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Impact of collaborative planning for mathematics and anticipating student responses to problems on teacher beliefs, knowledge and practice

A thesis presented in partial fulfilment of the

requirements for the degree of

Master of Education

at Massey University, Palmerston North, New Zealand

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2017

ABSTRACT

Six teachers engaged in collaborative planning for mathematics lessons that allowed for student-generated responses to problems. As part of their planning they anticipated a range of possible strategies students could use to solve problems and possible student misconceptions. This study explored how the teachers perceived these practices affected their beliefs and the teaching approaches they enacted in their lessons. The study also examined the affordances and barriers of collaborative planning and anticipating on teacher learning.

Mathematics education literature recommends a move toward student inquiry approaches in order to improve outcomes for all learners. Relevant literature was reviewed, illustrating the importance of providing the conditions required to enable teacher learning and change. Evidence was provided of the role of dissonance, teacher confidence and knowledge of both mathematics content and pedagogy, and effective leadership and systems of support. Teacher collaboration was identified as a potential catalyst for change.

A qualitative case study method was chosen as most appropriate for this study. A range of data was collected and analysed, including semi-structured interviews with all of the participants. Researcher field notes and documentary data allowed for triangulation. Ethical principals were strictly adhered to.

The study revealed some resistance to change and the constraints of teachers' prior learning and existing beliefs and practices on the outcomes of the collaborative planning intervention. The study demonstrated teachers' experimental approach to enacting new practices in mathematics lessons and their adherence to their current teaching practices and beliefs about grouping students for learning. Noteworthy benefits of anticipating and collaborative planning were increased teacher confidence to allow student-generated solutions to problems and increased teacher knowledge of mathematics strategies. These benefits were attributed to teachers learning from each other while collaboratively planning.

The results revealed teacher collaboration was perceived as an affordance to change and highlighted a number of factors which acted as barriers to teacher change. Identified barriers included either too much or too little dissonance experienced by teachers, attitudes towards risk and the desire to conform, and gaps in teacher knowledge of mathematics. The results offered insights into the effects of school culture and the design of professional learning experiences for teachers.

ACKNOWLEDGEMENTS

I would like to acknowledge and thank the many people who have made this study possible. Most importantly I wish to thank the teachers who participated in the study and acknowledge the value of their contributions to the study and to my own learning. I appreciate the time and effort that each of you put in and your willingness to share so openly with me.

I give acknowledgement and thanks to my supervisors, Dr Roberta Hunter, Dr Jodie Hunter, and Dr Glenda Anthony. You have all shown me patience, belief and support, both personally and professionally. Your suggestions and guidance have shaped the final presentation of this thesis. Bobbie, your contribution to my growth and personal development over the last twelve years has been invaluable, and will always be remembered.

Finally, I must acknowledge and thank my family and friends for coming on this journey alongside me. To my husband, Warren Snalam, who held everything together around me, I would like to say thank you for being my partner and my supporter. I want to thank my mother, father, and sister for their encouragement and unwavering belief in me. Lastly, I wish to express my sincere appreciation to my friend Becks, for her advice and input into my writing; and to Laurayne, who helped me get over the finish line. This study would not have been possible without any of the people mentioned here, and I acknowledge the collective effort that has gone into this thesis. Arohanui ki a koutou.

TABLE OF CONTENTS

ABSTRACT ii

ACKNOWLEDGEMENTS iii

TABLE OF CONTENTS iv

CHAPTER 1: INTRODUCTION

1.1 Background to the study 1

1.2 Research objectives 3

1.3 Overview 4

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction 5

2.2 Planning practices and the role of anticipation 5

2.3 Teacher change 6

2.3.1 Generative teacher change 7

2.3.2 Dissonance 7

2.3.3 Vision 8

2.3.4 New Knowledge 8

2.3.5 Relevance 9

2.3.6 Leadership 10

2.4 Professional learning communities 10

2.4.1 Culture of collaboration 10

2.4.2 Collective inquiry 11

2.4.3 Student learning 11

2.4.4 Action and results orientation 12

2.5 Teacher collaboration 12

2.5.1 Shared beliefs 13

2.5.2 Respectful challenge 13

2.5.3 Risk-taking and enquiry-mindedness 14

2.5.4 Facilitation 14

2.5.5 System-level support 15

2.5.6 Benefits of teacher collaboration 15

2.6 Teacher knowledge 16

2.7 Impact of teacher confidence and efficacy on teacher practice 17

2.8 Summary 17

CHAPTER 3: RESEARCH DESIGN

3.1 Introduction 19
3.2 Methodology 19
3.3 Case study 20
3.4 Role of the researcher 21
3.5 Data collection 21
3.5.1 Interview 22
3.5.2 Observation 22
3.5.3 Documentary data 22
3.5.4 Setting and sample 23
3.5.5 Research schedule 24
3.5.6 Reliability and validity 25
3.6 Data analysis 26
3.7 Ethical considerations 27
3.8 Summary 28

CHAPTER 4: FINDINGS

4.1 Introduction 30
4.2 Teachers' beliefs and prior learning 30
4.3 Teacher confidence and self-efficacy 33
4.3.1 Planning practices and the role of anticipation 33
4.3.2 Working as a team 34
4.3.3 Desire to conform 35
4.4 Teacher knowledge 36
4.4.1 Mathematics knowledge 38
4.4.2 Curriculum knowledge 38
4.5 Use of student responses 39
4.6 Teacher experimentation 41
4.7 Summary 42

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction 44
5.2 Analysis of barriers to teacher change 44
5.2.1 Teacher beliefs and prior learning – The individual teacher 45

5.2.2 Teachers' prior learning and the role of dissonance 45
5.2.3 Teacher beliefs and critical inquiry 46
5.2.4 Perceived pressure on teachers – The school 47
5.2.5 School norms and collegial expectations 47
5.2.6 Perception of risk 48
5.2.7 Time pressure 49
5.2.8 Teacher experimentation – The learning activity 49
5.2.9 Teacher knowledge 50
5.3 Analysis of affordances to teacher change 51
5.3.1 Working as a team 52
5.3.2 Planning practices and the role of anticipation 52
5.3.3 Expectations of teachers 53
5.4 Limitations and implications 53
5.5 Opportunities for further research 54
5.6 Conclusions 54
5.6.1 Affordances to teacher change 54
5.6.2 Barriers to teacher change 55
5.7 Summary and concluding thoughts 56
REFRENCES 58
APPENDICES
Appendix A: Initial Interview (I#I) questions 66
Appendix B: Final Interview (I#F) questions 67
Appendix C: Sample of teacher weekly planning (Phase 1) 69
Appendix D: Collaborative planning questionnaire (Phase 2) 70
Appendix E: Lesson sequence and teacher reflective questions 71
Appendix F: Example of completed planning template 72
Appendix G: Sample of coding and memoing 74
Appendix H: Teacher information letter 76
Appendix I: Example – Task 5, GLoSS Interview 1 78
LIST OF TABLES
3.1 Summary timeline of data collection 23

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Mathematics achievement in New Zealand

The current New Zealand mathematics education achievement statistics are cause for concern. In 2014 and 2015 New Zealand participated in two large international studies – the Trends in International Mathematics and Science Study (TIMSS), and the Programme for International Student Assessment (PISA). The results of these studies show current mathematics education practices in New Zealand schools are not significantly raising student achievement (Ministry of Education, 2017). Also problematic is that the gap between low and high achievers has widened significantly since the 2010/11 TIMSS. For example, for both of the tracked groups - Year 5 and Year 9 students, the range has increased, indicating growing inequity in educational outcomes for young people (Caygill, Hanlar, & Singh, 2016a, 2016b). Furthermore, Maori and Pasifika learners had lower average mathematics achievement than non-Maori and non-Pasifika learners, respectively. The growing gap between low and high achievers, and disparities in educational success for Maori and Pasifika learners have led researchers to question what is needed to improve the teaching and learning of mathematics in New Zealand schools.

Effective mathematics teaching

Widely-held understandings of what constitutes effective mathematics teaching and learning have changed in recent times from teacher-driven instruction to student inquiry approaches. The professional learning and development landscape for teachers in New Zealand has also changed over the last two years, from a centrally managed national delivery programme to an individual school directed approach. The aim of mathematics professional development initiatives for teachers is to improve teaching and learning. Beginning in the year 2000, in-service primary and intermediate school teachers were provided with the training and resources known as the Numeracy Development Project (Ministry of Education, 2008a). More recently, studies have found additional specific pedagogies and practices that teachers can enact to better address the needs of diverse learners in their classrooms (Anthony & Hunter, 2017; Averill & Clarke, 2013; Bills & Hunter, 2015; Bishop, Berryman, Powell, & Teddy, 2007; Boaler, 2016; Hunter, 2007; Stein, Engle, Smith, & Hughes, 2008; Stigler & Hiebert, 1999; Sullivan & Lilburn, 2004; Van de Walle, Karp, & Bay-Williams, 2016) Many current providers of professional learning draw on these studies and other recent mathematics education research. Teachers require

continuing access to quality professional support to change their beliefs and classroom practices if New Zealand is to address the current disparities in student outcomes.

The challenge of change along a continuum of practices

Alongside the implementation of the Numeracy Development Project, there is now an internationally recognised move to include more inquiry-based discourse approaches within the mathematics classroom. The specific approach the researcher had been advocating within recent in-service professional development included the enactment of pedagogical practices described by O'Connor, Michaels, Chapin, and Harbaugh (2016), Stein et al. (2008), and Hunter (2007). These practices included using 'Talk Moves' to encourage productive academic discourse amongst students, providing students with worthwhile mathematical problem-solving tasks to work on in mixed-ability groups and allowing student-generated responses to be the focus of the lesson, and teachers planning collaboratively to anticipate a range of possible student solutions to tasks before teaching them.

The underlying drive behind the current study was the desire to better support teachers to change their beliefs and enact teaching practices aligned with current research in mathematics education, in order to improve results in mathematics for all students. Punch and Oancea (2014) encouraged researchers to "be philosophically mindful in research, including questioning their assumptions, inquiring into alternatives, checking their arguments, and analysing their concepts" (p. 20). This is consistent with Schön (1983), who said the modern professional needs to constantly question and reflect upon their practice. The research questions addressed in the current study arose from the researcher's reflection on practice.

Worthwhile mathematical tasks: From anecdote to case study

Effective teaching should result in student learning. Researchers have pointed to the importance of task design in enabling student learning in mathematics (Choy, 2016). According to Anthony and Walshaw (2007), an effective mathematical task must be deliberately created to support mathematics learning; be sufficiently challenging for all students; and provide "opportunities for students to investigate mathematical structure, to generalise, and to exemplify" (p. 140). Best practice, cognitively challenging mathematical tasks are difficult for teachers to create; Choy (2016) states that, "to improve task design skills, teachers often engage in collaborative lesson planning activities" (p. 421). The aim of the current study was to explore how collaborative planning affected teacher beliefs and enacted practices through a case study investigation.

The value of anticipating student responses

Stein and her colleagues (2008), explain that the practice of anticipating can support teachers to manage the challenge of enacting more effective classroom pedagogy during their lessons. The planning practice of anticipating is one of five practices recommended by Stein and her colleagues (2008); the other four practices relate to teacher actions during mathematics lessons. Anticipating takes place prior to lessons as part of planning for teaching, and involves teachers predicting a range of possible student strategies for solving a problem. The anticipated strategies can be informed by observations of students' thinking, as well as teachers' own mathematics and curriculum knowledge. Furthermore, Stein and her colleagues (2008) stated that enacting these five specific practices (including anticipating) can improve teachers' sense of efficacy, as they become more adept at facilitating learning through discussion of student-generated solutions to problems during mathematics lessons. The current study sought to explore the impact of anticipating during collaborative planning sessions involving a team of teachers working together, with the ultimate aim to expand on current understandings of the effects of these practices.

1.2 RESEARCH OBJECTIVES

The purpose of this qualitative study was to investigate teachers' experiences of collaborative planning for mathematics problem-solving lessons, using planning practices based on the work of Smith, Hughes, Engle, and Stein (2009). The particular practice that was the focus of the collaborative planning intervention was anticipating. A case study research design explored collaborative planning sessions as they occurred within the context of a New Zealand primary school. The objective of the research was to develop understanding of how collaborative planning affected teacher beliefs and practices enacted in mathematics lessons, from the teachers' perspectives. The study also sought to understand the benefits and/or disadvantages of collaborative planning, in particular, the impact of this practice on teacher knowledge. The ultimate goal of this research was to add to the literature surrounding supporting teacher learning and thereby contribute to reducing educational disparities for learners of mathematics.

In particular, the study addressed the following research questions:

1) What are the barriers and affordances of teacher collaborative planning of problem solutions on teachers enacting pedagogical practices which include student generated mathematical solutions?
2) How does collaborative planning affect teacher beliefs about grouping and other mathematics teaching practices?

1.3 OVERVIEW

Chapter two reviews the relevant literature and provides both New Zealand and international perspectives on the impact for teachers and learners when collaborative planning is undertaken. This presents the theoretical background for the research. It summarizes publications on planning practices, teacher change, Professional Learning Communities, teacher collaboration, teacher knowledge, and the impact of teacher confidence and efficacy on teacher practice.

Chapter three describes the qualitative methodology used in this study. The research paradigm and approach is outlined, including a discussion on the role of the researcher. The research intervention design, sample, and the research schedule are discussed. In closing, the data collection and analysis methods employed are described and ethical considerations identified.

Chapter four outlines the findings of the study. Teacher beliefs and prior learning, teacher confidence and ways of working, and teacher knowledge and experimentation are outlined. The findings are presented with supporting evidence from the data.

Chapter five examines the research findings in relation to the literature. This chapter offers an analysis of the results of the study, discussing the explicit connections to barriers and affordances on teacher change. The findings are discussed and the research questions addressed. The chapter also outlines conclusions that can be drawn from the current study. The limitations of the research are identified and opportunities for further research are discussed.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This review of the literature provides a background for the current study and examines what is known about planning practices, anticipating, and teacher collaborative planning. Relevant literature is reviewed on the topic of teacher change and effective conditions to promote teacher learning through professional development. The literature review also includes a section on professional learning communities. For the purposes of this study, professional learning communities will be defined as, "processes of thinking and working together [that] build the capacity of the professional community to add value to classroom and school-wide practices, improving teaching and learning as a result" (Andrews & Lewis, 2007, p. 133). Teacher knowledge and efficacy literature is also included in this review in order to provide context for the role of the individual teacher factors in influencing outcomes of professional learning. The aim of this chapter is to outline relevant perspectives in the literature regarding affordances and barriers to teacher change, the effects of teacher beliefs and collaborative planning, and the implications of the literature for the current study.

In this chapter, Section 2.2 outlines and summarises the role of anticipating and planning practices on teacher beliefs and enacted practices in mathematics lessons. Section 2.3 reviews the teacher change literature, including providing a definition for generative teacher change and outlining the conditions required for effective professional development for teachers. Section 2.4 summarises literature about professional learning communities and what makes them effective. Section 2.5 examines teacher collaboration, including the support required to enable effective collaboration and the benefits for teachers of teachers working together. Section 2.6 considers the role of teacher knowledge in the teaching and learning and teacher change process. Section 2.7 outlines the impact of teacher confidence and efficacy on teacher practice.

2.2 PLANNING PRACTICES AND THE ROLE OF ANTICIPATION

Planning lessons for teaching helps teachers to be better prepared and therefore able to deliberately guide students in ways that support learning. Stein and her colleagues (2008) stated that anticipating a range of possible strategies students might use to solve a given task allows teachers to deliberately orchestrate productive mathematical discussions during lessons. Furthermore, they argue the planning practice of anticipating enables teachers to enact changes to their classroom practice by providing opportunities to select and sequence student responses

to be shared in advance. This equips teachers with a prepared structure and the ability to move beyond show and tell type sharing toward supporting students to make meaningful connections and improve learning. Similarly, Kotelawala (2010) found that anticipating students' struggles ensured teachers planned methods for developing essential student skills, such as making explicit connections between new problems and simpler problems they had previously solved. Gee and Whaley (2016) support these findings, adding that engaging in anticipating encouraged teachers to deliberately alter their pedagogy to allow space within the lesson for students' diverse ways of problem-solving and incorporate methods for developing student understanding. Anticipation is a worthwhile planning practice that adds value to teacher preparation for lessons by providing awareness of a greater range of possible student responses, while supporting teachers to feel more confident during the act of teaching.

Teacher isolation can result in teachers working alone when planning and executing lessons. This has been identified as a barrier to teacher learning and professional growth; one that school leaders and researchers have investigated ways to address (Davidson & Dwyer, 2014; Drago-Severson & Pinto, 2006). Kotelawala (2010) found when teachers collaborated for lesson planning, the power of their combined experience and knowledge contributed to a richer and more diverse set of potential student responses. Teachers were better able to include a wider selection of areas students may struggle in the lesson planning. Having a rich understanding of a broad range of student responses prior to the lesson enables the teacher to help the lesson flow and builds teacher confidence and enjoyment. Gee and Whaley (2016) reported that teacher collaboration with peers was beneficial to professional growth by providing both affirmations and recommendations, and creating opportunities to learn from one another. Moreover, collaborating resulted in changes to teacher practice, involving deepening "understanding of the importance of using problem based instruction to strengthen students' conceptual understanding of mathematics" (p. 95). Supporting teachers to collaborate and enact new practices is particularly important when teachers have been working in isolation, because opportunities to collaborate can magnify the impact of teacher learning.

