Professional Learning in Mathematics with Primary-Trained Teachers: A Flipped Approach

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Abstract

Teachers of mathematics in New Zealand are critical to the success of their students. In order for teachers to improve student outcomes, it is important for them to have the necessary skills and knowledge relating to mathematics and mathematics pedagogy, but also a positive disposition towards mathematics. Of concern are the many primary-trained teachers who enter their classrooms each day with negative dispositions towards mathematics, even fearing the subject area. This often dates back to their own schooling experiences. Changing these attitudes, along with levels of confidence and understanding, would appear to be crucial. Professional learning is one method for achieving this outcome.

Unfortunately, for teachers with low self-efficacy in mathematics, engaging in a professional learning experience relating to mathematics may be considered a threatening experience. Therefore, the aim of this study was to explore the ways in which a flipped professional learning programme might improve these dispositions of primary-trained teachers, along with their skills and understanding in mathematics, termed "teacher capacity" by Zhang and Stephens (2013).

This study adopted an action research approach, due to the alignment of this methodology with the desire to utilise volunteer participant teachers as co-researchers and for them to reflect on and change their practice. Qualitative data collection methods were used as the four participants engaged in a flipped professional learning experience. These qualitative data collection methods included semi-structured interviews with individual participants, blogs, and whole group participation in cluster meetings.

Following from this study it was found that the use of this flipped professional learning experience increased the self-efficacy ratings of participants in the focus

area of their intervention. It was also found that the flipped approach to professional learning had the potential to allow for and encourage teachers to take greater control of their learning journey in and for the teaching of mathematics, thus encouraging teacher agency. It also had the potential to allow for this learning to occur just-in-time, that is, as and when required by the teachers. Therefore, it is the contention of this thesis that a flipped professional learning programme in mathematics could be beneficial to improving the teacher capacity of primary-trained teachers in mathematics.

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Introduction

Preamble

> *… I wasn't good at school with algebra and I failed algebra… in Year 11, Level 1 NCEA... that brings in the negative talk with students… I'm totally guilty of saying to them, "Yeah I found algebra's always been really hard for me too. You don't use it a lot in real life contexts," and that type of thing … (Eva, Phase One, Chapter Four)*

Mathematics education in New Zealand has been a topic of concern for a range of stakeholders over the past few decades (Anthony & Walshaw, 2007; Patterson, 2015). In general, these concerns have linked to students' levels of achievement. Whilst various attempts have been made to address these concerns, students have continued to move through the education system, many of whom have emerged with less than desirable outcomes and attitudes towards mathematics. Some of these secondary school graduates have developed low self-efficacy and anxiety in relation to mathematics and have then gone on to become teachers themselves.

There are many primary school teachers who enter their classrooms each day fearing mathematics (Boaler, 2016). This can then lead to the well-meaning, but potentially, harmful comments made by teachers (and parents) to students, as they attempt to relate to their struggles: "I was bad at maths at school" (Boaler, 2016, p. 9). Comments such as these perpetuate the cycle of negative feelings towards mathematics, particularly for girls within the classrooms of female primary school teachers (Beilock, Gunderson, Ramirez, & Levine, 2009).

Perhaps another factor in the creation of maths-anxious students, who have low mathematics self-efficacy, is the way in which mathematics has been taught and the unconscious messages that have been conveyed about mathematics. One such message is a well-ingrained concept within our society that you are either a

maths person or not a maths person (Anderson, 2017). Streamed classes and groupings further contribute to this idea as students compare themselves to their peers in relation to the streamed group in which they have been placed. Fortunately, it has been found that there is no such thing as a "math brain" or a "math gift," but changing such ingrained societal ideas and discourses, as well as classroom grouping methods can be challenging (Boaler, 2016).

