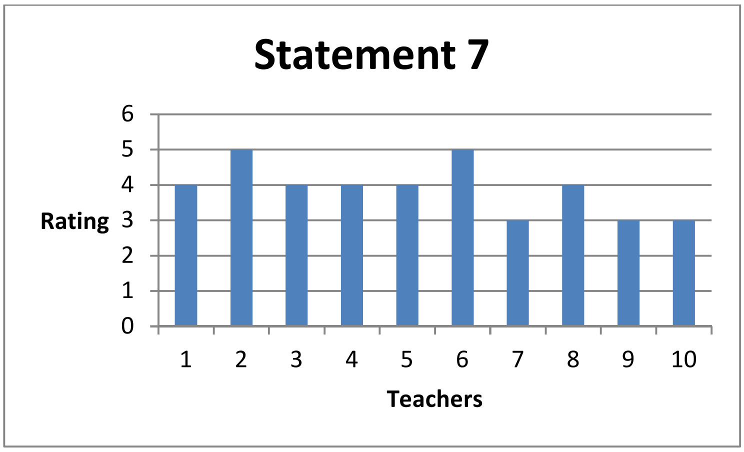

Figure A4.2.7: Statement 7: I often ask “How did you arrive at that answer, solution or idea?”

Half of the teachers rated the statement “How did you arrive at that answer, solution or idea?” as *often.* Two teachers rated this as *very often* and three teachers rated this as *sometimes* as shown in Figure A4.2.7. The range in ratings to this statement is fairly narrow ranging between very often and sometimes. This range is narrower than in Figure A4.2.4: Statement 4, which also examines teacher questioning.

Figure A4.2.8 presents Statement 8, ‘Students spend time working collaboratively in our maths class.’

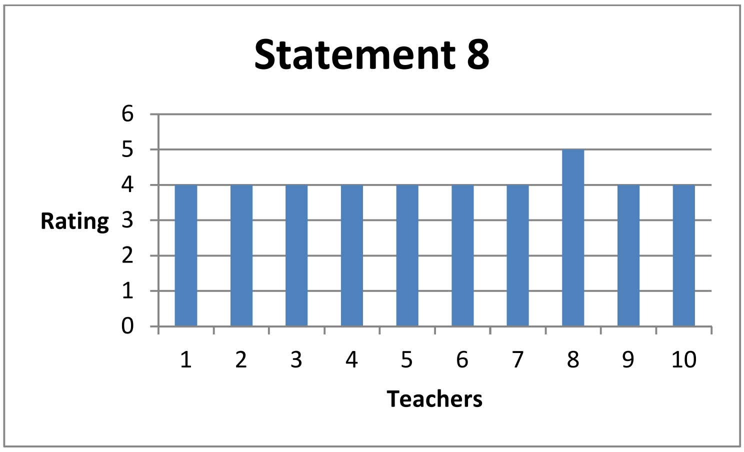

Figure A4.2.8: Statement 8: Students spend time working collaboratively in our maths class.

All teachers except one, rated that statement students spent time working collaboratively in maths classes as *often*. The one teacher rated this as *very often* as shown in Figure A4.2.8. These almost consistent ratings may relate to the collaborative learning approach at the school, and may also relate to a clear staff understanding of what this means when working in classrooms.

Figure A4.2.9 presents Statement 9, 'Students support their answers in maths with evidence, giving reasons for their thinking.'

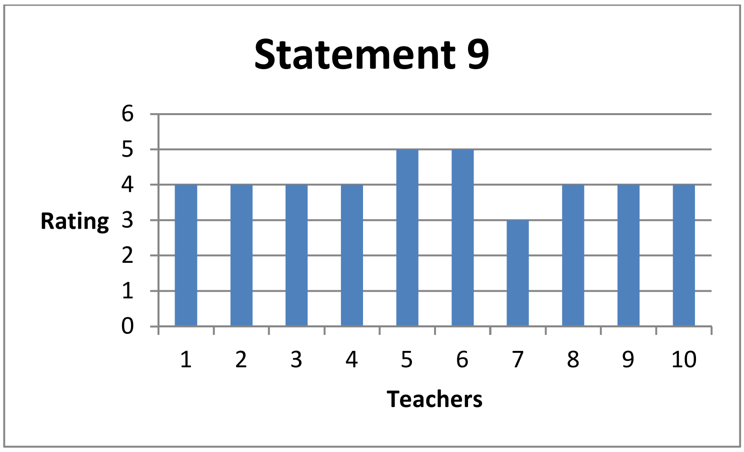

Figure A4.2.9: Statement 9: Students support their answers in maths with evidence, giving reasons for their thinking.