2.3 TEACHER CHANGE

Successful implementation and outcomes of teacher professional development interventions require specific conditions to enable teacher learning and change. These conditions include; seeing their current practice as problematic or identifying a problem of practice to address (Cobb, Wood, & Yackel, 1990; Timperley, 2011), having a vision of the ideal (Fullan & Quinn, 2016; Timperley, Wilson, Barrar, & Fung, 2007), being presented with new knowledge (Franke,

Carpenter, & Fennema, 1998), opportunities to enact new learning with relevance to their daily work (Clarke & Hollingsworth, 2002; Guskey, 2014), effective leadership for change (Clarke & Hollingsworth, 2002; Kaasila & Lauriala, 2010; Voogt et al., 2011; Wideen, Mayer-Smith, & Moon, 1996), and support and challenge within professional learning communities (Kaasila & Lauriala, 2010; Muñoz-Catalán, Carrillo Yáñez, & Climent Rodríguez, 2010). Not all teacher change results in long-lasting, embedded practices; Franke and her colleagues (1998) argue that professional development should aim to create self-sustaining, generative change. In order to maximise the effectiveness of interventions, teacher professional development should be checked against identified conditions proven to lead to successful teacher change.

2.3.1. GENERATIVE TEACHER CHANGE

Observation of effective practice is not sufficient to create long-term change in teachers' enacted daily practices. Franke and her colleagues (1998) conceptualise teacher change as "self-sustaining, generative change" (p. 67) rather than the acquisition of a static set of skills and new knowledge. They define generative teacher change as continuous changes in perspective, understandings about learning, and classroom practices. Furthermore, Franke and her colleagues (1998) state that for this type of generative teacher change to take place, teachers must engage in ongoing practices that contribute to their learning. Their findings indicated that the observation a particular practice is effective is not sufficient to cause teacher change. Rather, for deep understanding to develop and lead to self-sustaining change, teachers need opportunities for cognitive dissonance and reflection, to make sense of how and why the practice is effective and what role the practice had in causing student learning. They refer to this struggle for understanding as "practical inquiry" (p. 68). Teachers must be provided with sufficient challenge to their understandings and current practices in order for sustainable change to occur.

2.3.2 DISSONANCE

A fundamental condition necessary for teacher learning is for teachers themselves to see a need for change (Timperley, 2011). According to Timperley (2011), teachers are only motivated to change with any sense of urgency when professional learning is driven by their own need to solve a particular problem of practice. Cobb and his colleagues (1990) and Timperley (2011) suggest that one way of creating such a need is to encourage teachers to experience, and then resolve, cognitive dissonance. Dissonance is an incongruence between a person's beliefs and their actions, or a conflict between current beliefs and new ideas or information. Dissonance may be about curriculum, content, pedagogy, or students. Dissonance can be created by

revealing or creating a gap between the current and the ideal. For teachers this can mean observing certain teaching practices demonstrably achieve greater outcomes for student learning (McClain & Cobb, 2001). In their study, McClain and Cobb (2001) created dissonance by asking a teacher to reflect on a particular aspect of personal practice from a different point of view. Stouraitis and colleagues (2017) found self-reflection and discussion about contradictions and challenges to teachers' instructional approaches can help to dissolve dissonance and support teacher learning, resulting in a higher likelihood of change to a teacher's practice. When teachers implement new approaches and witness the resultant positive impacts on their students, dissonance is often (but not always) resolved; according to Franke and her colleagues (1998) the process of dissonance resolution often leads to changed teacher practice. Experiencing dissonance is a critical aspect of the process of teacher change.

2.3.3 VISION

Another vital contributor to teacher change is a clear vision of the ideal or desired practice (Fullan & Quinn, 2016). Teachers require clarity about goals, as well as strategies for moving towards them. Setting goals and establishing a vision is also referred to as developing moral purpose (Ministry of Education, 2008c). It is essential for the vision to directly relate to improved student outcomes in order for teachers to believe that change is possible and engage in meaningful inquiry into their impact (Timperley et al., 2007). Having a clear vision of the ideal is a necessary condition for change, particularly when a gap between the vision and the real, or current, state of teaching is highlighted (Wideen et al., 1996). Sharing an aspirational vision that evolves over time as teachers move closer to achieving it is a key component of effective change leadership. Change and progress often occur as teachers seek to "attain a vision that lies beyond their current practice" (Wideen et al., 1996, p. 196). When the vision lies beyond teachers' current practice, new knowledge will likely be required to extend their expertise so it is vital the vision is presented in a meaningful way.

2.3.4 NEW KNOWLEDGE

To enable teachers to shift their practice, Franke and colleagues (1998) stated teachers are more easily able to reach new understanding by being exposed to, and reflecting upon, new knowledge or ideas. Without new knowledge, there is a risk of teachers perpetuating the status quo and any discussion among teachers reinforcing current understandings and practices within the group, rather than resulting in significant change (Timperley et al., 2007). New knowledge can come from a variety of sources, such as student assessment information, external expertise, reading relevant research literature, or engaging in teacher inquiry (Timperley, 2011; Wideen et

al., 1996). To effect change in teacher actions and student outcomes, Timperley (2011) insists "teachers need to be operating within new frameworks and accessing different kinds of knowledge that will push their thinking and challenge their practice" (p.10). Franke and her colleagues (1998) engaged teachers in focusing on student thinking and offered opportunities for teachers to build on their existing knowledge. Teachers can more easily absorb new knowledge and extend their practices by having multiple avenues to "create their own ways of organising and framing the knowledge" (p.69). The journey to a shift in practice is unique for each teacher, requiring exposure to new knowledge and opportunities to engage in thinking critically about relating new ideas to current practice.

2.3.5 RELEVANCE

For new knowledge or ideas to be embedded teachers require opportunities to relate new learning to their daily activities in the classroom (Clarke & Hollingsworth, 2002; Cobb et al., 1990; Guskey, 2014). Professional learning for teachers needs to be job-embedded and relevant. Timperley (2011) states that teachers need to build their own new knowledge. One approach teachers can use to make meaning for themselves is through engaging in an inquiry and knowledge-building cycle. Inquiry should begin by identifying what students need to learn and then asking what knowledge and skills the teachers themselves require. New knowledge and practice is best tried and tested in the professional's own realm of influence where they can see for themselves the impact on valued outcomes and then reflect on the actions that led to the improvements (Schön, 1983).

For change to happen, teachers must reflect in action on how to apply new learning to a range of scenarios as they arise in their practice. The experience of authentic tensions can become a learning tool that leads to teacher change (Stouraitis et al., 2017). Schön (1983) and Spence (1996) found that problems of practice were likely to be unique in each instance and specific to the situation, further highlighting the importance of contextual learning. For learning to be relevant for teachers it must occur in their place of practice, the classroom and school environment (Wideen et al., 1996). Furthermore, Voogt and her colleagues (2011) state ideal teacher learning is not only situated in authentic contexts that are meaningful to their practice, but must also be situated in social contexts that allow opportunities for collaboration with peers and experts, and involve follow-up support. The creation of these conditions is often the joint responsibility of the providers of professional learning and school leaders.

2.3.6 LEADERSHIP

Teacher change requires effective leadership that provides relevant learning opportunities for teachers. Effective leaders create conditions to support the individual learning needs of their teachers, just like teachers need to do for their students (Timperley, 2011). This means ensuring that all teachers are engaged in professional learning and are supported and empowered to solve their problems of practice. Leaders also provide necessary models of self-reflection and inquiry, and can be the askers of "hard questions" within their organisations (Muñoz-Catalán et al., 2010, p. 437). This does not, however, mean that leaders control or direct teacher learning using compliance or telling (Timperley, 2011). It is widely accepted that student learning is expedited when the learners themselves have agency and decision-making power shared with them (Bishop et al., 2007). The same is true for teachers and "the key shift is one of agency" (Clarke & Hollingsworth, 2002, p. 948). Fullan and Quinn (2016) found effective leaders took a facilitation approach, rather than dictating to teachers; trusting them and allowing them to make decisions. Successful leaders use such approaches to create a school culture that is committed to change and to distribute ownership of learning (Kaasila & Lauriala, 2010).

2.4 PROFESSIONAL LEARNING COMMUNITIES

Creating a school culture that facilitates positive change requires establishing a social context for learning, and that is no easy task (Hargreaves, 2007). Collaborative groups must make teachers feel safe to take risks, create space for open communication and interaction, and offer the freedom and permission to transform existing knowledge (Wideen et al., 1996). Professional learning communities create a supportive environment for teachers to share their expertise and engage in professional growth when they are set up with effective norms for behaviour, promote reflection and allow for challenging dialogue, and are focused on improving student outcomes (DuFour, DuFour, Eaker, & Many, 2010). Teacher change can be encouraged through the development of professional learning communities within schools.

2.4.1 CULTURE OF COLLABORATION

Successful learning communities are built on a strong foundation of mutual trust and respect (Timperley et al., 2007). Relational trust can be built by co-constructing group norms and strengthened as individuals adhere to these agreed expectations (DuFour et al., 2010). When these agreed ways of doing things become conventional practices, they have shaped a new culture within the organisation. A culture of trust where risk-taking is accepted as a normal part

of growth is necessary for teachers to share their beliefs and open up their practice to others, engage in meaningful inquiry, and experiment with implementing new knowledge. According to DuFour and his colleagues (2010), creating a true culture of collaboration is one of the keys to the success of professional learning communities. Powerful collaboration is, "a systematic process in which teachers work together to analyse and improve their classroom practice" (DuFour, 2004, p. 9). Trust and respect among colleagues are the foundations for developing successful professional learning communities and encouraging teacher collaboration.

2.4.2 COLLECTIVE INQUIRY

In addition to being a supportive environment, successful learning communities should be underpinned by commitment to professional learning and development (DuFour et al., 2010), and must promote challenging dialogue (Bishop et al., 2007; Clarke & Hollingsworth, 2002; Muñoz-Catalán et al., 2010). When dialogue allows for reflection on the positive aspects and those aspects of a teachers' practice or beliefs that need to change, teachers are engaging in collective inquiry (Timperley, Kaser, & Halbert, 2014). It is necessary for problematic aspects of practice to be challenged or addressed in order to focus teacher attention on learning opportunities, rather than reinforce current thinking (Timperley et al., 2007). Heterogeneous groups of teachers can promote such challenge by virtue of the range of prior knowledge and experience that each person brings to contribute to the dialogue (Kaasila & Lauriala, 2010; Muñoz-Catalán et al., 2010). According to Timperley and her colleagues (2014), "inquiry is difficult for individual teachers to do in isolation from their colleagues or from leaders" (p. 5).

2.4.3 STUDENT LEARNING

Collective inquiry is an on-going cycle for continuous improvement that needs to be approached with curiosity about what is going on for learners (Timperley et al., 2014). DuFour (2004) identifies a key focus on student learning as essential for professional learning communities. Effective teachers focus on learning rather than teaching, and are prepared with a range of responses for when students experience difficulties in their learning. Maintaining a focus on student learning means assessing whether students have understood what you were trying to teach them. According to Timperley and her colleagues (2014), an effective way to gather this information is to ask the students themselves what works for them. Groff (2012) encourages teachers to put learners at the centre of their educational experience, apply a mix of pedagogies, and to develop students into self-regulated learners. Keeping discussion focused on the goal of improving student outcomes ensures that professional learning communities can have the greatest possible impact on teacher learning and change.

2.4.4 ACTION AND RESULTS ORIENTATION

DuFour (2004) insists that teachers must not allow themselves to become distracted by factors outside of the classroom that may be limiting learning. Instead, when teachers shift their attention to student learning, they are displaying the necessary commitment and persistence to make a difference. Timperley and her colleagues (2014) include taking action as one of the phases of the spiral of inquiry because new ideas must be put into action for students' learning experiences to change. They recommend that teachers ask themselves what they can do differently to make enough of a difference to student learning. According to DuFour and his colleagues (2010), one of the main reasons for teachers to work together in professional learning communities is to serve as a catalyst for action, to move quickly from vision to reality by maintaining an action and results-focused orientation.

2.5 TEACHER COLLABORATION

Teacher professional learning and development frequently happens within the teacher's own school environment (Timperley et al., 2007). Increasingly, school leaders are establishing systems that encourage teacher learning in collaborative groups and participation in professional communities of practice, in order to personalise learning and involve a wider range of stakeholders in school improvement (Stoll & Louis, 2007). Given that teacher change research recommends collaboration as a means of supporting learning and growth, this section considers the conditions required for effective teacher collaboration to take place in schools. Although, it is important to remember that collaboration is a means to an end, not the end itself (DuFour et al., 2010). DuFour and his colleagues (2010) refer to the establishment of Professional Learning Communities (PLCs) as an effective structure that can be used to encourage purposeful teacher collaboration with a focus on improving learning outcomes.

Stoll and Louis (2007) further break down participant engagement in Professional Learning Communities (PLCs) into three fundamental characteristics: respectful challenge, risk taking, and enquiry-mindedness. Enquiry-mindedness is about being open to challenges, and risk taking is about intentionally challenging others as well as being open to changing our practice. Effective leadership is needed to set up and maintain momentum and fidelity within these types of collaborative groups (Timperley, 2011). Kotelawala (2010) found similar conditions that are required for teachers to effectively collaborate, including; a commitment to respectful interactions amongst group members, agreement on fundamental issues and beliefs, active facilitation, and the support of school leaders or the system administration.

2.5.1 SHARED BELIEFS

When a group of teachers' fundamental beliefs are in agreement they are already part-way on the road to collaboration. Kotelawala (2010) stated that agreement on fundamental issues is a requirement for effective collaboration. By fundamental issues, Kotelawala (2010) referred to having underlying beliefs in common, such as valuing reform teaching of mathematics. Kotelawala (2010) illustrated in her study of a team of teachers who were planning collaboratively in New York, that the teachers shared a belief in prioritising student sense making; this made their collaboration easier because they were all trying to achieve the same thing. Fullan and Quinn (2016) described such examples of shared goals as having a collective purpose. Common beliefs enabled a shared purpose and this facilitated improved collaboration.

Furthermore, Fullan and Quinn (2016) state that engaging in meaningful collaborative work deepens and refines practice, which, in turn, reinforces the shared purpose and builds ownership. In one of the case studies presented by Hipp, Huffman, Pankake, and Olivier (2008), the teachers' moral purpose centred on the shared belief that all students can learn, regardless of their starting point. With this belief underpinning their thinking, the teachers saw challenges as opportunities and they came up with innovative ways of getting around problems of practice. The case study example demonstrates the motivation of teachers when they hold a common belief, and believe their actions will benefit students.

2.5.2 RESPECTFUL CHALLENGE

Shared beliefs can lay the foundation for establishing agreed ways of working to develop respectful relationships and an ethic of care. Wideen and his colleagues (1996) highlight the necessity of caring, respectful group norms to ensure a safe environment and create the conditions for teachers to engage in inquiry and challenge each other's thinking. According to DuFour and his colleagues (2010), when group members commit to a set of values or to behave in a respectful and critically supportive manner, they enjoy increased creativity and autonomy. Developing trust and respect can occur through processes of negotiating the norms for activity or the ways of working within collaborative groups, building a "culture of trust and enquiry" (Stoll, 2012, p. 56). Such group norms create a collaborative culture and a community of shared values.

With group norms in place respectful learning conversations can occur and teachers can listen effectively to each other. Stoll and Louis (2007) define being respectful as listening attentively to others, while challenging ideas in the role of a critical friend. Kotelawala (2010) described the

key elements that were critical to successful collaboration in her study of three teachers with varying experience, as they worked together to plan for their mathematics programmes. Firstly, it was important that ideas and input from all teachers were respected and valued within the professional learning community. An example of this was described by Kotelawala (2010), where the use of visual tools was suggested by a teacher to support student understanding. Another teacher in the group recognised that there were limitations to using the visual representations and shared her concern, leading the group to consider some examples where the visual would not be useful. The literature illustrated the consideration given to an alternate view may not have occurred had the teachers not been respectful of each other's contributions.

2.5.3 RISK TAKING AND ENQUIRY-MINDEDNESS

When teaching is seen as problematic and open to questioning and criticism it becomes permissible to challenge and seek new ways of doing things (Wideen et al., 1996, p. 198). Wideen et al. (1996) state that for groups to support change through collaboration, they must provide a safe environment and encourage risk taking and growth. This means accepting that, "the outcomes of innovation may be unpredictable" (p. 201) and these inevitable mistakes need to be accepted as part of the change process. DuFour and his colleagues (2010) refer to these conditions as an environment in which innovation and experimentation are viewed not as tasks but as ways of conducting day-to-day business.