Professional learning is one way of addressing the low self-efficacy and maths anxiety that are experienced by many teachers, whilst also developing teacher capacity, which is made up of teacher knowledge and teacher skill, as well as teacher dispositions (Zhang & Stephens, 2013). However, those teachers who need it the most may consider volunteering to attend professional learning in mathematics is a daunting prospect due to deep seeded concerns about returning to a "mathematics classroom."

> *I'm always scared… the presenter is going to go, "Give me the answer," when I am not one of those people and I suppose that's my own personal experience from school and from other teachers that I've worked with. (Anna, Phase One, Chapter Four)*

One of New Zealand's more ambitious, large-scale, and well-known professional development programmes for mathematics in recent decades was The Numeracy Project. This was a Ministry of Education-funded, system-wide attempt to increase teacher capacity within the Number strand of the New Zealand Mathematics curriculum, with the aim of improving student outcomes (Ministry of Education, n.d.). This programme was implemented between 2000 and 2009 at a cost of $70 million (Patterson, 2015) with teachers receiving 12 to 13 hours of professional development in their first year within the project and 6 to 7 hours in the second year. This ambitious project yielded mixed results.

This project certainly contained many features identified as promoting professional learning (Timperley, Wilson, Barrar, & Fung, 2007). In particular, it

provided the ongoing, school-based support for teachers to translate new teaching approaches and the theory behind these to classroom practice. In addition, modelling and observations were readily available.

However, several concerns were also identified such as the over-emphasis on number, at the expense of the other strands of the mathematics curriculum: geometry, measurement, statistics and to some extent, algebra, as well as an argument that the focus on strategy-based methods resulted in a lack of balance with instrumental learning (Patterson, 2015).

In addition, whilst the aim of the project was to work with all teachers across New Zealand, this professional development project was linked to the school. Therefore, whilst the school may have participated in the project, it was not certain that all of the teachers within the school had received the full professional learning programme at the time of the school's contract completion, particularly if they had moved between schools or taken leave during the period of the project implementation. Catch-up opportunities were offered; however, these could not provide the extensive professional learning of the initial contract.

Questions have also been raised about whether instructional strategy changes that have been centrally devised are appropriate and effective (Patterson, 2015). A blanket approach to professional development has the potential to lose the flexibility required to meet the variety of learning needs of teachers (Patterson, 2015). However, in apparent contrast to these views, it has also been argued that, despite its centrally devised blanket approach, The Numeracy Project was implemented in diverse ways and well-intentioned messages were easily misinterpreted (Patterson, 2015).

The roll out of another similar professional learning programme to address further gaps in teacher capacity may be an unrealistic option due to the cost of such an endeavour. In addition, with the education system changing rapidly, it is

argued that professional learning programmes need to be far more dynamic to keep up with the latest research into effective mathematics pedagogy as well as being responsive to the needs of teachers.

Therefore, the challenge remains as to how to provide ongoing professional learning opportunities to teachers with a range of attitudes towards mathematics and knowledge in and for mathematics teaching in a way that is non-threatening, dynamic, "just-in time," and relevant. One possible solution is to employ a flipped classroom model.

My particular interest in this area of research stems from my involvement in mathematics leadership and coaching roles over the past 15 years. I have seen first-hand many teachers who suffer from maths anxiety and have low self-efficacy in mathematics. I have also participated in a range of professional learning experiences which have varied dramatically in their effectiveness. However, I have also experienced and observed the way in which professional learning can have a positive impact. Therefore, it has been my focus to find a more effective method of providing professional learning in mathematics to all teachers, particularly those primary-trained teachers who struggle with maths anxiety and low self-efficacy.

Five years ago, I travelled to the United States of America to explore the use of the flipped learning model that was being implemented in mathematics classes throughout a schooling district. Upon my return, I utilised this model within my classroom teaching programme. Following from this experience, I began to see the potential for flipped learning to also provide an effective method of providing professional learning.

Therefore, it is the contention of this study that a flipped professional learning model could increase teacher capacity in an effective, personalised and ongoing manner. It is also suggested that this method of professional learning may be particularly helpful for teachers with low self-efficacy in mathematics.