Most (seven) of the teachers rated that statement students supported their answers in maths with evidence, giving reasons for their thinking as *often*. One teacher rated this as *sometimes* and the remaining two teachers rated this as *very often* as shown in Figure A4.2.9. The range of ratings to this statement is similar, even more narrow in comparison to Figure A4.2.7: Statement 7 which is considering students supporting their responses to solutions and ideas (thinking).

Figure A4.2.10 presents Statement 10, 'I think that maths questions should be marked as either right or wrong.'

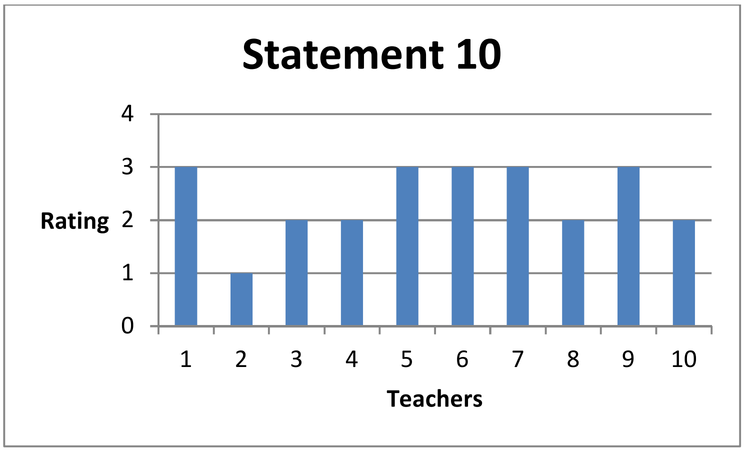

Figure A4.2.10: Statement 10: I think that maths questions should be marked as either right or wrong.

Half of the teachers rated the statement that they thought maths questions should be either marked either right or wrong as *sometimes*. Four teachers rated this as *seldom* and one teacher as *hardly ever* as shown in Figure A4.2.10. This range of ratings could illustrate teacher beliefs of mathematics, and it is not unexpected that it is so varied.

Figure A4.2.11 presents Statement 11, 'I model thoughtful behaviour in maths.'

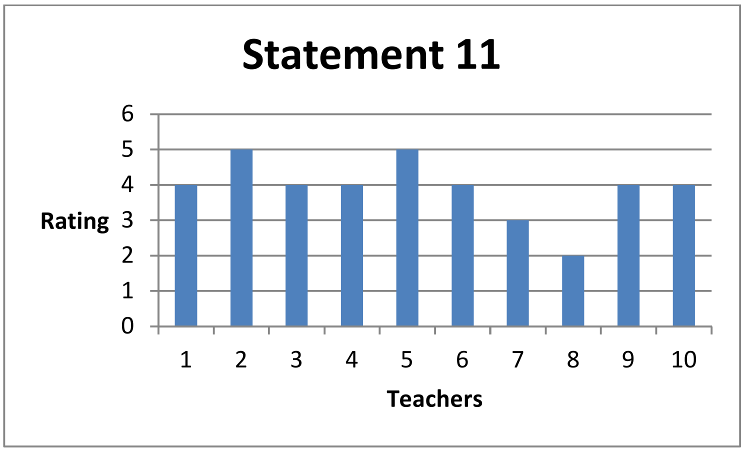

Figure A4.2.11: Statement 11: I model thoughtful behaviour in maths.