Professional learning communities make ideal situations for collectively inquiring into practice (DuFour & Eaker, 1998). Grant and Kline (2010) found for change to occur, teachers must be engaging in reflective thought about their practice and implementing changes by taking action. Teacher inquiry is a process of self-reflection and reflection-in-action that can give rise to new knowledge to be applied in practice (Schön, 1983; Timperley et al., 2007). However, for such reflective practice to result in new learning and changed practice, teachers must approach inquiry with the underpinning attitudes of open-mindedness, fallibility, and persistence, which Benade (2015) argues have become divorced from the process. Approaching inquiry with a lens of curiosity and being open to the chance of failure are essential conditions which support change.

2.5.4 FACILITATION

The act of facilitating inquiry through leading learning conversations with teachers is one of the main functions of professional learning providers (Davey, Ham, Stopford, Callender, & MacKay, 2011). Although effective collaboration is enhanced by active facilitation, the person who is

facilitating does not always need to be an external expert in the area of inquiry (Kotelawala, 2010). Stoll (2012) highlights facilitation as a required process in professional learning communities. Whether the facilitation comes from inside the group or from an external expert, it is needed to ensure that intellectual, open dialogue occurs and to maintain the afore-mentioned critical balance between comfort and challenge (Stoll, 2012, p. 54).

Kotelawala (2010) states that facilitation can also be informal. She suggests the use of guiding questions can provide a structure to support facilitation from within the group. Guiding questions can be used as a tool for informal planning and to support the process of engaging in learning conversations between adults. Effective questioning can, "activate a crucial transition to focused reflection on a problem of practice," (Little & Horn, 2007, p. 84). In an example provided by Little and Horn (2007), skilled facilitation from within a group of teachers directed their conversation away from just normalising one teacher's experience, to beginning a deeper analysis of the problem through the ensuing learning conversation.

2.5.5 SYSTEM-LEVEL SUPPORT

Strong, deliberate leadership is crucial to the development of the conditions required for teacher collaboration. Timperley (2011) found that successful school leaders viewed their teachers as learners that they had responsibility for, and set up systems of support to enable teachers' professional learning. This often means engaging others who have more specific expertise and then working alongside the external experts to plan goals for teacher learning. In many cases, leaders themselves need to commit to their own professional learning and be open to changing their mind-sets as they become adaptive experts at the organisational level (Timperley, 2011). Leaders can enable teacher collaboration by allocating sufficient time and resource (such as teacher release from the classroom) to support and allow their staff to work together. By setting aside meeting time, leaders are acknowledging the value and importance of opportunities for teachers to collaborate (Kotelawala, 2010). Stoll (2012) agrees that providing the time and space for learning conversations in important, adding that these do not always have to be face-to-face in today's world of digitally-enabled communication. Clear leadership and decisions to resource teacher collaboration are essential for enabling professional learning.

2.5.6 BENEFITS OF TEACHER COLLABORATION

Teachers benefit from collaborating with their peers and colleagues in many ways. The more tangible benefits, such as time savings and shared workload are described by Kotelawala (2010)

in her study of teacher collaborative planning. In addition to the positive benefits of discussion and sharing ideas, teachers identified sharing the work as a significant benefit of planning together. The process created a greater sense of ownership and investment in the success of the group (Kotelawala, 2010). Furthermore, Bauml (2014) stated that other colleagues serve as important sources of professional growth and support, especially for teachers who are newer to the profession. When teachers share the responsibility for planning lessons it saves time for everybody involved (Bauml, 2014). Shared lesson planning has many advantages for teachers in terms of time saved and work load reductions, as well as providing a sense of teamwork and shared responsibility.

2.6 TEACHER KNOWLEDGE

A clear framework for identifying what teachers need to know to become effective practitioners is not yet clearly defined in the literature. However, there is consensus in the literature that teacher knowledge includes a complex set of skills and understandings, rather than consisting solely of mastery of the content they teach. According to Ball, Hill, and Bass (2005), "how well teachers know mathematics is central to their capacity to use instructional materials wisely, to assess students' progress, and to make sound judgements about presentation, emphasis and sequencing" (p. 14). Mathematical knowledge required for teaching is not simply about being able to do the mathematics; teachers must also be able to analyse the source of student errors, use effective representations, explain the mathematics and how it works, as well as apply both mathematical reasoning and pedagogical thinking (Ball et al., 2005).

Hiebert, Gallimore, and Stigler (2002) highlight how teachers develop practitioner knowledge. They state that teachers create knowledge linked to practice because their new knowledge arises from problems of practice. Each subsequent piece of knowledge is "connected to the processes of teaching and learning that actually occur in classrooms" (p. 6). Furthermore, Sherin (2002) found teachers not only develop new knowledge while they are teaching, but their existing content knowledge is modified during instruction. As students' solutions cannot be entirely predicted in advance, teachers must attend and respond to the ideas that students raise in class, calling for a "more adaptive style of teaching" (Sherin, 2002, p. 122). The implications of these findings reinforce the importance of supporting the teacher change process and understanding how teacher knowledge is created and adapted.

2.7 IMPACT OF TEACHER CONFIDENCE AND EFFICACY ON TEACHER PRACTICE

Variations in teacher efficacy impact on teacher practice and influence teacher implementation of new practices. In their study on teachers' reactions to professional learning experiences, Bobis, Way, Anderson, and Martin (2016) found teacher responses were mediated by teacher efficacy beliefs and teacher confidence in mathematics. They discovered that teachers' own mathematical beliefs can be a barrier to their implementation of new practices. Similarly, teachers who believed they lacked the capacity to effect change in student learning (teachers with weaker self-efficacy) were found to be unlikely to make adjustments to their practices (Bobis et al., 2016). They stated, "teacher efficacy beliefs act as a buffer to the stress created when teachers face change" (p. 37). Huang, Liu, and Shiomi (2007) found offering support to teachers can increase teacher efficacy, and that all social support makes a positive difference. They also found that individual performance and the experiences of teachers in their own practice increase self-efficacy, providing one explanation for differences in efficacy levels between newer and more experienced teachers (Huang et al., 2007). The literature highlights the important role of teacher confidence and efficacy as mediators of effectively implementing change in teacher practice.

2.8 SUMMARY

In order to address the disparities in educational outcomes for New Zealand learners, mathematics education professional learning and development literature has recommended teachers implement new practices and pedagogies to improve the teaching and learning of mathematics. The move toward student inquiry approaches requires many teachers to change their beliefs and enacted practices in mathematics lessons, as well as the ways in which they prepare for these lessons. Suggested planning practices include anticipating a range of student responses to problem-solving tasks, to allow teachers to respond more nimbly during instruction.

Change is challenging for teachers. The literature describes the conditions required to support teachers to change their beliefs and practices, and to sustain, embed, and continue to adapt these changes over time. Many studies demonstrate the important role of dissonance in creating motivation to change. The literature also highlights the mediating influence of teachers' attitudes to taking risks and how these attitudes are influenced by the culture teachers are operating within. Collaboration among teachers is outlined as an enabling factor for teacher change with many benefits. Many studies also emphasise the impact of teacher knowledge and teacher efficacy on practice, and on teacher learning and change. Effective professional learning

and change is enabled by teacher knowledge of mathematics and pedagogy, teachers' self-belief and approach to risk, and carefully facilitated teacher collaboration. Collaboration can be encouraged and supported by decisions leaders make. Learning is more likely to occur for teachers when they are faced with dissonance and their current practices are challenged, while new approaches are provided and they have opportunities to incorporate learning into their work.

CHAPTER THREE

RESEARCH DESIGN

3.1 INTRODUCTION

This chapter outlines the design and methods used in the study. Section 3.2 provides justification for the methodology and outlines the research paradigm. Section 3.3 describes the case study method employed in the research. Section 3.4 explains the role of the researcher. Section 3.5 outlines the data collection methods used in the study, including interviews, observation, and documentary data. Also in Section 3.5, the setting, sample, and research schedule are outlined, and reliability and validity are considered. Section 3.6 outlines the approach taken to data analysis in the research. Section 3.7 outlines the ethical considerations of the study.

3.2 METHODOLOGY

Research is a logical inquiry process that uses empirical information in a systematic way to find answers to questions or to generate theories (Punch & Oancea, 2014). The current research questions arose from the researcher's reflection on practice as a provider of professional learning and development programmes for teachers. As is often the case in the professional field of education, the professional issues central to this study derived directly from daily practice. The focus of the current study is teachers' perceptions and interpretations of the impact of collaborative planning for mathematics lessons allowing student-generated solutions.

Although there are commonalities across qualitative research methods in education, methodologies cannot be implemented by following a series of steps in any situation (Egbert & Sanden, 2014). Rather, "a researcher's conceptual framework, epistemology, and paradigm position the researcher to make decisions based on individual beliefs and perspectives" (p. 77). The most important consideration is that the methods used are consistent with his or her viewpoint and will lead to reasonable ways of gathering the information needed to address the current topic of inquiry.

The paradigm being drawn on in the current study is the interpretive paradigm. Also called the naturalistic paradigm, this approach focuses on in-depth analyses of human behaviour and perceptions (Basit, 2010). The interpretive paradigm is hermeneutic; interpreting social phenomena as they are viewed by the research participants and acknowledging that reality is subjective. The purpose is to investigate deeply, rather than widely, and does not necessarily seek to result in generalizable findings. "The interpretivist paradigm tries to show how choices

are made by participants or 'actors' in social situations within the process of interaction" (Burton & Bartlett, 2005, p. 22).

The research paradigm influences the methods used to gather information in response to the research questions, and may even influence the research questions themselves (Egbert & Sanden, 2014; Punch & Oancea, 2014). Qualitative methodologies, including the collection of information such as verbal and written texts, are typically used to build deep understandings of phenomena with a particular interest in the meanings that people have constructed about their experiences (Merriam, 1998). For this research, involving a group of teachers (n=6), in a naturalistic professional learning and development experience, case study method has been selected as most appropriate methodology.

3.3 CASE STUDY

According to Punch and Oancea (2014), case study is more of a strategy than a method – in that there are multiple methods that can be applied within a case study. Hamilton and Corbett-Whittier (2013) argue that case study is an approach to research that aims to capture the complexity of relationships, beliefs and attitudes within a bounded unit; often using a combination of methods in order to develop as full an understanding of the case as possible. Organising the complexity that is the reality of rich case study data can be a challenge, however, Basit (2010) recognises that case study research is "ideally suited for a lone researcher specifically the one enrolled on a master's or doctoral programme" (p. 21).

A case can refer to an individual, a group, an organisation, community or nation. A case can also refer to a process, policy, or event. Rather than attempt to fully capture the entirety of a case, many practitioner researchers use an instrumental case study focus, where the purpose of the work concerns an aspect of the case, such as changes as a result of curriculum reform (Hamilton & Corbett-Whittier, 2013). The current research applied case study as a means of organising social data, such as interviews, and maintaining a holistic focus on the teachers' perceptions and experiences. Specifically, this research used an instrumental case study focused on teachers' understandings of engaging in collaborative planning and how this impacted on their beliefs and practices in ensuing mathematics lessons.

Case study models can be further specified as to whether the emphasis is on reflection, longitudinal study, or collaborative case studies (Hamilton & Corbett-Whittier, 2013). The current study could be categorised as both reflective and collaborative, according to the definitions provided by Hamilton and Corbett-Whittier (2013). Reflective case study is described

as having a personal, evaluative component, as in the collecting of journals or notes about participants' feelings and responses. These reflections may relate to experiences and interactions amongst colleagues or in the classroom during teachers' daily practice. Interviews can also provide evidence to support reflective case study. With reflection comes the challenge of managing personal biases and raises ethical concerns in relation to colleagues and students. Collaborative case studies involve working in conjunction with colleagues for a shared purpose, as in the implementation of a curriculum innovation. In the current study the researcher used interviews and field notes to collect teacher reflective responses to their experience of both collaborative planning and classroom enactment of problem solving lessons. The aim of the current study was to both improve the educational practice of the teachers involved as participants, and to inform the improvement of the researcher's practice as a provider of in-service teacher professional learning and development.

3.4 ROLE OF THE RESEARCHER

As with everything in research design, the role of the researcher depends on the purpose of the research and ideally follows on from the research questions. In the current study the researcher acted as a participant observer. This was necessitated by the situation, where the researcher was both providing professional development to the teachers and studying their perceptions and experiences of these practices. In the early stages of the intervention the researcher was actively involved in supporting teachers' development of collaborative planning practices, in order to provide a model and examples of the practices in action. As time passed and the teachers became more comfortable with planning collaboratively, the researcher withdrew and took on more of an "observer as participant" role, which Punch and Oancea (2014) describe as being less obtrusive and allowing for fuller recording of researcher 'notes'.

3.5 DATA COLLECTION

In qualitative research, as with all empirical research, data collection techniques are determined by the data that are needed and by the research questions. Case study can include a variety of research designs and data collection methods. It is also common, and even desirable, to gather data from multiple sources, especially when working in a naturalistic setting (Punch & Oancea, 2014). In the current study, interviewing, audio recording of collaborative planning sessions, and documentary data collection allowed for triangulation to take place. Focused on understanding the perceptions of teachers involved in the research, carefully conducted interviews provided useful background information about teachers' reflections and understandings. The summary timeline (see Table 3.1) provides an overview of the data collection schedule.

3.5.1 INTERVIEW

Interviews were chosen for this study due to being a tool that can provide some of the richest data about the depth of understanding of participants' understandings of phenomena (Hamilton & Corbett-Whittier, 2013). The teachers were each interviewed twice during the current study, using semi-structured interviews. The initial interviews were conducted before the teachers were introduced to collaborative planning and were designed to provide baseline information regarding the teachers' current planning and teaching practices, including the grouping methods used in their classroom programme (Appendix A). The questions also focused on teacher beliefs about student learning, teacher expectations of students, and teacher confidence, content knowledge and pedagogical knowledge. The teachers were asked to anticipate any support they might need to implement changes to their planning practices, as well as any foreseeable enablers or barriers to the process of collaborative planning. Similar questions were posed in the final interviews (Appendix B). The interviews were audio-recorded and field notes taken during and immediately after the interviews supplemented the recordings.

3.5.2 OBSERVATION

Case study research takes place in real-world settings and allows for direct observation (Yin, 2014). Participant observation is a special form of observation where the researcher is not merely a passive observer (Yin, 2014). In the current study, the researcher was positioned as a participant observer through involvement in leading the collaborative planning meetings in the early stages of the intervention. Eight of the planning sessions were attended by the researcher at various points in time during the intervention phase of the study, who acted as a participant observer. The researcher deliberately did not attend every planning session; this allowed the participating teachers to adapt the sessions and potentially supported a more natural evolution of practices.

3.5.3 DOCUMENTARY DATA

Yin (2014) suggests that documentary information is likely to be relevant to every case study. In the current study documentary data was collected to augment the interview and observation data. Samples of teachers' weekly planning for their mathematics programmes were collected at the beginning of the study, before they began collaborative planning sessions, and then again after the final interview for comparison (e.g., Appendix C). The researcher also collected examples of the completed planning documents that were created collaboratively during the meeting sessions. These documentary texts took both hard copy and electronic form.

Teachers' perceptions were also gathered through a short questionnaire (Appendix D) administered after three collaborative planning sessions had taken place. One advantage of using questionnaires in the current study was the ability to gather responses from participants concurrently, thus saving on both teacher and researcher time during the intervention period.

Table 3.1 Summary timeline of data collection

DATES	ACTIVITY	DATA COLLECTED
Term 3, 2016	*Phase 1* Whole school professional learning, facilitated by the researcher	• Semi-structured interviews • Teachers' weekly planning documents collected
Between September 8th, 2016 - April 10th, 2017 (During Term 4, 2016 and Term 1 in 2017)	*Phase 2* Weekly team collaborative planning sessions (six teacher participants), followed by each teacher enacting the planned lesson in their classroom. [The researcher attended eight of these planning sessions during the intervention, as a participant observer.]	• Audio recordings of planning sessions • Researcher field notes • Teacher questionnaire (mid-way through intervention) • Samples of planning templates completed during sessions
Term 2, 2017	*Phase 3* Post-intervention	• Semi-structured interviews • Teachers' weekly planning documents collected

3.5.4 SETTING AND SAMPLE

The research was conducted at a large suburban contributing primary school in Auckland, New Zealand. The study took place between September of 2016 and April of 2017.

Six out of the seven teachers who were invited by the researcher to join the study, participated in the research. These teachers were all teaching classes of Year 5 and 6 students (10 and 11 year olds). The teachers represented a range of ages and experience levels (ranging from less than two years of teaching to over 20 years), and there were two males and four females. In order to preserve anonymity, all six teachers have been assigned female pronouns and pseudonyms.

Prior to the research study the participants had not had any recent, formal whole-school Professional Learning and Development (PLD) in Mathematics and Statistics within their school. However, several teachers had organised individual PLD opportunities. Specifically, one teacher had undertaken post-graduate study at university, and another teacher had attended workshop days held by an external PLD provider as part of her role in leading mathematics within her area

of the school. Prior to their involvement in the study, the teachers had no experience of the planning practices described by Stein and her colleagues (2008).