The research question for this study was:

> *In what ways might a flipped professional learning model provide a method of increasing teacher capacity in mathematics for Year Seven and Eight teachers in a provincial city school, particularly those with low self-efficacy in mathematics?*

The four teachers who volunteered to participate in this study were known to the researcher as colleagues within the same school. This raised complexities in power relationships, but also had the benefit of established working relationships of trust prior to the commencement of the study. It also allowed a shared understanding of many of the intricacies of the school environment. The approach taken to explore this question was action research, enlisting the four participants as co-researchers in the study. The design of the research was based on a critical research paradigm due to the desire for the study to challenge current realities in professional learning within mathematics education and to suggest new solutions, particularly for those with low self-efficacy.

Outline of Chapters

A review of relevant literature is the content of Chapter Two. The literature explored related to professional learning, including: a focus on the "Flipped" model; teacher knowledge in and for teaching mathematics; teacher attitudes to mathematics, specifically self-efficacy and maths anxiety; and teacher agency. This provided a useful background to relevant research that was considered in the implementation of the study and also highlighted any gaps in the research. Subsequently, it also assisted in determining explanations for some of the findings.

Chapter Three explains the methodology used for this study. It explores the theoretical background and research approach. It also provides background information about the participants in the study. Finally, it explores the data

collection methods used, the approach to data analysis, and the measures taken to help ensure that the research was valid and ethically sound.

The results and findings of the study are explored in Chapter Four which discusses these in the light of the literature explored in Chapter Two. This chapter is organised using the three phases of the action research model, thus demonstrating the way in which each phase informed the next. In addition, the discussion of each phase was organised around three themes which were found across the study. These themes were mathematics self-efficacy, teacher agency, and *just-in-time* professional learning.

Chapter Five provides a conclusion and suggests implications, limitations, and recommendations based on the findings of the study. The conclusions are again explored in light of the themes identified in Chapter Four. This provides considerations for future professional learning initiatives in mathematics education, along with suggestions for future research.

Chapter Two

Literature Review

Introduction

A range of literature was explored in preparation for this study. This was then synthesised in order to gain an understanding of the relevant research and to consider gaps within the research. The review of the literature within this chapter played a role in informing the present study.

Through this exploration of research, the concept of teacher capacity was determined to be pivotal in providing a structure for this literature review. Teacher capacity has been defined by Zhang and Stephens as "…professionally informed judgement and disposition to act" (2013, p. 482). They highlight the three key aspects that make up teacher capacity as teacher knowledge, teacher skill, and teacher dispositions. The first two aspects relate to knowledge and skill requirements and the third relates to the affective domain. It was also determined that professional learning is an important mechanism for increasing teacher capacity. The role of professional learning, along with an in-depth consideration of these three aspects of teacher capacity, is the content of this chapter.

The review begins with a discussion of the difference between professional learning and professional development and clarifies the use of the term "professional learning" within this study.

Teacher knowledge and skill are then explored, including highlighting the need for teachers to develop a knowledge of mathematics, as well as a knowledge of how to teach mathematics, with particular reference to the work of Shulman (1986) and Ball, Thames, and Phelps (2008). Gaining this required knowledge and skill *just-in-time* is also considered.

Teacher dispositions are then discussed, with particular focus on self-efficacy, maths anxiety, and teacher agency as the relevant affective aspects.

The chapter concludes with an unpacking of the flipped professional learning model as a possible means of improving all three aspects of teacher capacity.

Professional Learning

In education, as in most professions, it is accepted that ongoing learning and development are required throughout one's career, despite an initial university qualification (Webster-Wright, 2009). Indeed, highly effective teachers of mathematics are more likely to have engaged in mathematics-specific learning over a prolonged period and tend to credit this with their growth (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997). For the purposes of this study, a distinction should be made here between the two common methods of engaging in this ongoing journey - professional development and professional learning - due to the tendency for these two terms to be used interchangeably.