One teacher rated the statement they felt they modelled thoughtful behaviour in maths as *seldom* and one teacher rated it as *sometimes* as shown in Figure A4.2.11. Six teachers rated the statement as *often* while two teachers rated it as *very often*. There is a wider variation of ratings to this statement perhaps located against different peoples' perceptions around what is thoughtful behaviour.

Figure A4.2.12 presents Statement 12, 'I give adequate time to thinking and reflecting in the maths session.'

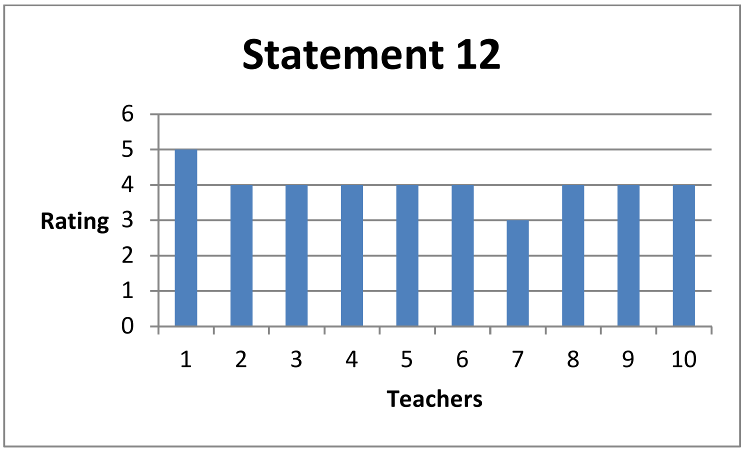

Figure A4.2.12: Statement 12: I give adequate time to thinking and reflecting in the maths session.

All except two teachers rated that statement they give adequate time for thinking and reflecting in the maths session as *often*. The other two teachers rated this statement as *very often* and *sometimes* as shown in Figure A4.2.12. This graph is reflective of Figure A4.2.9: Statement 9 which is considering students supporting answers in mathematics and providing reasoning, and perhaps these aspects are linked.

Figure A4.2.13 presents Statement 13, 'I encourage students to seek alternative ways of approaching problems, interpretations and solutions.'

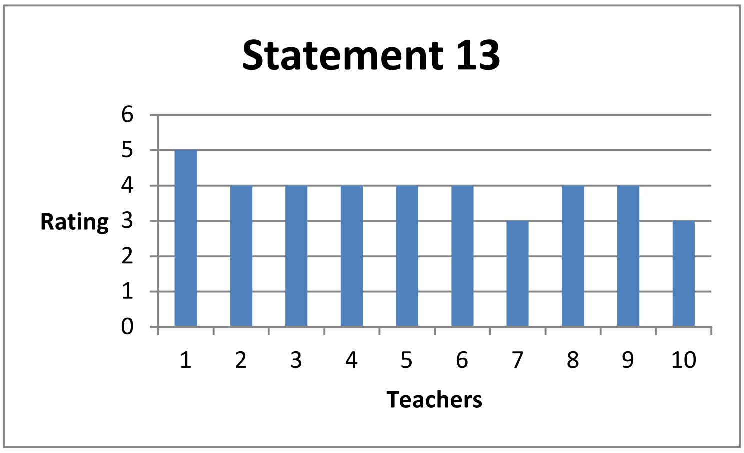

Figure A4.2.13: Statement 13: I encourage students to seek alternative ways of approaching problems, interpretations and solutions.

Most (seven) of the teachers rated the statement they encourage students to seek alternative ways of approaching problems, interpretations and solutions as *often*. Two teachers rated it as *sometimes* and one teacher *very often* as shown in Figure A4.2.13. This is similar to the spread of ratings to the previous Figure A4.2.12: Statement 12, which is about providing time for reflection and thinking. It is also similar to Figure A4.2.9: Statement 9, which is also about students supporting answers in mathematics.

Figure A4.2.14 presents Statement 14, 'Students spontaneously comment on each other's responses and ideas.'