3.5.5 RESEARCH SCHEDULE

The research study was conducted over two school terms: Term 4, 2016, and Term 1, in 2017, and included a very small scale intervention.

Phase 1: Effective teaching workshops

At the beginning of the research study the teachers participated in two sessions of whole-school professional learning. Led by the researcher, the focus of professional learning was based on three key pieces of research, chosen for their relevance to the effective teaching of mathematics:

1. *Effective pedagogy in mathematics/pāngarau: Best evidence synthesis* (Anthony & Walshaw, 2007);
2. *Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell* (Stein et al., 2008); and
3. *Academically productive talk: Supporting students' learning in mathematics* (Chapin & O'Connor, 2007).

Initial data collected prior to collaborative planning workshops included semi-structured interviews with each participant and the collection of a sample of each teacher's planning documentation for a typical week of their mathematics classroom programme.

Phase 2: Collaborative planning intervention

The intervention involved the researcher supporting the six participants to engage in planning collaboratively for problem-solving. Stein and her colleagues' (2008) five practices for orchestrating productive mathematics discussion were promoted in the workshops, with particular emphasis placed on working together to enact the first practice: anticipating a range of possible student responses to the task and possible misconceptions. The remaining four practices — monitoring, selecting, sequencing, and connecting — relate to teaching practices during in-class lessons.

At the beginning of the intervention period, the researcher provided each teacher with resources designed to support their understanding and implementation of the practices including a summary sheet (Appendix E) of the recommended teaching and learning sequence of a problem-solving lesson, in accordance with the five practices outlined by Stein and her

colleagues (2008). The researcher also provided a model of a completed planning template (Appendix F), which included a sample range of solution strategies and possible misconceptions anticipated and recorded in the manner suggested for the research study intervention.

During this initial session the researcher facilitated a discussion where participants were encouraged to raise questions relating to the suggested practices of collaborative planning and allowing student-generated solutions to solve problems. Topics raised included: establishing classroom norms for collaborative student problem-solving, grouping students for mathematics lessons allowing student-generated responses, and supporting productive student discourse during problem-based lessons.

At the end of this session, the teachers were provided with self-reflection prompts related to their evaluation of how successful their follow-up problem-solving lesson was (Appendix E). Subsequently, the teachers were expected to meet weekly to engage in collaborative planning with a focus on anticipating. Each teacher then taught the planned lesson in their classroom (usually on the Friday). The lessons were then discussed at the beginning of the following week's planning session, and another lesson planned. The researcher attended eight of these sessions as a participant observer. The teachers expected – and did receive – some support for their discussions, but the questions raised and the ways of addressing them were generally a result of their discussions among themselves.

Data collected during this phase included audio recordings of collaborative planning meetings, researcher field notes, and documents created during these sessions, including planning completed collaboratively and teacher reflective questionnaires.

Phase 3: Post-intervention

Data collected at the conclusion of the intervention included semi-structured interviews with each participant and the collection of a further sample of each teacher's planning documentation for a week of their mathematics classroom programme. As the intervention ran over the transition from one school academic year to the next (Term 4 and Term 1), the students and classes of each teacher had changed mid-way through the intervention.

3.5.6 RELIABILITY AND VALIDITY

The reliability and validity of each data collection method can be analysed separately. Reliability and validity of qualitative research can be increased when research is conducted with neutrality, accuracy, and credibility, and data has been triangulated wherever possible. Basit (2010) points out the possibility of bias during interviews, created by the subjective nature of the interview

experience, both for the researcher and the participant. However, bias can be minimised by keeping an open mind about what data will be generated, asking further questions to check the reliability or validity of earlier responses, and asking for examples or explanations. The validity of documentary data can depend on whether the reason for writing the documents aligns with the purpose of the research. In this study the document lesson plans represented were used to gauge the outcome of collaborative planning experiences – but the level or impact of the collaborative planning was unable to be determined from the documents themselves. However, the documents, in providing another source of evidence, could be viewed as triangulation sources (Yin, 2014).

A common criticism of the case study method is its lack of generalisability. Statistical generalisations are not usually able to be made from case studies due to their unique contexts, small sample sizes, and emphasis on accounts of events, feelings and perceptions (Basit, 2010). However, case study researchers are not typically attempting to generalise to the whole population. Rather, more naturalistic or analytical generalisations may be made that arise from the data, where new understandings have the potential to illuminate other similar situations and cases. The aim of the researcher in the current study was not to generalise to the whole population, but to gain insight into the experiences and perceptions of the participants involved in order to understand the impact of collaborative planning on teachers' beliefs and enacted practices after the professional learning.

Unlike in quantitative research, qualitative methods are often difficult to replicate, due to the nature of the participants, their contexts, and the small scale of the research. Replicability, though, is not the only type of reliability. Qualitative researchers can maintain reliability by being true to the research process and consistent and authentic in their data collection and analysis (Basit, 2010). For case study Yin (2014) recommends keeping the raw data in its original form separate from any researcher interpretations or reporting of the case. In the current study, care was taken to maintain accuracy and neutrality in all dealings with the data.

3.6 DATA ANALYSIS

Qualitative research designs are not always linear and chronological; as Merriam (1998) describes, data "collection and analysis should be a simultaneous process" (p. 155). In the current study, data analysis began during the data collection process, including the intuitive reflections by the researcher, noted as field notes in Phases 1 and 2, that formed tentative themes, and ideas in progress.

The current study used a content analysis approach, through a cyclical process of coding and memoing (Appendix G), supported by researcher reflection. Coding is the process of attaching meaning to pieces of data and allows for summarising and identification of emerging themes and patterns (Punch & Oancea, 2014). For the interviews, initial coding was first descriptive and then evolved to become more interpretive as analysis proceeded and affordances and barriers began to emerge.

As codes became more inferential the researcher made connections, reflections and interpretations in relation to the research questions; a process also referred to as memoing. Coding and memoing occurred simultaneously as the data was analysed and the researcher theorised about codes and their relationships. Memos record ideas and can be more "creative-speculative" than coding (Punch & Oancea, 2014, p. 229). In the current study, samples of the researcher's coding were reviewed by the research supervisors and memoing occurred throughout the data analysis and the draft writing processes, supported by ongoing discussions and reflection.

3.7 ETHICAL CONSIDERATIONS

The research was conducted in accordance with the Massey University code of ethical conduct for research, teaching and evaluations involving human participants (Massey University, 2015). Ethics approval was sought and obtained prior to data collection being undertaken. All participants were provided with the relevant information required to gain their informed consent (Appendix H). As the focus of the study was on teachers and the researcher had no contact with students, the research was deemed to be low risk. As the researcher is also a registered teacher and an accredited facilitator the research was conducted in accordance with the Education Council code of ethics for certificated teachers (Education Council, 2015).

The particular ethical issues arising from the current study concern participant confidentiality, avoiding bias (Yin, 2014), the role of the researcher, beneficence (Punch & Oancea, 2014), and specific ethical considerations relating to each method of data collection (Basit, 2010). Yin (2014) notes that in case study particularly, it can be difficult for the researcher to maintain an open mind and put aside any preconceived position due to their understandings of the issues before beginning the research. In the current study the researcher used open-ended questions and avoided leading participants with questioning in order to reduce bias as much as possible. The researcher refrained from making any evaluative judgements regarding teacher practices, beliefs, or pedagogical content knowledge. In the written documents of the study, all participant

names have been replaced with pseudonyms in order to preserve anonymity and protect the confidentiality of the participants.

Punch and Oancea (2014) state that while carrying out potentially beneficial work researchers must aim to distribute any benefits and risks non-discriminatorily throughout a research project. In the current study the participants were provided with professional development and support to implement the planning practices described by Stein and her colleagues (2008), while other teachers in the same school were not. The reason was the small scale of the study and the limited time and availability of the researcher. This was unfortunate for the other teachers who were not involved in the study, however the aim of the researcher was to ensure that the findings of the study are made available to all teaching staff at the school, and the school has the option of engaging further professional development for the entire staff. There were potential issues arising from the role of the researcher, who could have been perceived as being in a position of power as an external expert. In order to alleviate this concern, participants were provided with comprehensive information about the scope and the purpose of the study and the researcher applied no pressure to participate. The decision by one of the seven teachers in the syndicate (teaching team) to abstain from taking part in the research provided evidence the teachers understood their freedom to choose. The remaining six teachers gave their voluntary informed consent.

Basit (2010) describes ethical considerations that are relevant to specific methods of data collection. Interviews should be conducted cheerfully, while reminding the participants that their time and contributions are valued. The interviews in the current study were conducted at times and locations chosen by the participants and in some cases these were off-site, rather than at the school. The researcher accepted all participant contributions without judgement or imposing the researcher's own view. According to Basit (2010), observations call into ethical question the researcher's entire research practice, the most relevant aspect of this for the current study is the degree to which the researcher participated during the observations. As stated above, the complex role of the researcher was managed in the current study and a balance found between participant-observer and observer as participant. The questions in the questionnaires were chosen carefully so as not to offend, confuse, or patronise participants and the planning and documentary data were only used for the express purposes of the study.

3.8 SUMMARY

The current case study examines the experiences and interpretations of a group of New Zealand primary school teachers engaging in a regular, collaborative, planning process. In order to clearly

define the boundaries of the case, the research questions specify a focus on the interpretations and perceptions of the participating teachers. The case includes a focus on: the benefits and challenges of planning collaboratively; teachers' perceptions of any resulting changes in their practice or impact on their students; teachers' perceptions of the conditions required for collaborative planning to be successful and sustainable; and, the teachers' reflections on their learning, including any changes in their beliefs about teaching and learning. The case does not include any observations of the lessons that the teachers planned, or any contact between the researcher and students in the classes of the participants. Samples of student work were shared and discussed during the collaborative planning meetings, as teachers reflected on the previous lesson they had delivered and then collaboratively planned the next week's lesson.

A qualitative research design was selected as the most appropriate research method for this study. In order to understand the rich contextual factors at play a case study method was used. Data was collected using three key methods: interviews, participant observations, and documentary artefacts. Reliability and validity were ensured through systematic documentation, triangulation, and analysis of data. Ethical principles were maintained throughout the study. The findings of this study are documented in Chapter four.

CHAPTER FOUR

FINDINGS

4.1 INTRODUCTION

The aim of the study was to explore how collaborative planning affected teacher beliefs and practices enacted in mathematics lessons. This chapter describes the impact of collaborative planning from the teachers' perspectives. The findings of the study are outlined in this chapter. These findings are based on a combination of documentary data, observation, and semi-structured interviews with participants, which were conducted at the beginning and end of the intervention. Section 4.2 describes the teachers' prior learning experiences relating to teaching and learning in mathematics. The origin and impact of the teachers' existing beliefs and practices are outlined. Section 4.3 outlines the effects of collaborative planning and anticipating on teachers' confidence and efficacy. Section 4.4 outlines how teacher knowledge changed during the study. Section 4.5 outlines the teachers' discussion of student responses to problem-solving tasks and how teachers perceived these. Section 4.6 describes the experimentation approach teachers took to enacting problem-solving lessons.

4.2 TEACHERS' BELIEFS AND PRIOR LEARNING

All of the teachers (n=6) began with strong beliefs about how students learn best in mathematics and how mathematics should be taught. These existing beliefs appeared to be largely due to two main factors. The first related to the impact of sustained professional development experiences associated with the Numeracy Development Project (NDP), which provided explicit guidance for teachers around pedagogical practices. The second related to the NDP professional development experience, in that the project provided a whole-school set of practices that came to be embedded and viewed as norms of practice within their current school.

Prior to the intervention used during this research, when the teachers were asked how they typically planned for their mathematics programmes, they all said they planned individually. The NDP pink books (Ministry of Education, 2008b) were used by the majority of the teachers' for their decisions about what to teach and how to teach it. All of the participants reported grouping their students based on assessment information that identified students' strategy stages, as defined by the number framework (for an example of a task from the Global Strategy Stage (GLoSS) assessment (Appendix J). This type of grouping, widely known as 'ability grouping', is supported by guidance in the Numeracy Book 3: Getting started (Ministry of Education, 2008a).

Ability grouping relies on assumptions about students' academic ability as indicated by teacher assessment of strategies they have used to solve a set of levelled tasks.

Before the intervention, the teachers' programmes were organised around a tumble or rotation of independent learning tasks involving a set group of students. Each group worked with the teacher on average twice a week. In most of the classes, this programme ran four days a week. On the fifth day of the week teachers' planning included; students working independently on word problems, teaching strands of mathematics other than number (e.g. statistics or geometry), or individuals or small groups of students working with the teacher to "fill gaps" or "front-load" strategies or knowledge. The teacher-described teaching methods of modelling particular solution strategies to be emulated by students, conformed to a traditional approach of teacher-driven instruction. Where problem-solving was included as part of the mathematics programme, it was commonly something that was "done on Fridays". Typically, these sessions required students to work individually to try and solve a word problem. The individual work was followed by either a 'show and tell' type sharing session or with students being provided another problem to 'go on to next'. The mathematics programmes were described by the teachers during initial interviews and the documentary data from teachers' weekly planning examples aligned with the descriptions. The pre-existing programmes focussed on teacher-led instruction in a predictable format.

The strength of teacher beliefs about the effectiveness of existing practices was evident in the range of rationales for planning and teaching in this way for mathematics that were offered within the interviews. For example, before the intervention, teacher W said:

> "I think in ability-based grouping everyone still learns from each other, but they can be stretched a bit more…I think if we just do problem-solving it doesn't stretch those top kids" (TW, I#I).

Likewise, teacher Z noted although she was committed to giving the intervention a go, "I'm not going to give up the things that I believe work well; I don't think anyone should do that" (TZ, I#I). This resistance to the idea of change was evident across the group of teachers, many of whom placed high levels of confidence in their current practices. As noted above, the confidence observed is not unexpected, with these pedagogical and grouping practices being informed by the last significant professional learning and development these teachers had received in mathematics. That is, the teachers believed the NDP and its associated ways of grouping, planning and teaching, were the 'right' ways of doing things. The views expressed by the teachers, to the best of their current knowledge, were based on a combination of both personal experience and received policy information.

In line with the 'ability' grouping organisation of their classrooms, it was not surprising that all of the teachers defined the students according to their perceived ability, or their strategy stage of the number framework (which originated from the NDP). Within the initial and subsequent interviews, the teachers frequently referred to their students as the "top kids" and the "middles and bottoms", or the "low group". Moreover, many of the teachers believed that students actively disliked problem-solving in mathematics, and in particular, several of the teachers (n=3) explicitly assigned this dislike to the 'low' ability students. For example, teacher Z noted that the "ones that struggle, who don't like maths to start with, and then it's in words so they don't like that. It's the lower ones who don't like it" (TZ, I#I). Overall, the teachers' beliefs in the value of the NDP and the strategy stages of the number framework for assessing where each student was at and therefore what they needed to teach next, were well embedded and seen as standard teaching practice within the syndicates and the school. For example, teacher W noted at the beginning of the study that "the term overview is done at the beginning of the year…team leaders plan these" (TW, I#I), indicating his perception of the school's expectations for teachers to conform to teaching according to these plans. Similarly, at the beginning of the study, teacher Z shared that she used "plans we have used over the years in our teams" (TZ, I#I). Students received instruction based on the 'ability' grouping labels they were given.

As the intervention proceeded, teachers were exposed to recent research and resulting new practices, in particular, new ways of grouping students for mathematics. However, for the most part the teachers held fast to their traditional grouping beliefs. The trialling of more flexible grouping practices occurred in most instances only on one day a week and appeared to be regarded by most teachers as a 'one-off' arrangement. For example, although teacher Z reported that she could immediately see the benefits of her mixed-ability student groups, she did not transfer that practice to the rest of her mathematics programme. At the very beginning of the study she acknowledged that, "when they worked in threes, I heard such rich language coming out of what they were doing," (TZ, CP#2). However, at the end of the study she reported that the majority of her programme had remained unchanged throughout the intervention, "just on the Friday when I do the problem-solving, that's different." (TZ, I#F). Similarly, teacher X was not sufficiently convinced of the effectiveness of mixed-ability grouping practices to fully change her beliefs, or for the new practices to be applied across her mathematics teaching programme:

> "Because I'm still not 100% happy with that whole mixed-ability in my normal teaching…I like ability grouping and I know there is a whole swing against it, but I think for maths I think it's quite important - apart from the problem-solving, which I

understand is different - but in my normal maths programme I still ability group" (TX, I#F).

While these teachers could see heterogeneous student groupings working well in the context of lessons where they allowed students to generate solutions to problems, they were not convinced that students would be able to generate their own solutions to problems without first having been shown prescribed ways of using solution strategies. Thus, the teachers continued providing transmission strategy lessons for much of their programme. In the context of these prescribed, teacher-directed lessons the teachers grouped students according to perceived student readiness to learn certain strategies. Their existing beliefs were not sufficiently challenged to cause them to change.