Professional development can be described as the delivery of episodes of a set of predetermined information, detached from the specific workplace in which implementation would occur (Webster-Wright, 2009). It tends to focus on the concept of training and often raises connotations of compliance. It is often seen as something that participants receive or something that is done to them (Calvert, 2016). At its worst, professional development can seem completely irrelevant to the real world of the participant. This may be attributed to a haphazard, infrequent, compartmentalised, and surface approach that focusses on updating rather than instigating a prolonged and in-depth study of students, teaching, and the curriculum (Ball, Lubienski, & Mewborn, 2001). Indeed, short programmes and non-specific mathematics courses have been shown to have little effect (Askew et al., 1997).

Professional learning, on the other hand, focusses on the ongoing nature of learning and the need to situate this learning within its authentic context

(Webster-Wright, 2009). It sees learning as an active and social process. It tends to allow for and encourage agency within a nurturing professional community (Calvert, 2016). This shift from compliance to agency more actively advocates for life-long learning and is more likely to encourage a change in practice. As the name suggests, in professional learning situations there is a shift from a focus on teaching to a focus on learning (Webster-Wright, 2009).

These views regarding professional learning are supported by Timperley et al. (2007) in their Best Evidence Synthesis in which they explored the factors that have been found to create a successful mathematics professional learning environment. They too highlight the social nature of professional learning and the need for teachers to have collegial support within a professional learning community, with opportunities for observation and feedback. They discuss the importance of teacher engagement. However, in contrast to the literature above, their findings appear to place less emphasis on whether this teacher engagement is intrinsically or extrinsically motivated, as long as it occurs.

Their synthesis also emphasises the need for clear goals to be established for the professional learning programme and stresses that these should link to student achievement (Timperley et al., 2007). Importantly, "…the success of professional learning should be measured not just in the benefit to the teachers, but in the improved outcomes for the students" (The Australian Senate Standing Committee of Education and Workplace Relations, 2013, as cited in Beswick, Anderson, & Hurst, 2016, p. 92). To achieve this, Timperley et al. (2007) argue the need for a professional learning programme to have policy, theory, and practice balance, and also argue that it be expertly delivered in order to challenge prevailing discourses. Timperley et al. (2007) also point out the need to consider the effective use of additional funding and time. Indeed, as professional learning can be extremely expensive, it would seem vital to ensure that professional learning opportunities are capable of achieving results (Schwartz, 2017).

A professional learning programme then is far from a simple linear one-off event. Instead, the following diagram depicts the complex and dynamic nature of professional learning (Timperley et al., 2007).