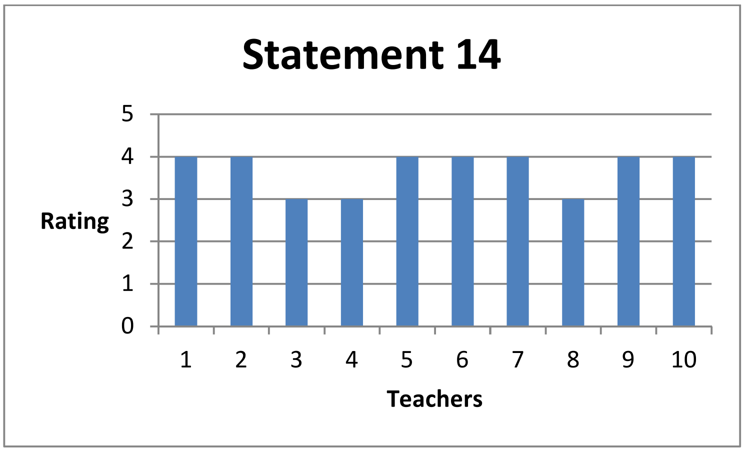

Figure A4.2.14: Statement 14: Students spontaneously comment on each other's responses and ideas.

Seven of the teachers rated the statement students spontaneously comment on each other's responses and ideas as *often*. For three teachers, they rated the statement as *sometimes* as shown in Figure A4.2.14. This is a narrow range in rating of *sometimes* to *often*.

Figure A4.2.15 presents Statement 15, 'We ask questions in class that require complex thought processes.'

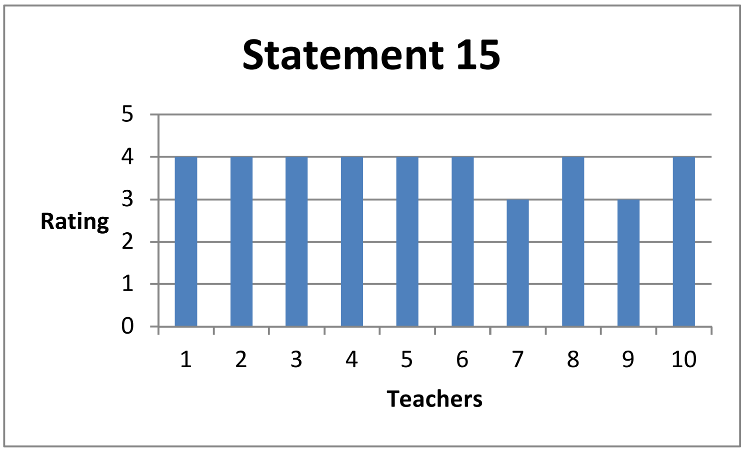

Figure A4.2.15: Statement 15: We ask questions in class that require complex thought processes.

All except two teachers rated the statement they asked questions in class that require complex thought processes as *often*. The other two teachers rated the statement as *sometimes* as shown in Figure A4.2.15. The range of the ratings is narrow and high for this statement. It is much more consistent with the value of *often* than responses to other statements about questioning such as Figure A4.2.4: Statement 4 and Figure A4.2.5: Statement 5.

Figure A4.2.16 presents Statement 16, 'Students confidently and willingly discuss their thinking in maths.'

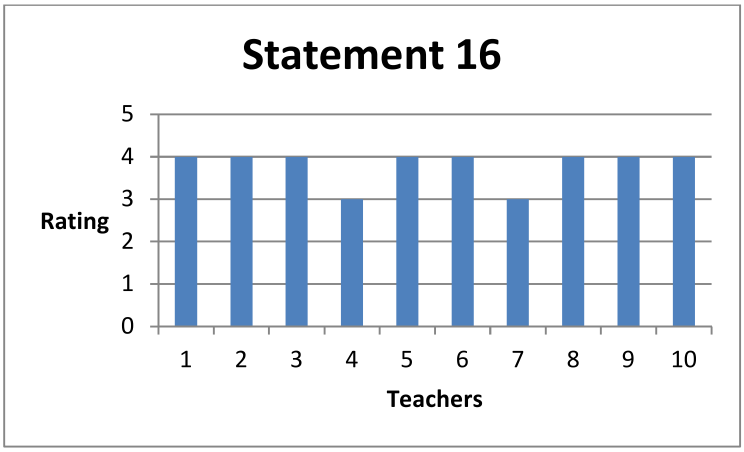

Figure A4.2.16: Statement 16: Students confidently and willingly discuss their thinking in maths.