4.3 TEACHER CONFIDENCE AND SELF-EFFICACY

Following the intervention, one of the main themes to emerge from the interviews was the enjoyment teachers received from the process of planning collaboratively in a team. Teachers repeatedly used language such as, 'positive', 'helpful', and 'worthwhile' to describe their experiences and the results of having been involved in the study. Teachers perceived many benefits from planning collaboratively, including sharing work-load. Teachers reported gaining confidence in a number of areas, including planning, teaching of problem-solving lessons, their own mathematical identities, and their autonomy to make changes to their classroom programmes. Teachers expressed feeling better prepared and better able to teach effectively during problem-solving lessons as a result of engaging in anticipating when planning. Furthermore, the teachers reported an increase in their collaboration in other areas and an increased sense of collegiality. Collectively, all of these areas contributed to teachers' reports of increased efficacy.

4.3.1 PLANNING PRACTICES AND THE ROLE OF ANTICIPATION

Several of the teachers (n=4) outlined their increased confidence in their teaching of problem-solving lessons by the end of the study. Teacher W made the connection to her ability to notice and respond to student thinking and learning in the moment during lessons: "The more confident you are, the better you are at teaching, I feel. If you feel confident in what you are doing, you are better at teaching; reacting and things" (TW, I#F). To illustrate the effect of collaborative planning, teacher X noted that before the study she would avoid teaching problem-solving due to her own difficulty with solving problems. She also reported feeling out of her depth and unable to control the lesson as much as when she was teaching a specific strategy to

a small group. At the conclusion of the study this teacher stated that she had got better at teaching problem-solving: “It was easy for me to push it aside because I never felt confident about it so this has improved my confidence in teaching it, definitely” (TX, I#F). Teacher X attributed her growth in confidence to the specific practice of anticipating a range of possible student responses:

> “When we planned collaboratively and we looked at the different ways that the kids might solve it and where their misconceptions might be, I was prepared. Nothing would just come out of left field and confuse me, I was just better prepared; I knew what they might do, I knew how the problem should be answered or could be answered, and then I could share all the ways with the kids at the end, so it was because I knew it myself. So if you just give them a problem and they come with a solution you are just like, *oh yeah that’s a good idea,* but I could do a bit more depth of teaching because I knew all the options, I could see where they might go wrong, and I could be prepared for that as well”. (TX, I#F)

Teacher confidence in responding to student-generated solutions grew over the course of the intervention period, and resulted in teachers feeling encouraged about delivering lessons that allowed for a range of responses and solution pathways to solve problems.

4.3.2 WORKING AS A TEAM

Not only did planning collaboratively enhance the teachers’ confidence in their mathematics and their teaching, but it also strengthened their confidence to work together as a team. As the study progressed, the teachers discussed feeling more able to take risks in front of each other when anticipating solutions to problems and this built cohesion among the group. Teachers also acknowledged valuing the knowledge and contributions of colleagues. For example, teacher Z noted that “hopefully someone came up with something – and they did – and you thought *‘oh thank goodness for that; I’m not put on the spot’”* (TZ, I#F). By the end of the intervention, teacher Z had become more aware of the individual strengths of her colleagues and the mutual benefits of more collaboration within the team: “I love that; I love to see other people shine at things they are good at and it must feel good for them, too” (TZ, I#F). The teachers became more aware of the benefits of collaborating and this appeared to lead to the desire to collaborate in other ways.

This increased collegiality and respect for colleagues had other impacts on the way that the team worked together outside of planning collaboratively for mathematics. For example, teacher W described the spread of the team's collaboration as follows:

> "As a syndicate we have done our appraisal goal…for reading, so we followed a similar sort of model where we are using more of Google Classroom. All four us are planning it together and then it gets put on there together [and the students] all work through the same thing. So there's a lot of discussion goes around…about what works best…so yeah the collaboration has sort of moved on into other areas rather than maths" (TW, I#F).

The teachers increased their collaboration in other ways as a result of seeing the benefits of working together. The resulting heightened sense of being part of a team supported teachers to feel comfortable taking risks and sharing their ideas; including enabling discussion of a wider range of possible student solutions among the teachers.

The collegiality of the collaboration has been described as a positive experience for the teachers: "It has been good to talk to everyone else in the team" (TW, I#F); and, "we get along really well as a team anyway and have a bit of a laugh, so that was good, just being able to think together and use each other's ideas" (TY, I#F). The teachers could see that this collaboration was an extension of the way they had been working together in the past, with added benefits, including sharing the work load. As teacher Z noted: "If we are doing it as a team then it cuts down on work, I think, for all of us" (TZ, I#F). A reduction in individual teacher workload appeared to be a strong incentive for teachers to continue to collaborate and therefore provide ongoing opportunities for teachers to share their knowledge of student generated solutions and strategies.

4.3.3 DESIRE TO CONFORM

While being part of a team had positive outcomes for the teachers, it also created the perception of pressure on teachers. Prior to the intervention, many of the teachers noted they were open to learning new ways of doing things. In her first interview, Teacher W noted she was feeling positive about the change. However, during the course of the intervention teacher W noted that she had been following the norms of behaviour set by the rest of the team. On reflection, teacher W identified being influenced during the study by "what everyone else is doing," and that she viewed her practice as "going with the crowd, I suppose" due to feeling like "the new kid on the block" (TW, I#F). Although teacher W had seemed open to changing her practice, at

the end of the intervention she noted her practice had been constrained by her desire to fit in with her colleagues: "I don't feel comfortable sort of saying to the rest of my team, *'Nah, what you're doing is wrong'*" (TW, I#F). This teacher adapted her behaviour to align with the perceived expectations of her peers. Had the collegial expectations been aligned with heterogeneous grouping practices and lessons that allow student-generated responses to problems, then the desire to conform may have enabled the teachers to make changes to their beliefs and enacted practices. However, in this situation, the desire to conform became a barrier to teacher W adopting changes to her practice, instead creating anxiety about disapproval from her peers.

4.4 TEACHER KNOWLEDGE

In the current study, discussions within the collaborative planning sessions surfaced teachers' limited depth of understanding of mathematical content knowledge at Level 3 of the New Zealand Curriculum, which is the expected level for students in Years 5 and 6. In several instances, a lack of knowledge hindered the teachers' ability to plan for and anticipate a range of solution strategies to a problem. However, on the positive side, one of the benefits of the teachers planning collaboratively and anticipating for problem-solving was an increase in teacher mathematical content knowledge during the period of the study.

At the beginning of the intervention, teacher Z noted that she felt overwhelmed by the volume of curriculum and content knowledge that teachers are required to teach. This feeling meant that she sometimes showed her students a rule or procedure that would allow them work out more difficult problems, "why not show them a short cut because that could lead to understanding later?" (TZ, I#I). Teacher Z reported forgetting things that were relevant to the later stages of the number framework and explained that she dealt with that by keeping herself "one step ahead" (TZ, I#I). During the first shared planning session, the teachers' discussions revealed that they were learning from each other, as they questioned each other and compared strategies for solving the following problem:

> Jenna and her seven friends were at the movies. They had 13 chocolate bars to share equally. What fraction of a chocolate bar did each person get?

Teachers' contributions during the first shared planning session included expressing their struggle with the problem:

> "I hate maths…when I come to problem-solving I freak out" (TX, CP#1);
>
> "I don't think it's going to work" (TY, CP#1);
>
> "So how did you do it the adult way? Oh of course; isn't it weird how you are thinking like the kids" (TZ, CP#1).

However, the increase in teacher content knowledge over time was evidenced by the greater range of strategies that teachers could describe to solve problems by the end of the intervention. When asked about the initial barriers to anticipating student responses, teacher W noted that, "only being able to think of one strategy was the biggest barrier" (TW, I#F). However, social interactions during collaborative planning sessions provided opportunities to probe and clarify: "just being able to discuss it with other teachers...bouncing ideas off each other has been good" (TW, I#F). Likewise, teacher X identified insufficient mathematical knowledge as having been a challenge in the beginning: "Possibly teacher knowledge, whereas we wouldn't think of all those options, for example on one of those times you said *'do a double number line'*, none of us had done that before…it's in the book, we should be teaching it, but we wouldn't have thought of using it, which I do now, but I wasn't before" (TX, I#F).

As the project progressed the sharing of examples of different strategies during the collaborative planning meetings impacted positively on teachers' content knowledge. For example, teacher W noted that:

> "Going through and seeing how other people were doing it, like the one when you went and drew the arrays on the board, which is a strategy I wouldn't have chosen to use…it just expands my content knowledge" (TW, I#F).

In particular, teachers noted that the social nature of the collaborative planning meetings support learning in a way that reading or planning independently could not:

> "I think my content knowledge has definitely increased, just from discussing other ideas and other strategies to teach…rather than just sort of reading one of the pink books before you are trying to teach" (TW, I#F);
>
> "When you have got your colleagues around you…they talk it through as well…so I think that was really good because we all came up with our own strategy and we used it. There was a range of different strategies, so you would have the basic to the more complex, which is great" (TY, I#F).
>
> "Hearing other people's ideas helped me with mine and it helped clarify my own ideas" (TX, I#F).

Teacher W shared that although she had previously solved the problems she was using before presenting them to students in the classroom, "it would just be one strategy; it would be the strategy that I would use. I wouldn't go, '*what other strategies might the kids use to solve it?*'" (TW, I#F). Although the teachers could see and describe many benefits from the collaborative

planning process, they reflected that even after taking part in the research study, it would be much more difficult to anticipate a range of strategies when planning on their own. This is further evidence of how teachers working collaboratively can extend and add to each individual teacher's knowledge of mathematics by providing access to a greater repertoire of shared, possible student solutions for solving problems.

4.4.1 MATHEMATICS KNOWLEDGE

The teachers also talked about how they had gained confidence in their own mathematical ability and applying their knowledge to solving problems. For example, teacher X, a very experienced teacher, admitted suffering from maths anxiety, especially when faced with a word problem to solve noted that she:

> "quite liked the collaborative planning because I am not always confident when it comes to problem-solving, because I always think, *I don't know how to solve that,* until I've worked through it, and hearing other people's ideas helped me with mine" (TX, I#F).

Likewise, teacher Z shared that she had come to be more accepting of herself as a mathematician and a learner, "it just made me realise that we are all human and that we all don't know everything and it kind of put you on an even plane really…and it helps to build up your confidence as teachers, too" (TZ, I#F). The experience of collaborative planning and anticipating appeared to have given the teachers a renewed appreciation of what it is like to struggle when faced with a mathematical problem. For some teachers, this experience allowed them to learn from their colleagues through sharing and discussing the strategies they had each used themselves to solve the problems, as well as the possible student responses they had anticipated.

4.4.2 CURRICULUM KNOWLEDGE

Teacher W, one of the less experienced teachers, described how the shared planning sessions felt "comforting". Comfort was related to her knowing that what she was doing in her class was the same as what other teachers were doing. Even though this was only for the one shared lesson plan each week that all the teachers had planned collaboratively, teacher W felt that the resulting "confidence boost" flowed over into the rest her weekly teaching of mathematics:

> "It has made sure that we are all going in the same direction, because we were all doing these problems together - now the rest of our teaching sort of fits around that. Well, that's what I've tried to do in my class anyway, is fit the rest of my week's teaching around what the problem is" (TW, I#F).

Teacher W noted that the new focus on problem-solving influenced all of her lessons:

> "If we were doing a multiplication problem it's trying to build towards learning multiplication strategies and then doing problem-solving…I kind of figured that other people would have been doing the same" (TW, I#F).

As the project progressed, teacher W explained that she didn't feel the need to check with the other teachers so much about what strategies she was planning to teach to her students and where they fit within the strands of the curriculum and the number framework domains. This growth in acting autonomously was tied to the teacher's increased confidence in her own teaching, which, in turn, was strengthened by a sense of more consistent practices between the teachers. This led to a feeling of meeting collegial expectations, "it has made sure that we are all going in the same direction" (TW, I#F). It appeared that discussions within collaborative planning sessions provided teacher W with greater clarity around the content and structure of mathematics in the curriculum and increased her knowledge of how to plan her programme accordingly.

4.5 USE OF STUDENT RESPONSES

As part of the intervention, the teachers were provided with a series of reflective questions to guide their thinking about the impact of their practice on students learning (refer to Appendix E). However, unfortunately the teachers chose not to formally use these prompts to guide their conversations or to record their thinking about successes or adaptations they could make to their teaching. In their collaborative planning meetings, their preference was to briefly discuss how the previous week's lesson had gone, before moving on to planning for the next problem. Teacher Y noted that their discussion about the previous problem usually centred on whether students had been able to solve the problem correctly, and the ease of understanding of the context of the problem:

> "After each problem … if they didn't quite get that, if most of the class didn't get it then we need to come back and have a look at something similar, but different" (TY, I#F).

Although some teachers brought along examples of students' work to share at this time, the focus of the discussion about student work was largely related to the perceived difficulty of the problem, with the teachers seemingly wanting all students to finally solve the problem. Students correctly solving the problem was deemed to be an indicator of the success of the lesson. Teacher Z shared that they talked about, "how some kids did not get it at all, so what could you do, could we adapt the problem, do we need to go back and we put like an easy step in for one lot and we said for others we could have this more difficult step" (TZ, I#F). However, for the most

part, the teachers' discussion focused on whether students had arrived at the 'right answer' or not, rather than trying to understand what the common misconceptions were, or to use evidence of student thinking to inform their practice and to learn from. This was evidence that the teachers were still focusing on correct responses rather than the rich information that can be gleaned from students' mistakes and how to support students to make connections between key mathematical ideas.

Explicit discussion around opportunities to learn from students' work and to use student responses to previous problems to think about how to notice and respond to student thinking to further the learning for students and teachers were largely absent from the teachers' evaluations of the planning sessions. The exception was teacher X who identified these missed opportunities, and said that this was something she would ensure they did differently if they were to continue planning collaboratively after the conclusion of the research study. She stated:

> "That was the problem, once we did the lesson well, we would kind of just grab another one out of the sky; we didn't think '*what's one that could build on this knowledge and move on?'.* It was very much just like, '*here's a problem; here's a problem…"* (TX, I#F).

Clearly this teacher had extended her understanding of the potential to use student responses as building blocks for new knowledge and connections, and was showing awareness of the need for planning strategically and with key mathematical learning goals in mind.

Without explicit and extended engagement with children's thinking, for many teachers the objective of a problem-solving lesson became more of a show-and-tell session. As teacher Z noted, she felt obliged to, "just let them share", and, "because they got different answers then they could compare and see why they got different answers…but they wanted to share and I just felt that that gave them more confidence to actually approach a maths problem" (TZ, I#F). Teacher Z's focus on having students enjoy the lesson, alongside her focus on arriving at the correct solution, appeared to override a focus on supporting deeper understanding of mathematical concepts and practices.

For many of the teachers, students being able to use more than one pathway to find the solution to a problem seemed to become a goal in and of itself. As teacher X noted, "at first, they would only write one way, but over the process they got better, and I showed them different ways of showing me their working, so they were like, *'we found five ways!'* and they were quite excited about it" (TX, I#F). However, in contrast, teacher Y shared how much she valued students learning different strategies, even when these did not result in a correct solution. Her responses suggested that a correct answer alone was not the end-point for her:

> "I'm not going to tell them they haven't got the right answer, but what have they learnt from it today? So it's not necessarily just getting the answer correct; it's actually them thinking about ways they can solve it…we can all think in different ways" (TY, I#F).

This is evidence teacher Y was aware of the potential for a range of student solution pathways to extend students' thinking. Unfortunately, for most of the teachers, these lessons which encouraged student-generated solutions to problems remained a very small part of their weekly mathematics programmes.

4.6 TEACHER EXPERIMENTATION

For most teachers (n=5), problem-solving was still seen as something to be done once a week as an add-on to their normal, traditional classroom programme – even at the end of the intervention. Given a small concession to integrating problem-solving, teacher W explained that although she was now including more problem-solving type tasks in her group rotations and her tumble activities, the majority of her programme still closely resembled the NDP model of teaching particular strategies from the pink books according to the stage of the number framework that the students had shown they were working at. She viewed problem-solving as a way of allowing students to apply what they have learnt from their group teaching during the week, for example she noted, "I've tried to fit the rest of my week's teaching around what the problem is. If we were doing a multiplication problem it's trying to build towards learning multiplication strategies and then doing problem-solving" (TW, I#F).

Several of the teachers noted that they had been trying different things during their teaching of problem-solving. Although teacher X had expressed her commitment to following "the process that we had agreed to" (TX, I#F), she also experimented with different ways of grouping her students for problem-solving:

> "I made sure I had two separate lots of groupings because sometimes the Gifted and Talented Education (GATE) kids wouldn't be there" (TX, I#F).

Similarly, teacher Z noted that she had taken a bit of an eclectic approach to teaching the problem-solving, and adapting it in the vein of, "I'll take a bit of that and I'll put it in and I'll see how it goes" (TZ, I#F). Teacher W also experimented with implementing problem-solving lesson formats:

> "Sometimes I do it as a warm-up before I go into group teaching and teaching strategies, and then other weeks I have done it as a whole class and we will just concentrate on

> one problem, and then go onto another problem. It's all sort of trial and error to see what works best for me" (TW, I#F).