All of the teachers except two rated the statement students confidently and willingly discuss their thinking in maths as *often*. The other two teachers rated this statement as *sometimes* in as shown in Figure A4.2.16. The range of ratings is reflective of the previous graph, Figure A4.2.15: Statement 15 which also examined students asking higher order questions. These ratings are higher in comparison to Figure A4.2.9: Statement 9, which also examines students supporting answers with responses for their thinking.

Figure A4.2.17 presents Statement 1, 'Students have the opportunity to use a variety of materials to explore concepts.'

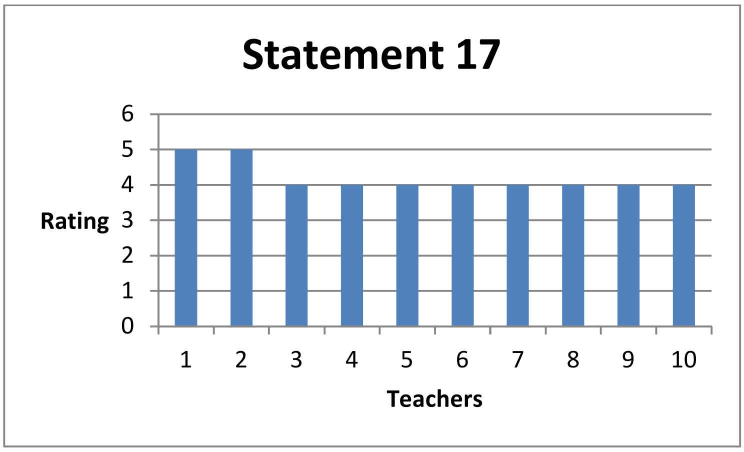

Figure A4.2.17: Statement 17: Students have the opportunity to use a variety of materials to explore concepts.

All of the teachers except two rated the statement that students have the opportunity to use a variety of materials to explore concepts as *often* as shown in Figure A4.2.17. The other two teachers rated the statement as *very often*. The spread of ratings is similar to the responses about collaborative work in Figure A4.2.8: Statement 8, both of which tend to be regularly featured in classroom teaching.

Figure A4.2.18 presents Statement 18, ‘Students respond to my questions with short, one or two-word answers.’

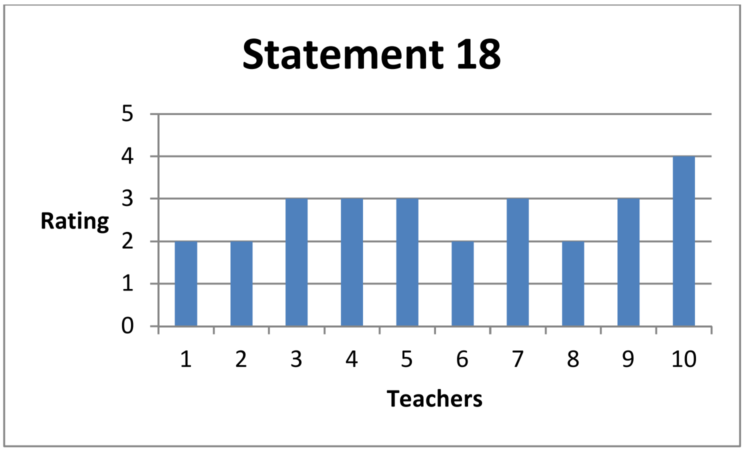

Figure A4.2.18: Statement 18: Students respond to my questions with short, one or two-word answers.

Half of the teachers rated the statement students responded to questions with short, one or two-word answers as *sometimes* as shown in Figure A4.2.18. One teacher rated that this occurred *often* and the other four teachers rated the statement as *seldom*. There is a wider range of ratings to this statement in the lower end of *seldom* and *sometimes*, which may reflect student willingness to respond to questioning with details which is also indicated in Figure A4.2.9: Statement 9.