This inconsistency of teaching the shared planned lesson concerned teacher X, who noted, "I don't think we could compare it properly, because we weren't all going through it the same; we weren't doing the same thing" (TX, I#F).

Despite the experimental approach to the teaching of problem-solving during the period of the study, these changes did not seem to significantly affect the balance of the teachers' practice. Only teacher Y seemed open to the possibility of moving to a more problem-solving based pedagogy in her mathematics programme, by the end of the intervention:

> "It's definitely something that I could see you could move towards. I'm not as reluctant to go, *let's do it this way,* it would be something that you could easily give it a go and we could look at as a team and go, *okay, let's try doing it a little bit differently*…it's a great way to collaborate with kids and to take the stress out of maths for them" (TY, I#F).

However, she did acknowledge the barriers to teacher change, including teacher workload and a perceived lack of time, as well as teachers' attitudes to change: "It does take a while to shift your thinking, especially after 20 years of teaching [laughs]" (TY, I#F).

4.7 SUMMARY

This chapter has described how teachers' prior learning, existing beliefs and practices, and teachers' confidence in their current practice, resulted in some resistance to the idea of change. However, teachers reported gaining confidence in their teaching of problem-solving lessons – albeit these once-weekly lessons were seen by teachers as an add-on to their programmes. The teachers gained confidence in enacting the shared planning practice of anticipation for their once-weekly lesson and enjoyed working together as a team. The findings demonstrated that weekly collaborative planning and anticipating for one lesson, resulted in increased teacher knowledge of mathematics strategies, and teacher knowledge of the curriculum and alternative ways to structure their mathematics programmes. Increased teacher knowledge was attributed to teachers learning from each other during collaborative planning sessions.

The chapter outlined the nature of teacher discussions about student responses to problems, and revealed the missed opportunities to use student responses to help teachers build on student thinking or inform their practice. The study highlighted the experimental approach

teachers took to enacting problem-solving practices in mathematics lessons. The implications of these findings are discussed in Chapter five.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

In this chapter the effects of collaborative planning will be explained. In particular, explanations will be provided for how collaborative planning affected teacher beliefs and practices enacted in mathematics lessons. The barriers and affordances of collaborative planning on teacher change are discussed in relation to the literature. The findings of the current study are put into context of the wider literature on teacher collaboration and the conditions required to effect teacher change. The analysis has identified both barriers and affordances to teacher change within the findings from the study. The barriers and affordances will be discussed in separate sections. Some of the barriers have been further categorised according to the three subsystems Opfer and Pedder (2011) argued have the biggest influence on teacher learning; the individual teacher system, the school system, and the activity system.

Section 5.2 outlines and discusses the barriers to teacher change in beliefs and practices enacted in mathematics lessons. These barriers include; teachers' prior learning and beliefs, the pressure within the school system, the limitations of the intervention design in the current study, and teacher knowledge. Clearly evident in the results of the study were also affordances to teacher change. Section 5.3 outlines these affordances, including; working collaboratively, planning and anticipating, and teacher expectations. Section 5.4 considers the limitations and implications of the study. Section 5.5 outlines opportunities for further research. Section 5.6 identifies conclusions that can be drawn from this research.

5.2 ANALYSIS OF BARRIERS TO TEACHER CHANGE

Although the teachers outlined a number of positive outcomes of being involved with planning collaboratively for problem-solving, this remained something that happened on average once a week in each classroom, without resulting in changes to the rest of their mathematics programme. This indicates that there were insufficient conditions to enable extensive teacher change to occur.

The results of the study have shown there are several barriers that impacted on how collaborative planning affected teacher beliefs and enacted practices in mathematics lessons. These included the influence of previous professional learning and teacher beliefs, perceptions of school expectations, a teacher experimentation approach, areas of limited teacher knowledge, and flaws in the design of the research intervention that may have resulted in the

teachers' missed opportunities to engage with students' thinking. Although teachers' knowledge of mathematics acted as both a barrier and an affordance, it is discussed primarily in this section.

5.2.1 TEACHER BELIEFS AND PRIOR LEARNING – THE INDIVIDUAL TEACHER

The teachers' prior professional learning and resulting beliefs about mathematics teaching practices proved to be more dominant than the new knowledge about planning, grouping and teaching practices that they were exposed to during the research study. After the intervention, the teachers' beliefs had not significantly changed with regards to their grouping practices, or the need for teacher direction and transmission styles of teaching. Furthermore, the teachers held onto their assessment view of students' learning. Although the teachers did all try doing problem-solving in their classes on a weekly basis, they reportedly did not all implement the lessons they had planned collaboratively with fidelity to the agreed lesson process and teaching practices. Teacher X said after the intervention, "I think people didn't do it properly in their class…that wasn't the process we were supposed to follow" (TX, I#F). These results are aligned with the assertions of Bobis et al. (2016), that "mathematics teachers' practices are influenced by what they believe to be true about mathematics and about its teaching and learning" (p. 36). Teacher beliefs mediated the impact of the collaborative planning sessions.

5.2.2 TEACHERS' PRIOR LEARNING AND THE ROLE OF DISSONANCE

The results of this study show that teachers' prior learning had influenced their beliefs about teaching mathematics and subsequently these beliefs acted as a barrier to teacher change. Opfer and Pedder (2011) state that "teachers bring both past experiences and beliefs to their teaching and learning" (p. 387). Opfer and Pedder (2011) define teachers' learning orientation systems as "the interactions among their experiences, beliefs, knowledge, and practices" (p. 389). At the beginning of the study, the teachers held varying attitudes to the proposition of collaborative planning and enacting new pedagogies and grouping practices in mathematics lessons (see Section 4.2). These attitudes included a range of teacher 'orientation to learning systems'. According to Opfer and Pedder (2011), teachers' orientation to learning systems determine both the instructional decisions that teachers make and the extent of their own learning and growth. The current study has shown the teachers' degree of open-mindedness and their self-expressed willingness to learn and change, were not accurate predictors of their actual, reported change at the end of the intervention.

Out of the six teachers who took part in the intervention, four teachers had articulated positive attitudes to trialling collaborative planning for mathematics teaching and using problem-solving

before the study began. However, at the end of the intervention, only one of these four teachers, teacher Y, reported significant changes to her beliefs and noted her willingness to extend changes to her enacted practices in mathematics lessons. One factor that could explain the limited effect of the intervention on teachers' enacted practices might have been the large extent of the dissonance teachers' experienced. As described in the previous chapter, the intervention presented new knowledge and ideas that were in conflict with the teachers' strong, existing beliefs and practices. Coburn (2001) found that when new ideas were too different from teachers' current beliefs and practices, the extent of this gap seemed to cause teachers to dismiss new ideas as inappropriate to their practice. Although Opfer and Pedder (2011) state that dissonance within teachers' learning orientation systems can act as a catalyst for change, in the current study this was only found to be true for teacher Y. In most cases, the cognitive dissonance gap between teachers' existing belief systems and new knowledge might have been too wide for teachers to bridge. Alternatively, for the five teachers who did not change their beliefs about grouping and teaching practices, the delivery of the professional learning and engagement in the collaborative planning sessions might not have caused sufficient dissonance or critical inquiry.

5.2.3 TEACHER BELIEFS AND CRITICAL INQUIRY

The dominance of the teachers' existing beliefs is described in the previous chapter (see Section 4.2). The beliefs the teachers held appeared to have acted as a barrier to teacher change. The teachers' beliefs, although shared, were not aligned with the pedagogical practices being promoted during the research intervention. This is another factor that could have contributed to limiting the effects of collaborative planning on teacher beliefs and enacted practices. The relatively homogeneous nature of the participant group (teachers' similar existing beliefs and positons) seems to have limited the teachers' engagement in critically reflective inquiry. As described in chapter two (see Section 2.4.2), heterogeneous groups of teachers allow for a greater range of prior learning and experiences to be brought to discussions and promote challenge, rather than reinforce the status quo (Kaasila & Lauriala, 2010; Muñoz-Catalán et al., 2010; Timperley, 2011). At the beginning of the intervention, all six teachers held shared beliefs about the perceived benefits of ability grouping students, the "good results" they had been attributing to their current teaching practices, and the norms of expected grouping and pedagogical practices within the school. This apparent lack of challenge, and the resulting lack of acknowledgement and discussion of dissonance, seemed to have led teachers to reject the enactment of new learning and allowed the teachers to perpetuate the status quo.

5.2.4 PERCEIVED PRESSURE ON TEACHERS – THE SCHOOL

Individual differences in teachers' levels of confidence in themselves as teachers, and within their role in the team and school, impacted on how teachers responded to perceived pressure from their colleagues. The more self-confident the teacher was, the more they were able to resist the need to adapt to fit the norm. In addition to the individual teacher system, Opfer and Pedder (2011) identified two other subsystems that interact and combine to influence teacher learning; these are the school system and the professional development activity system. The current study found that individual differences in self-confidence among teachers affected the extent to which teacher beliefs were influenced by the school system. According to Opfer and Pedder (2011), social norms of action that exist within a school can reinforce teachers' practices that align with school-level beliefs and sanction those that do not. This was evident in the current study. Teacher W, the newest teacher to the profession, expressed the strongest desire to conform. According to Bobis and her colleagues (2016) this may be attributable to this teacher's more limited confidence in her own ability; they noted that teachers with weak efficacy beliefs tend to reject responsibility and are less likely to make changes to their practices.

In contrast to teacher W, teacher X articulated her autonomous position by stating her confidence to continue to support the other teachers in the team with implementing new practices. She was willing to do this regardless of the perceived position of the school system. The results of the study show that teacher X, who was one of the most experienced teachers involved in the research, noted that collaborative planning for problem-solving could be continued after the conclusion of the intervention and even increased if she made the decision to "make sure that we do it" (TX, I#F). This sense of efficacy and empowerment may be partly due to her role as a team leader. The contrasting positions of these two teachers are an example that corroborates the work of Opfer and Pedder (2011), who stated that "new or inexperienced teachers are especially vulnerable to constraining their practice to fit with collective pedagogical beliefs" (p. 392). The results of the current study show that differences in teacher confidence mediated the extent that teacher beliefs and enacted practices were constrained by the collective pedagogy of the school system.

5.2.5 SCHOOL NORMS AND COLLEGIAL EXPECTATIONS

The results of the study show that the teachers were influenced by their perceptions of what was expected of them by their colleagues and the school's senior management team. The

influence of the school system had a large effect and acted as a barrier to teacher change. In the initial interviews the teachers noted their reservations about the possible implications of changing their practice, including some of the same concerns that Anthony and Hunter (2017) identified were held by mathematics support teachers who were in the early stages of engaging with the research literature around grouping practices. These concerns included feelings of uncertainty pertaining to current grouping practices within their schools and the pressures of managing student behaviour and learning while covering content required for standardised assessments. Teachers in the current study reported that for them to commit to changing their practices they would need to feel supported by each other (more specifically, their whole team) and their senior leaders as part of a whole-school approach to changing the way that mathematics was taught. This supports the proposition that professional development is more effective when teachers from the school participate collectively (Opfer & Pedder, 2011) and may explain why changes to grouping practices appeared to be "both tentative and gradual" (Anthony & Hunter, 2017, p. 86). School and team norms acted as barriers to teacher change because goals and expectations were not made to explicitly, and publicly, align with moving towards collaborative planning and teaching problem-solving across the school.

5.2.6 PERCEPTION OF RISK

Clearly evident in the results were teachers' perceptions of a significant level of risk involved with enacting changes to their practice. In her work investigating barriers to implementing pedagogical change, Le Fevre (2014) found that perceptions of risk and the desire to avoid taking risks can act as a major barrier to change, even when teachers espouse a desire to change their practices. Teachers in the current study perceived many risks involved with the intervention. These perceived risks included the possibility of diminished results for the students in their classes, losing control of student behaviour and the direction of the lesson during teaching problem-solving, and fear of not conforming to pedagogical norms or of losing face among their peers due to differing levels of mathematical capability. These fears are similar to the concerns that Anthony and Hunter (2017) found to impede change to the grouping practices of mathematics support teachers, and also align with the findings of Bobis and her colleagues (2016) regarding the detrimental effects of anxiety on teacher change. Perceptions of the risks of enacting changes to practice may be another explanation for the limited actual, reported enactment of practices in teachers' mathematical lessons.

5.2.7 TIME PRESSURE

All of the teachers identified time pressure as a significant barrier to maintaining fidelity to the agreed process and agenda for the collaborative planning meetings. Teacher X noted, “There were issues around it in that it was time consuming and we just struggled to do it, and when you weren’t there we did it a lot quicker because we didn’t go through all of the elements quite as well as we should have” (TX, I#F). Although the researcher had provided teachers with a set of reflective questions to guide their thinking and help focus their discussions on student learning, they constantly felt under time pressure resulting in this part of the collaborative planning process not being sustained by the group. Had the teachers examined “his or her practices in relation to his or her own thinking and the thinking of his or her students” (Franke, Carpenter, Fennema, et al., 1998, p. 68) they would have been engaging in what Franke and her colleagues defined as a different level of practical inquiry, and therefore been more likely to experience generative teacher change.

5.2.8 TEACHER EXPERIMENTATION – THE LEARNING ACTIVITY

Teacher change is a complex process; the design of the current study did not provide sufficient conditions for sustainable teacher change to occur. As outlined in the literature review (see Chapter two), there are many conditions required for teacher professional development interventions to be successful and result in teacher learning and change. According to Opfer and Pedder (2011), the third subsystem required to influence teacher learning is the activity system. The activity system consists of the nature and design of the intervention.

The current study found that self-sustaining, generative teacher change did not occur as a result of the intervention. As discussed in the previous chapter (see Section 4.2 and Section 4.6), some change and teacher learning did occur during the study, however, these changes were not of the self-sustaining type described by Franke and her colleagues (1998). Although the participating teachers acknowledged the benefits of providing their students with problems to solve and encouraging more discussion and collaboration among students during these lessons, the design of the intervention did not explicitly cause the teachers to struggle to understand why the practice worked. As teachers tried out the collaborative problem-solving pedagogy, they noticed that their students were better able to think and learn together than they had previously thought. Teacher Y noted that her misgivings were assuaged: “Initially I thought possibly this could be a disaster because they haven’t done a lot of stuff like that…but it worked really well; the kids were actually quite motivated” (TY, I#F). However, observing the success and enjoyment of their students was insufficient to create the dissonance required for

sustainable change. A more explicit requirement to engage in inquiry or active reflection as part of the study may have resulted in the teachers acknowledging their role in causing student learning to occur and encouraged them to pursue and spread the problem-solving practices.

This study found that the teachers perceived the pedagogy of collaborative problem-solving as effective, when used once a week as an opportunity for students to consolidate and apply the strategies that they had been taught by the teachers. Once the participants had observed that the practice was effective they did decide that it was worthwhile and should be continued (once a week, in the manner that they had been implementing during the intervention period). However, this aligns with what Franke and her colleagues (1998) give as an example of changes that are likely to erode over time. Because the teachers in the current study were not explicitly required as part of the intervention to consider the conditions required for success, Franke and her colleagues (1998) argue that it would prove difficult for them to adapt the practice to new contexts. Indeed, many of the teachers stated their doubts about being able to transfer the practice to the rest of the mathematics programmes, or to see how students could learn the strategies while working together to solve problems. Teacher W explained that she tried to, "fit the rest of my week's teaching around what the problem is; if we were doing a multiplication problem it's trying to build towards learning multiplication strategies and then doing problem-solving" (TW, I#F). These results indicate that teachers did not generalise their implementation of the use of problems with student-generated solutions to other mathematics lessons. Furthermore, the teachers' existing understandings of the nature of mathematics as a body of knowledge to be transmitted to students remained unchanged.

5.2.9 TEACHER KNOWLEDGE

Effective teaching of mathematics requires teacher mastery of mathematical content knowledge as well as other pedagogical knowledge that enables teachers to effectively support student learning. Ball et al. (2005) refer to this specific knowledge and skill-set as 'mathematical knowledge for teaching' and note that it includes both knowing the "topics and procedures they teach" and the "work of teaching" (p. 17). While the purpose of the intervention was partly to strengthen teachers' ability to effectively plan for lessons, the results of the study indicate that some of the teachers first needed to overcome limitations in their knowledge of the mathematics at the curriculum level they were teaching (see Section 4.4). The teachers identified their struggle to anticipate a range of solution pathways and strategies that students would be likely to use to solve the problems that they were planning to teach, and noted that this acted as a barrier to them engaging effectively in the process of planning collaboratively.

This is an example of how limited teacher knowledge of mathematics acted as a barrier to change and enactment of new practices in mathematics lessons.