Figure A4.2.19 presents Statement 19, 'Covering content and CSF II outcomes is one of my major goals.'

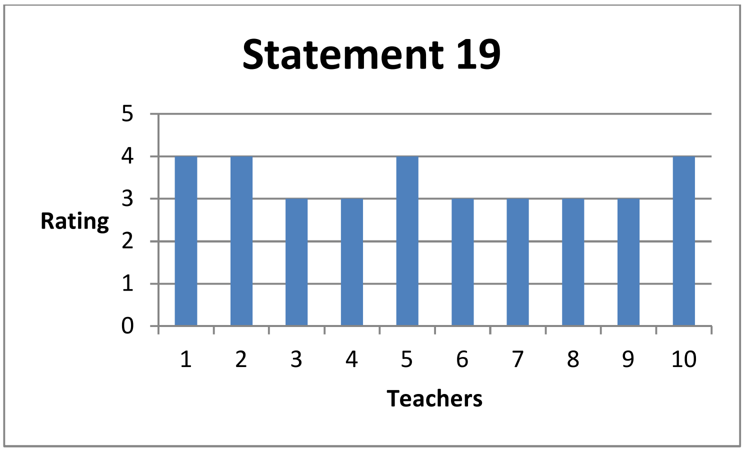

Figure A4.2.19: Statement 19: Covering content and CSF II outcomes is one of my major goals.

Six of the teachers rated the statement covering content and curriculum (CSF II) outcomes is one of my major goals as *sometimes* as shown in Figure A4.2.19. The other four teachers rated this statement as *often*. The range of ratings to this statement are narrow, either *sometimes* or *often*, perhaps indicating a consistency in approach across the staff when addressing the curriculum.

Figure A4.2.20 presents Statement 20, 'I use a wide variety of assessment experiences in maths and use the information to drive my teaching.'

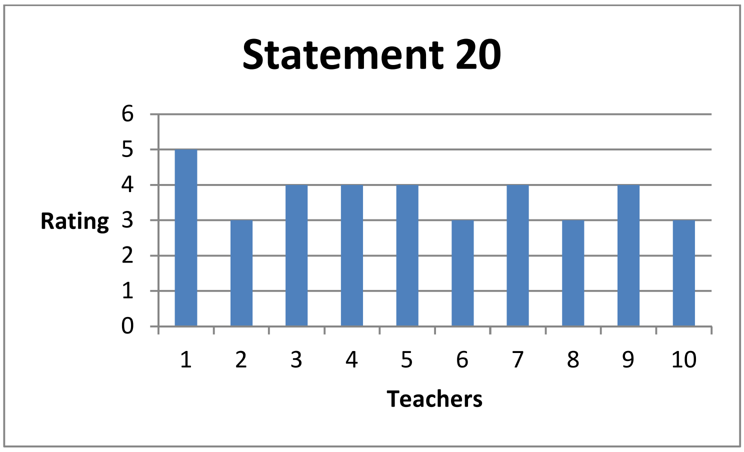

Figure A4.2.20: Statement 20: I use a wide variety of assessment experiences in maths and use the information to drive my teaching.

Half of the teachers rated the statement they use a wide variety of assessment experiences in maths and use the information to drive their teaching as *often* as shown in Figure A4.2.20. Four of the teachers rated this as *sometimes*, while one teacher rated this as *very often*. This may indicate a varied approach to the assessment experiences within classes. Teachers may be considering both formal and informal aspects of assessment when responding to this statement.

Figure A4.2.21 presents Statement 21, 'I am flexible in my lessons, I allow students' questions to divert me form the planned lesson.'

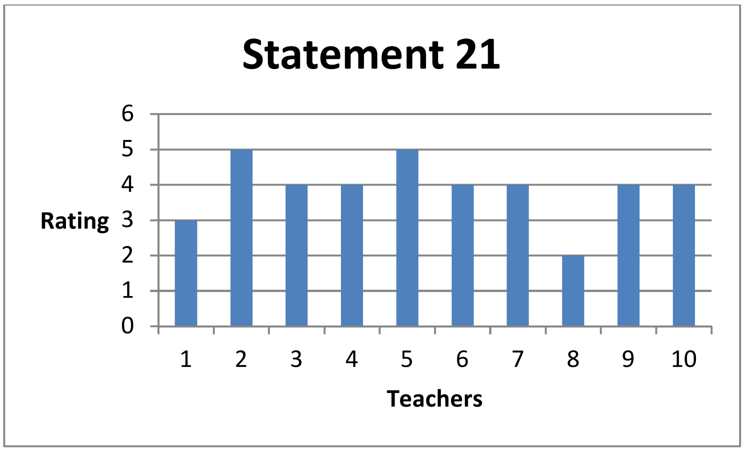

Figure A4.2.21: Statement 21: I am flexible in my lessons, I allow students' questions to divert me form the planned lesson.

One teacher rated the statement they were flexible in their lessons, allowing students' questions to divert them form the planned lesson as *seldom*. One teacher rated this as *sometimes*. The majority of the teachers (six) rated the statement as *often*, and two teachers as *very often* as shown in Figure A4.2.21. The range of ratings reflect teachers' different teaching styles. It may illustrate a confidence in taking teachable moments or a reluctance to move away from the planned lesson; with strengths and weaknesses for both approaches.

Figure A4.2.22 presents Statement 22, 'One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.'

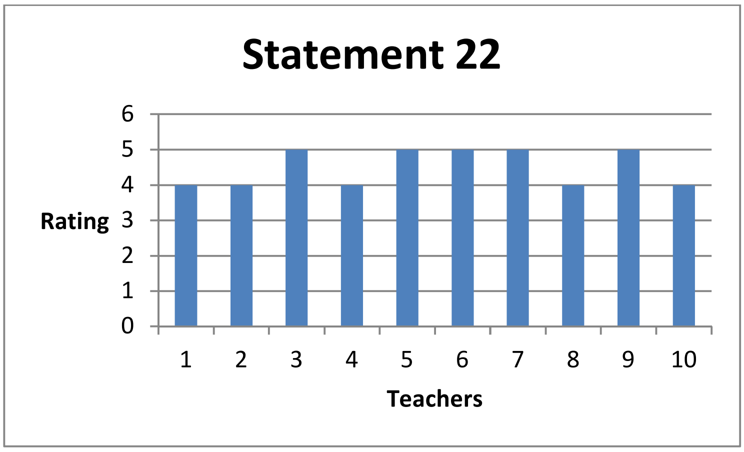

Figure A4.2.22: Statement 22: One of my goals is ensuring that students understand and can apply mathematical concepts to life experiences.

Half of the teachers rated the statement it was one of their goals to ensure that students understand and can apply mathematical concepts to life experiences as *very often*. The other half rated the statement as *often* as shown in Figure A4.2.22. This narrow range in ratings for this statement may illustrate a consistency across the staff in valuing mathematics outside the classroom. Teachers may also focus on the students' understanding element of the statement when responding.

Figure A4.2.23 presents Statement 23, 'We work to build a community of inquiry in our maths class.'

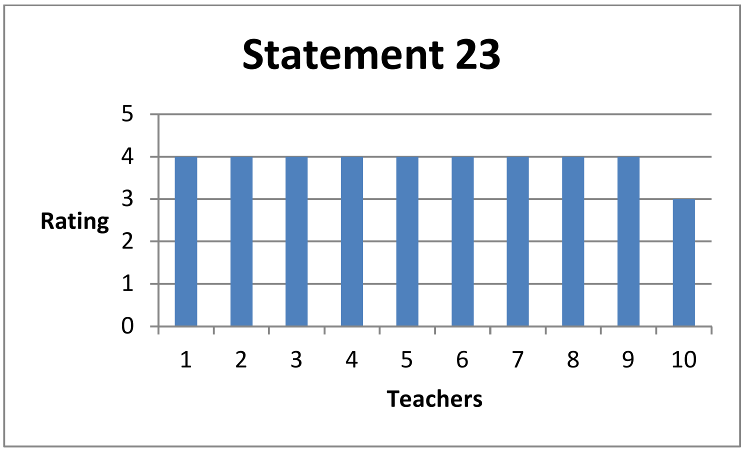

Figure A4.2.23: Statement 23: We work to build a community of inquiry in our maths class.