Although limited teacher knowledge of mathematics appeared to be a barrier to teacher change in the current study, Sherin (2002) found that existing content knowledge can be adapted during teaching and new content knowledge can be developed in the act of instruction. The nature of enacting the planned lessons allowing for student-generated responses to problems, meant teachers encountered student responses they were not prepared for. The results of the study show that teachers' felt better prepared to use these student responses and to manage their own comments and actions while teaching, as a result of having participated in the collaborative planning sessions prior to teaching. When considered from this perspective, teacher knowledge appeared to be increasing over the course of the study through the teachers' weekly implementation of new practices (problem-solving lessons). Sherin (2002) stated that teachers' implementation of mathematics reform is influenced by their current practices and that this can create difficulties for teachers as they endeavour to make changes. The results of the current study show the teachers understood and valued the knowledge others brought to the group, but they were not necessarily aware of the impact of their own lenses through which they viewed this new (shared) knowledge, nor how their own knowledge grew through listening to each other and the students.

Teacher knowledge also acted as an affordance to teacher change. This dual impact can be explained by individual differences in teacher knowledge within the group, as well as by the flexible nature of teacher knowledge. In accordance with the findings of Sherin (2002), the teachers in the current study developed new content knowledge "by engaging in a cycle of negotiations among their understanding of the lesson, views of student learning, and knowledge of mathematics" (p. 125). As teachers built on their existing knowledge by learning from each other when sharing strategies during co-planning sessions, their knowledge compounded and acted as an ever-increasing bank of solution pathways, strategies and procedures that were relevant to the tasks and problems they were teaching. Without the existing teacher knowledge that was brought to the collaborative planning sessions, the teachers would not have had such a range of ideas to collect and share together.

5.3 ANALYSIS OF AFFORDANCES TO TEACHER CHANGE

Analysis of the results showed that there were a number of barriers to teacher change that existed as part of the collaborative planning intervention, there were also some affordances to teacher change. One example of this is teacher knowledge acting as a catalyst for teacher change

within the collaborative environment (see Section 4.4). However, sufficient teacher change took place to warrant further discussion of other factors that enabled collaborative planning to positively impact on teacher beliefs and enacted practices. These affordances included working as a team, the prescribed planning practices of anticipating and reflecting, and the expectations of being involved in the study. These affordances led to positive perceptions of the intervention and the results show that teachers identified a number of benefits of engaging in collaborative planning as a team.

5.3.1 WORKING AS A TEAM

There is an abundance of literature which illustrates the positive impact of teacher collaboration on learning and change. Kotelawala (2010) found that teacher collaborative planning for mathematics strengthened lesson-planning practices and provided opportunities for professional growth, resulting in teachers deepening their understanding of content, adjusting learning goals, learning from colleagues and developing a sense of community. Stoll (2012) stated that learning conversations among teachers play a critical role in creating meaningful and sustained change by allowing teachers to talk through the complexity of taking on board new knowledge about learning. Gee and Whaley (2016) emphasised the positive influence of collaborating with peers to develop lessons and discuss students' responses to learning. In accordance with these researchers, the results of the current study show that working collaboratively when planning for problem-solving provided teachers with opportunities to share their strengths, learn from each other's knowledge and teaching experience, and strengthen their collegial relationships. For example, Teacher V noted that she made manipulatives more available for students to use during her lessons after observing her colleagues use physical materials to demonstrate their thinking during collaborative planning sessions. It was clear that working as a team acted as an affordance to teacher change by influencing teachers' beliefs and enacted practices in problem-solving lessons.

5.3.2 PLANNING PRACTICES AND THE ROLE OF ANTICIPATION

Anticipating during collaborative planning sessions with colleagues provided teachers with a greater range of possible solution strategies, which helped the lesson flow and built teacher confidence and enjoyment. Stein and her colleagues (2008), and other researchers (Gee & Whaley, 2016; Kotelawala, 2010), have discovered that anticipating during planning can be a powerful affordance to teacher change. The results of the current study show that teachers reported engaging with the planning practice of anticipating allowed them to feel more in control of the teaching and learning during lessons, as well as to respond more deliberately to

students on the days when they were enacting lessons involving student-generated responses to problems. The teachers reported being better prepared to deal with student errors and mistakes as they occurred due to having a wider awareness of a range of alternative strategies that students could use to solve problems. These results illustrate how anticipating acted as an affordance to teacher change in the current research intervention.

5.3.3 EXPECTATIONS OF TEACHERS

While the results of the study indicate that teacher change was inhibited by the expectations that teachers perceived from the school system (see Section 5.2.2), the opposite also appeared to be true. By way of explanation, although the teachers' desire to conform to norms and expectations of their peers acted as an impediment to creating sustained teacher change of enacted practices, this appeared to be the result of teacher perceptions that school norms of practice were not aligned with the intervention practices and problem-solving. However, the expectations on teachers of being involved in the current study and intervention also created an environment where the participating teachers wanted to meet the expectations of the researcher. The results show that teachers expressed the desire to conform to the norms created in their team, which included engaging in anticipating, collaboratively planning, and then teaching the planned lesson each week for the duration of the intervention (20 weeks during school terms). These results indicate that the expectations of teachers involved in the research acted as an affordance to enacting some teacher change during the period of time that these expectations were shared by the team members who were participating in the research. It would be worthwhile investigating how these results could be used to inform the deliberate creation and communication of expectations of teachers to create a more supportive environment for teacher change to be sustained after the conclusion of the research.

5.4 LIMITATIONS AND IMPLICATIONS

This study was bound by the unique context of the case and mediated by situational factors present in the chosen school. Interpretation of the results requires consideration of the complex interaction of many factors influencing teacher learning and change. These context-specific factors include individual differences among teachers, the timing and environment of the study, and the impact of the role of the researcher. In addition to these factors, the results must be viewed from a perspective of acknowledging the constraints of a very small sample size, and a study conducted over a relatively short intervention period. Notwithstanding these limitations, the implications of the results from this research are outlined in the following sections of this chapter.

5.5 OPPORTUNITIES FOR FURTHER RESEARCH

Although it was within the scope of this study to explore barriers and affordances to teacher learning and change from the teachers' perspectives, it was beyond its scope to quantitatively measure changes in teacher knowledge. Considering the important influence of both teacher knowledge of mathematics and 'mathematical knowledge for teaching' on student learning (Ball et al., 2005), further investigation of the effects of collaborative planning on teacher knowledge is warranted.

In addition, other researchers (Gee & Whaley, 2016; Stein et al., 2008) have noted the opportunities anticipating provides teachers, including opportunities to adapt their practice to allow space within lessons for building on student thinking, and to incorporate methods for developing student understanding of key mathematical ideas. Within the current case study, teacher interviews provided data on reported change to enacted practices. An investigation into observed changes to teachers' enacted practices as a result of anticipating, and the impact of enacted practices in mathematics lessons on students' opportunities to learn mathematics is an important area for further research.

5.6 CONCLUSIONS

5.6.1 AFFORDANCES TO TEACHER CHANGE

Importantly, the results of this study support the contention made by other researchers (Gee & Whaley, 2016; Kotelawala, 2010) that collaborative planning provides teachers with opportunities to learn with and from each other, while improving the quality of the lessons planned. It was evident in the current research that working as a team had a positive impact on teacher confidence and efficacy, and teacher knowledge of mathematics and of the curriculum. For one teacher, engaging in collaborative planning resulted in increased openness to change and willingness to move towards enacting new practices outside of the specific requirements of the intervention. Furthermore, teacher collaboration provided benefits for teachers in the current study that align with benefits described by other researchers (Bauml, 2014; Kotelawala, 2010). This highlights the value of teachers planning collaboratively for mathematics problem-solving lessons.

Similarly, the results of this study support the position of other researchers (Gee & Whaley, 2016; Stein et al., 2008) who noted the planning practice of anticipating supports teachers to enact changes to their classroom practices in mathematics lessons. While these researchers

indicated anticipating supports teachers to be better prepared and allow a range of student-generated solutions, it was evident in the current study that teachers only enacted these changes in a limited number of lessons. The teachers felt more prepared to respond productively to student errors and to accept a wider range of strategies from students during these lessons as a result of having anticipated possible solutions with their colleagues while planning. It was apparent in this study that collaborative planning and anticipating provided affordances for one teacher to change her beliefs and become more open to enacting changes to future mathematics lessons.

5.6.2 BARRIERS TO TEACHER CHANGE

Opfer and Pedder (2011) conceptualised three subsystems that interact and combine to influence teacher learning; the individual teachers' orientation to learning, the school system, and the learning activity. Each of these three subsystems were evident in the current study as influences on teacher change. Specifically regarding the subsystem of the individual teachers in the current study, teachers' past experiences and beliefs influenced what they were willing to learn. Moreover, dissonance failed to act as an enabler of teacher change – this may be due to either too much, or too little dissonance being experienced by the teachers. Too much dissonance may have acted as a barrier to the adoption of new learning because there remained too great a contrast between existing teacher beliefs and new ideas. Alternatively, too little dissonance may have been created by a failure of the professional learning to encourage critical reflection. Five out of the six participating teachers maintained their position regarding the value of ability grouping practices throughout the study. Additionally, teacher beliefs and practices continued to align with earlier professional learning and existing practices of transmitting prescribed strategies rather than allowing students to generate solutions to problems.

Further to this, anxiety and risk avoidance have been identified as barriers to teacher change in other studies (Bobis et al., 2016; Le Fevre, 2014). The current research identified teacher perceptions of risks such as loss of control during lessons and the fear of diminished status. Teachers require both knowledge of the mathematics they teach and knowledge that is particular to the craft of teaching (Ball et al., 2005). At the beginning of the study, most of the teachers had limited knowledge of ways mathematical problems could be solved. Although teachers' mathematical knowledge was developed during the study, limited knowledge of possible student solutions for problems made it challenging for the teachers to engage in anticipating. All of these aspects of the teachers' individual orientation to learning systems

interacted with other factors in the environment and the activity in such a way that generative teacher change was not created.

The current study provided evidence supporting the influence the school subsystem can have on professional learning, in accordance with other research (Clarke & Hollingsworth, 2002; Opfer & Pedder, 2011). Teachers reported the absence of support from school leaders for enacting new practices in mathematics lessons. Teachers are time-poor and the results of the current research indicate the need for time pressure to be reduced to enable teachers to fully engage with collaborative planning opportunities. In addition to this, evident in the results of the current study is the requirement for goals to be in alignment, rather than in conflict with, any intervention designed to enable teachers to enact changes to their practice. The requirement for clearly a aligned vision is in accord with other international studies (Fullan & Quinn, 2016; Wideen et al., 1996). The effects of the school subsystem on individual teachers and their orientation to learning were mediated by teacher experience level. The teacher newest to the profession reported feeling the strongest desire to constrain her practice to fit with that of her colleagues. By not providing the conditions of sufficient time, clear goals, and coherent leadership and support, the school system acted as a barrier to teacher change.

During the period of this case study, teachers were provided with opportunities to engage in learning activities designed by the researcher. These activities consisted of collaborative planning sessions for mathematics lessons which included student-generated solutions for problems. Collaborative planning and anticipating provided the teachers with some, but not all, of the conditions recommended in the literature to enable effective teacher professional learning and development to take place (Cobb et al., 1990; Franke, Carpenter, Fennema, et al., 1998; Guskey, 2014; Kaasila & Lauriala, 2010; Schön, 1983; Stouraitis et al., 2017; Timperley, 2011). Notably, it was the absence of a number of required conditions that created a barrier to teacher change. The intervention did not establish a Professional Learning Community; this was evident because of teacher critical reflection and a focus on student learning was absent from the discussions observed during collaborative planning sessions. An absence of collective inquiry and respectful challenge was possibly due, in part, to a lack of explicit facilitation and direction by the researcher. The current research failed to create the conditions needed for generative teacher change.

5.7 SUMMARY AND CONCLUDING THOUGHTS

This chapter has discussed the findings of the study in relation to whether the impact of collaborative planning was positive or negative for teachers' learning and change. The discussion

noted the various barriers to teacher change and the influence that each of these had on teacher beliefs and enacted practices in mathematics lessons. The analysis of the results of the study also identified limited affordances to teacher change and these have been discussed in this chapter along with the resulting benefits perceived by the teachers.

The chapter clearly points to the elements of success within the intervention. Teachers reported feeling positive about the impacts of the study, and the findings illustrated a range of degrees of change in teacher beliefs and enacted practices. The reasons for these variations have been discussed in this chapter. The discussion of the barriers to teacher change identifies areas that could have been altered in order to achieve greater teacher change. The discussion of the affordances to teacher change highlights aspects of the intervention that could be built on in future studies.

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APPENDICES

APPENDIX A: INITIAL INTERVIEW (I#I) QUESTIONS

1) How do you currently plan for mathematics? (E.g. daily / weekly planning, unit or long term planning, strand vs. number, alone vs. collaboratively, involve students? What resources / support do you use? Templates? Consistency? How long does it take you / time spent? Digitally or on paper? Does what you have planned change / how flexible is your planning? How far in advance do you plan?
2) What does a typical maths lesson look like? (E.g. do you plan for multiple groups? Levels? Independent tasks? Follow-up? Homework? Task board?)
3) On a Likert self-rating scale of 1 to 5, where 1 is the least and 5 is the most:
    a) How confident are you in your own maths content knowledge?
    b) How confident are you in your curriculum knowledge in mathematics? (Knowing that you are teaching the right things?)
    c) How confident are you in your pedagogical knowledge for teaching mathematics? (Knowing that you are teaching mathematics effectively?)
    d) How confident / prepared do you feel to deal effectively with students' responses during lessons, while you are teaching?
4) Do you enjoy planning for and teaching maths?
5) How well supported do you feel by your colleagues / team leader / senior management?
6) What do you anticipate / predict will be the outcomes / impact of collaboratively planning and anticipating student responses for problem-solving?
7) What support do you think you will need to be able to effectively plan collaboratively? Required conditions? Enablers / barriers?
8) How do you believe students learn best in mathematics?
9) How do you feel about this proposed change to the way you work / plan / possibly teach?
10) Would you be willing to share a copy of your daily / weekly mathematics planning with me?

APPENDIX B: FINAL INTERVIEW (I#F) QUESTIONS

1) How would describe your experience of collaborative planning?
2) What were the outcomes / impact of collaborative planning on your teaching of problem-solving in your classroom?
3) What would you say were the benefits (if any) of collaborative planning?
4) What would you say were the challenges / barriers (if any) to collaborative planning?
5) What would have made a difference to the success of the collaborative planning? What conditions do you think are required for teachers to implement and sustain collaborative planning practices?
6) Would you have liked any more, or a different type of, support to enable you to collaboratively plan more effectively?
7) In particular, did you notice any consequences / effects / results of having anticipated a range of possible student responses to tasks before teaching them?
8) Were there benefits / challenges / barriers / other conditions required in particular for anticipating student responses to tasks? Selecting tasks?
9) What are your reflections / did you notice about the selection of tasks? Their appropriateness for learning?
10) In particular, did you notice any benefits / consequences of collaborating in this way with your colleagues? Did it impact your practice? Your knowledge? How so? Did working collaboratively influence your relationships in any way?
11) How much did you talk to other teachers about maths before the research? During the research? Now?
12) Can you describe how you typically plan for maths now? Has this changed as a result of being involved in the research?
13) Can you describe a typical maths lesson? (Groupings?) Has this changed as a result of being involved in the research?
14) How do you believe students learn best in maths? Has this changed as a result of being involved in the research?
15) Have your expectations of students changed in any way? / Has your expectation of what students can do changed as a result of being involved in the research? How do you express your expectations of students in your maths lessons?
16) On a Likert self-rating scale of 1 to 5, where 1 is the least and 5 is the most:
    a) How confident are you in your own maths content knowledge?
    b) How confident are you in your curriculum knowledge in mathematics? (Knowing that you are teaching the right things?)

c) How confident are you in your pedagogical knowledge for teaching mathematics? (Knowing that you are teaching mathematics effectively?)
d) How confident / prepared do you feel to deal effectively with students' responses during lessons, while you are teaching?
e) Have any of these changed as a result of your involvement in the research?

17) Were any of your beliefs or practices challenged by being involved in the research? What created the challenge / dissonance? Was it resolved? If so, how?
18) Did you have a clear vision / understanding of what the desired practice / ideal looked like?
19) Were you exposed to new knowledge or ideas?
20) Did you feel like there was leadership of the collaborative planning sessions when the researcher was not present?
21) Did you discuss student learning / student responses to the tasks? What did you notice?
22) Do you think the collaborative planning sessions will continue? Embedded?