All of the teachers except one rated the statement they work to build a community of inquiry in their maths class as *often*. The one teacher rated this as *sometimes* as shown in Figure A4.2.23. Similar to Figure A4.2.8: Statement 8, which has teachers considering opportunities for collaborative work in the classes, the ratings to Figure A4.2.23, are also very consistent across the responses perhaps indicating a common understanding and use of language (Atkin, 1996).

Figure A4.2.24 presents Statement 24, ‘We discuss teaching strategies at unit or staff meetings.’

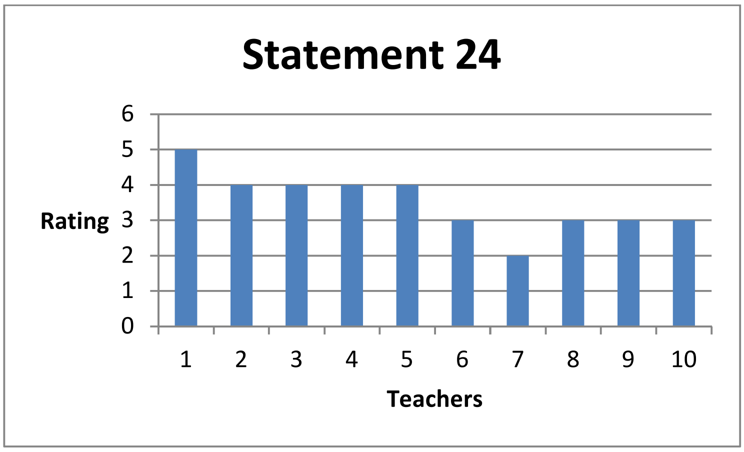

Figure A4.2.24: Statement 24: We discuss teaching strategies at unit or staff meetings.

Only one teacher rated that statement teaching strategies were discussed at unit or staff meetings as *very often*. Four teachers rated this as *often*, four as *sometimes* and one teacher rated this statement as *seldom* as shown in Figure A4.2.24. There is a wider range of ratings in response to this statement, perhaps indicating other things are discussed in meetings, such as day to day running of classes and this is then overlaid by an individual perception if these aspects are teaching strategies or not.

Figure A4.2.25 presents Statement 25, 'As a staff we work to reach a consensus on what it means to be an effective maths teacher.'

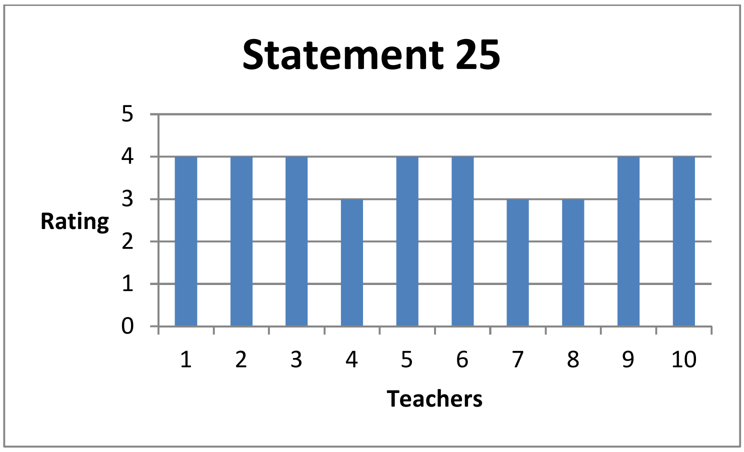

Figure A4.2.25: Statement 25: As a staff we work to reach a consensus on what it means to be an effective maths teacher.

Most (seven) of the teachers rated this statement as a staff they work to reach a consensus on what it means to be an effective maths teacher as *often* as shown in Figure A4.2.25. The other three teachers rated this as *sometimes*. There is little variation in the ratings to this statement, again indicating a consistent understanding across the staff, this also may be reflective of the effect of the professional learning.