APPENDIX C: SAMPLE OF TEACHER WEEKLY PLANNING (Phase 1)

<table>
<tr><td>Term:3</td><td>Week: 9</td><td>Year: 6</td><td colspan="3">Number topic Addition, subtraction, and division
Whole class warm up: Look at numerators and denominators and what each represents.</td></tr>
<tr><td>Groups</td><td></td><td>Monday</td><td>Tuesday</td><td>Wednesday</td><td>Thursday</td></tr>
<tr><td rowspan="2">Stage 5/E6(EA/AA)</td><td rowspan="2"><u>Strategy</u>
I am learning to:
identify the place number of a decimal number
<u>Independent Knowledge</u>
I am learning to:
#find a the perimeter of a shape</td><td><u>Independent Knowledge</u>
Text Book Stage 6 pg. 108-109</td><td><u>Maths Comprehension cards</u></td><td><u>Independent Knowledge</u>
Text Book Stage 6 pg. 110-111</td><td><u>Computer</u>
GC</td></tr>
<tr><td><u>With Teacher</u>
Split multiplication 24x5
10x5=50
50x2=100
4x5=20
100+20=120</td><td><u>With Teacher</u>
Split multiplication 24x5
10x5=50
50x2=100
4x5=20
100+20=120</td><td><u>With Teacher</u>
Split multiplication 24x5
10x5=50
50x2=100
4x5=20
100+20=120</td><td><u>With Teacher</u>
Split multiplication 24x5
10x5=50
50x2=100
4x5=20
100+20=120</td></tr>
<tr><td rowspan="2">Stage 6(AA/AM)</td><td rowspan="2"><u>Strategy</u>
I am learning to:
identify the place number of a decimal number
<u>Independent Knowledge</u>
I am learning to:
#find a the perimeter of a shape</td><td><u>With Teacher</u>
Large Division 330/15=</td><td rowspan="2"><u>Computer</u>
GC

<u>Independent Knowledge</u>
Text Book Stage 6 pg. 128-131</td><td><u>With Teacher</u>
Large Division 330/15=</td><td><u>Independent Knowledge</u>
Text Book Stage 6 pg. 132-135</td></tr>
<tr><td><u>Problem Solving</u>
Question set by the teacher</td><td><u>Problem Solving</u>
Question set by the teacher</td><td><u>Computer</u>
Mathletics</td></tr>
<tr><td rowspan="2">Stage 7/E8 (AA/AM)</td><td rowspan="2"><u>Strategy</u>
I am learning to:
identify the place number of a decimal number
<u>Independent Knowledge</u>
I am learning to:
#find a the perimeter of a shape</td><td><u>Independent Knowledge</u>
Text Book Stage 7 book 1 pg. 74-75

<u>Computer</u>
GC</td><td><u>With Teacher</u>
Fractions of decimals
⅕ of 18.5= 18.5 / 5 =</td><td rowspan="2"><u>Computer</u>
Mathletics

<u>Independent Knowledge</u>
Text Book Stage 7 book 1 pg. 76-77</td><td><u>Teacher</u>
Fractions of decimals
⅕ of 18.5= 18.5 / 5 =</td></tr>
<tr><td><u>Problem Solving</u>
Question set by the teacher</td><td><u>Problem Solving</u>
Question set by the teacher</td></tr>
</table>

APPENDIX D: COLLABORATIVE PLANNING QUESTIONNAIRE (Phase 2)

1. Before you began participating in the research, how often did you have conversations or discussions with colleagues about the teaching and learning of mathematics?

_____ times per day

OR

_____ times per week

OR

_____ times per month / per term (please circle one)

2. What would have typically been the topic of these discussions? (e.g. Recommending a good resource to use; mentioning a difficulty you had had with a particular students during a maths lesson)

3. Before engaging in the research, did you usually solve problems or do the mathematics that you were setting for the students, yourself beforehand?

   Yes, Often / Yes, Sometimes / No, Not Usually / No, Never (please circle one)

4. What have you noticed so far as a result of planning collaboratively for problem solving and anticipating a range of possible student responses?

Name: _____

APPENDIX E: LESSON SEQUENCE AND TEACHER REFLECTIVE QUESTIONS

Problem Solving Lesson Sequence – Teachers Role	Self-reflection questions to consider
1. Launch the Problem Provide worthwhile problems which are appropriately pitched based on student assessment data, NZ Number Frameworks and Planning Sheets. **2. Independent thinking time** Notice and understand student responses or possible misconceptions **3. Small Group Sharing** Facilitate student discussion to explain and justify their thinking. **4. Reporting back to the larger group** Select and sequence who will present their thinking to elicit the big ideas. Explicitly connect and develop the big maths ideas and vocabulary. **5. Student-Self Assessment** Involve the students with co-constructing learning intentions, evaluating their progress and goal setting.	***Building on Students Thinking / Worthwhile Tasks*** *Was this task too easy? Too hard? How do you know? Was an extension or practice ready?* *Were any connections made to key prior knowledge?* ***Mathematical Communication / Tools and Representations / Making Connections*** *Who did most of the talking?* *What deliberate acts of teaching were used to promote student discussion?* *Who was asked to share back their thinking? Why? In what sequence? Had you anticipated the possible responses and misconceptions beforehand?* *How were materials / diagrams /modelling book used throughout the teaching to connect key ideas?* **Assessment** *Do the students **and** teacher know what they were learning, how they got on, and where to next? How do you know?*

What went well	Suggestions / Goals for next time.

APPENDIX F: EXAMPLE OF COMPLETED PLANNING TEMPLATE [Acknowledge Marie Hirst, Cognition Education]

Cognition Education

Big Maths Ideas and Learning Goals

- Solve measurement problems with related fractions. *
- Equivalence using multiplication
- Multiplication + Division are inverse.
- ÷ = put into groups of.

The Problem

Marion wants to make peach tarts for her friends. She needs two thirds of a peach for each tart and she has 10 peaches. What is the greatest number of tarts that she can make with 10 peaches?

Enabler: *(a question or prompt if they are stuck and don't know where to begin)*

Try 2 peaches (provide fraction circles) | $10 \div \frac{2}{3} = \square$

Launch the problem

- *What's the problem asking you to find out?*
- *What's the key information & how will you use it?*
- *Have you seen a problem like this before?*
- *Repeat the problem in your own words.*

Sequence	Possible strategies (and incorrect misconceptions)	Possible visual respresentations / Equipment	Who?
1	Drawing 10 peaches and making into groups of 2 thirds.	◔◔○○○○○○○○ etc.	
2	Repeated addition $\frac{2}{3} + \frac{2}{3}$ until you get $\frac{30}{3}$	$\frac{2}{3} + \frac{2}{3}$ (1⅓) + $\frac{2}{3} + \frac{2}{3}$ (2)	
3	multiplication $\frac{2}{3} \times 15 = 30$ thirds	$15 \times \frac{2}{3}$	
4	Ratio.	$\frac{2}{3}$: 1 tart → (×?) 10 : ? tarts	
		Peaches: $\frac{2}{3}$ $\frac{4}{3}$ $\frac{6}{3}$ $\frac{8}{3}$ ..... $\frac{30}{3}$ Tarts: 1 2 3 4	
5	Division. $10 \div \frac{2}{3}$ (put into groups of $\frac{2}{3}$) $\Rightarrow 10 \Rightarrow \frac{30}{3} \div \frac{2}{3} = 15$ as denominator is the same	10 $\frac{2}{3}$ $\frac{4}{3}$ 10 $\frac{10}{1} \times \frac{3}{2}$ invert and flip	

* Misconception : $10 \times \frac{2}{3} = \frac{20}{3} = 6\frac{2}{3}$.

Frontloading so that all students can access the task	Extension to provide a high ceiling for all
Key Knowledge ◦ Improper fractions → mixed numbes as nice rep ◦ Equivalent • How many make a whole.	For example : • What if.... • Here's the answer what could the question be? • Are there any other possible answers. How will you know when you have them all? • Student make up their own (easy and a hard version) • Add another step or related problem with higher content. How many tarts can you make with .. 12, 18, 26 peaches
Key Vocabulary Improper fraction mixed number ratio raho table	
Success starter to generate thinking, relevance and curiosity peach or apple tart world record.	**Plenary Reflection Questions:** • What are some big maths ideas we've learnt about today? • What did you learn from someone else today? • How are you/we going? Where are you/we going? What might you/we focus on next?

APPENDIX G: SAMPLE OF CODING AND MEMOING

Teacher X post interview transcript (I#F)	Coding and Memoing
R: How would you describe your experience of the process of collaborative planning?	Teacher enjoyment
T: I quite liked the collaborative planning because I am not always confident when it comes to problem-solving because I always think "God I don't know how to solve that" until I've worked through it, and hearing other people's ideas helped me with mine and it helped clarify my own ideas. But there were issues around it in that it was time consuming and we just struggled to do it, and when you weren't there, we did it a lot quicker because we didn't go through all of the elements quite as well as we should have, but we did still share our ideas, which was very good.	Teacher confidence Teacher content knowledge – lack of Barrier - time
R: Even when you went through it more quickly, did you still anticipate a number of strategies that students might use to solve the problem?	
T: We did, yes we'd look at the different ways and think about what would our Stage 4 and 5 kids do, the Stage 6 kids…	Anticipating – range of strategies
R: What would you say were the benefits of collaborative planning?	
T: Just discussing what other people thought the kids in their class would be doing, so you could kind of compare your children in your class, you could see what level they were all at. And also just getting the help with some of the problems, which none of them were actually too hard for me to do but sometimes I would look at them and think "Oh my God I can't do it" because I think I suffer from maths anxiety. I'm doing my masters on that. I'm self-diagnosing.	Teachers – sharing level of students in class Teacher content knowledge – lack of
R: What do you think was the impact in your lessons of having done the planning collaboratively and anticipated student responses?	
T: I think that planning the way we did, and anticipating what could go wrong, meant that as I saw things going wrong, or the things that we thought would go wrong, I would know to say "maybe you could look at that again", "would you like to use different equipment", and I would guide them, whereas usually if I just gave them a problem I would just kind of leave them longer to just try and work it out without actually thinking about where they might go wrong, and then, you can be prepared for it so you know where to guide them.	Anticipating – better prepared, range of strategies, better pedagogy
R: Were there any other challenges or barriers to the collaborative planning?	
T: Sometimes people's attitudes were a little bit negative towards the idea of planning together, and of doing the problems, and it could be a little bit frustrating at times. When you were like, right we've got to do it, let's do it really quickly, but we couldn't spend the time we needed, because they just wanted to get it out of the way really quickly. I think it felt like just one more thing, and she was always in a hurry, whereas the others,	Barrier – teacher attitude to process, view it as an extra thing to do, negative about co-planning and about doing

they actually were very keen, they were quite happy to go through the process and sit there as long as we needed to, but she wasn't so much. R: Do you think there was anything that would have made it more successful or made a difference? T: I think people didn't do it properly in their class. I was very careful to make sure that I had mixed ability and did groups, whereas I know for sure, some people just did it in pairs and some people just did it by themselves, and that I think wasn't the process that we were meant to follow. It is because I'm very rule-y and quite anal about things, and whether I wanted to do it or not, that was the process that we had agreed to follow, so I was doing problem-solving groups. So I don't think we could compare it properly, because we weren't all going through it the same, we weren't doing the same thing. And I often thought about how this would affect your study but I guess you go on results, and that's people – they don't do it exactly how you might want them to. R: Do you think it will carry on? T: I think it will definitely, I think I'd maybe just do it with the Year 6s, because we don't always have our meetings together, so we could do it whenever we just have a team meeting of Year 6s, every couple of weeks we do that, then we could do one then. Because I think it's really worthwhile and I know I wasn't doing enough problem-solving in my class, which I am trying to build up anyway, so it'll keep us all on board. R: What conditions do you think will be required for it to be sustained? T: Well it's probably down to me, as the team leader, to make sure that we do it and to make sure that I encourage that, and I think we just need to make sure that we make the time to do it – it doesn't have to take as long and possibly with a smaller group it won't take as long. R: Did you notice any effects of having anticipated a range of student responses before you taught the lesson? T: I think I just made sure that I made it as open as possible when I would present it, like you can solve it in any way. What I did do, there are always those kids that can solve it quite quickly, is I made them come up with different solutions, and then I'd say, "maybe you could go back and do a skip-counting way" or something, so I might have made them come up with more of those solutions that we'd thought of. R: Do you think that there were barriers to coming up with a range of solution strategies? T: Possibly teacher knowledge, whereas we couldn't think of all those options, for example on one of those times you said do a double number line, none of us had done that before, which we all…it's in the book, we should be teaching it but we wouldn't have thought of using it, which I do now, but I wasn't before. And teaching arrays, which I never did a lot of, and then I was showing my children arrays, and they were like, they had never seen them before, so I went to everybody "can we make sure that we are teaching them arrays" I think perhaps some teachers don't see the value of drawing the pictures and making sure they can understand that.	problems/anticipating (one teacher). Most teachers happy to spend the time Barrier – process not stuck to in classes/inconsistent practices Benefit – teacher consistency, improved pedagogy Condition – leadership Anticipating – better launch, Anticipating – better responding, pedagogy not just a focus on getting the right answer, increased content knowledge (range of possible strategies) Barrier – teacher content knowledge (lack of) Anticipating – benefits, increased teacher content knowledge (range of strategies), pedagogy more use of tools and representations

APPENDIX H: TEACHER INFORMATION LETTER

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

Teacher Information Sheet

Research project: Impact of Teacher Collaborative Planning in Mathematics

(In partial fulfilment of the requirements for completion of Master in Education)

Researcher: Jenna Crowley, Massey University

I would like to invite you to take part in a qualitative case study that I am conducting as part of my Master in Education research for the thesis component.

What is the research about?

The research aims to investigate the impact of teacher collaborative planning in mathematics on their practice. Teacher collaborative planning involves the 'anticipating' practice described by Smith, Hughes, Engle and Stein (2009)*. The researcher is interested in teachers' experiences of collaborative planning for mathematics problem-solving lessons, using these suggested planning practices.

Why have I been chosen to take part?

You have been invited to take part because you are teaching in Year 5 or 6 at an accessible primary school for the researcher, and are part of a large enough team of teachers to allow you to participate in the collaborative planning practices as suggested. Also, your school has not been part of recent in-depth mathematics Professional Learning and Development (PLD), so this provides the researcher with the opportunity to compare your experiences prior to using these planning practices with your experiences of engaging in collaborative planning in this way in your team (pre- and post- intervention).

Do I have to take part?

It is entirely up to you whether you wish to participate. You may also withdraw your consent to participate at any time during the research, without any repercussions to you, by contacting the researcher on 021 155 3349 or jennalouisenz@gmail.com.

What will happen if I take part?

You will have an initial interview with the researcher to gather baseline information about your current planning processes for mathematics. The researcher will work with your team, providing PLD around collaborative planning practices for problem-solving. Your team will collaboratively plan for mathematics on a regular basis over the next eight to ten weeks, with support from the researcher if necessary. After this time there will be another interview with the researcher to gather information about your experience of collaborative planning for mathematics, and your perceptions about the impact that this has had on you and your practice, including any potential impact on your students' learning. There may be some follow up questions from the researcher to gain clarification.

What are the benefits and risks of taking part?

I anticipate that the findings of the study will be useful to teachers reflecting on their planning practices for mathematics. You will have the benefit of engaging in PLD with the researcher around collaborative planning for problem-solving. There are no known risks involved in participating in this research.

What will happen to the data?

Any data collected will be anonymised and no real names will be used in this study or in any subsequent publications. Research information will be stored securely at the researcher's address or on a password-protected computer. The findings will be submitted in the researcher's thesis, and subsequently may be published or presented. If you are interested in reading the publications, please contact the researcher on 021 155 3349 or jennalouisenz@gmail.com.

What happens if I change my mind?

You can change your mind at any time without any repercussions. During the research you can stop completing the activities at any time or ask for the recorder to be turned off at any time during an interview. If you change your mind after collection has been completed, your data will be discarded.

Where can I get more information?

You can get more information by contacting the researcher or supervisor(s).

Who has reviewed the study?

This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.
If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director (Research Ethics), email humanethics@massey.ac.nz.

This research is being supervised by:

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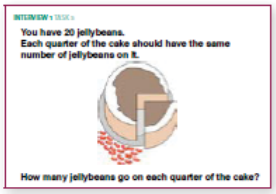
Thank you very much for your time.

Yours sincerely,

Jenna Crowley

APPENDIX I: EXAMPLE – TASK 5, GLoSS INTERVIEW 1

TASK 5



ACTION: *Provide 20 counters (jellybeans).*
Allow the student access to these counters if necessary.

SAY: You have 20 jellybeans.

Each quarter of the cake should have the same number of jellybeans on it.

How many jellybeans go on each quarter of the cake?

Note: Say "fourth" instead of "quarter" if this is more familiar to your student.

Stage	Strategy observed
2–4	**Cannot solve the problem** **Equally shares the beans, on materials or by imaging** (Stage 2–4)
Early 5 or higher	**Uses an additive or multiplicative strategy e.g.,** - Additive partitioning e.g., 10 + 10 = 20; (5 + 5) + (5 + 5) = 20 - Multiplication strategy e.g., 5 × 2 = 10; 10 × 2 = 20 - Multiplication or division fact e.g., 5 × 4 = 20 **or** 20 ÷ 4 = 5

DECISION: If **any** "E5" are circled in **Tasks 3**, **4** or **5**, **or** if the "4s" are circled in **both Task 3** and **Task 4**, CONTINUE the interview.

Otherwise STOP the interview. If in any doubt, CONTINUE the interview.