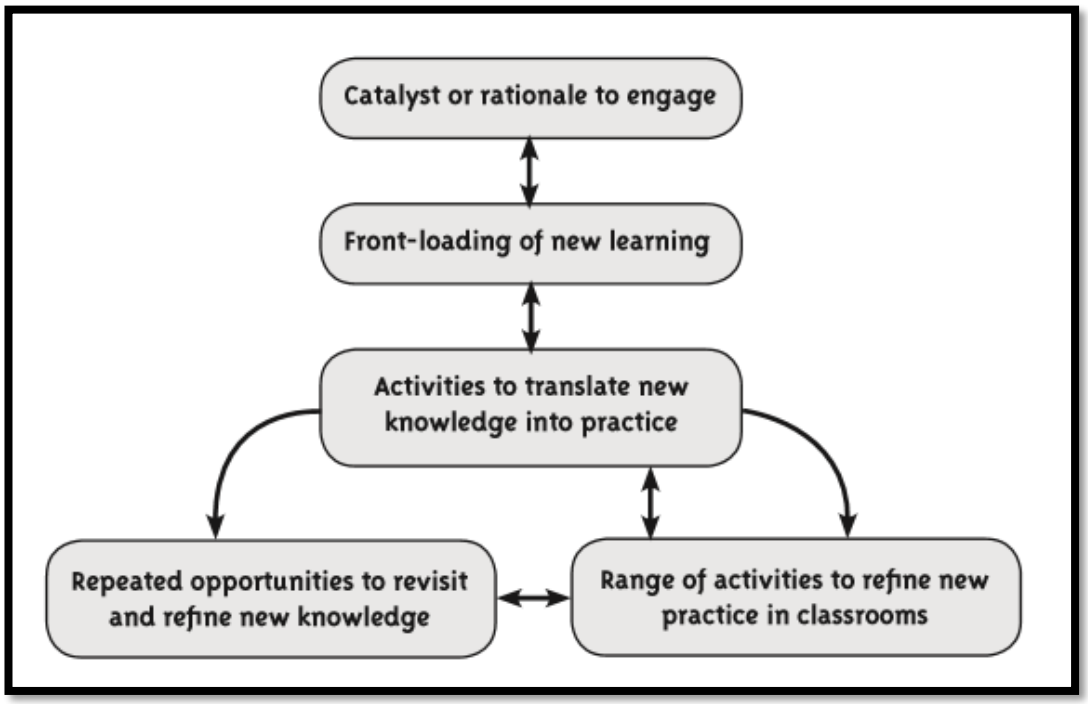

Figure 1: Timperley et al.'s (2007) Professional Learning Sequence (p. 85)

This diagram appears to suggest two additional considerations for effective professional learning. Firstly, it suggests the possibility of accessing new knowledge and skills mentioned by Zhang and Stephens (2013) *just-in-time,* and secondly, it brings into question the importance of teacher agency in the engagement phase, which relates to the more affective aspect of teacher dispositions, also espoused by Zhang and Stephens (2013).

Professional learning then has the capacity to help teachers to develop knowledge and skills on a *just-in-time* basis. However, it is argued that it also has the potential to address the affective domain, particularly related to self-efficacy and maths anxiety, by promoting teacher agency. This will be explored in greater depth in the following sections.

Teacher Knowledge and Skills

The development of teacher knowledge and skill is important due to the concern raised over many school mathematics programmes. This concern particularly relates to the difference between the mathematics of school and the mathematics of mathematicians (Boaler, 2016; Stager, 2015). Stager (2015) goes so far as to suggest that there is no other discipline in which the school version and the real-world version are so unrelated, commenting that school mathematics should only be called "ma" due to its lack of correlation to real world mathematics. He comments on the need for students to engage in mathematics rather than just being taught mathematics to encourage them to discover its beauty, power, wonder and utility.

Due to confusion in pedagogy, the most logical human discipline is often converted to memorisation of rules and procedures and students fail to be introduced to the beauty, power, and rich traditions of mathematics (Ball et al., 2001). Indeed, Ball et al. (2001) argue that the mathematical experience of many students can range anywhere from uninspiring to intellectually and emotionally crushing.

Boaler (2016) agrees that students need time to generate their own questions in mathematics, rather than seeing mathematics as a performance subject where they apply procedures to answer questions that they have never asked, often under time pressure and in complete silence. Instead she argues that students need to be curious, see connections between concepts, embrace challenge, think creatively, collaborate with others, justify their thinking, and develop an understanding that deep and slow thinking is allowed. It is hoped that through this approach students would see mathematics more as mathematicians see mathematics - as the study of patterns, an aesthetic, creative, and beautiful subject.

This approach is echoed by Anthony and Walshaw (2009). They too argue the importance of teachers building the skills required to create a safe, caring

environment where students can work independently and with others on worthwhile, real-world tasks using a variety of tools and communicating their learning using the language of mathematics. Indeed, the use of problems that encourage students to make connections, rather than simply following a procedure, is a common feature of mathematics programmes in countries with high levels of achievement in mathematics (Stigler & Hiebert, 2004).

In order for school mathematics programmes to change, building teacher capacity is critical. Indeed, effective mathematics teaching includes not only the development of mathematical knowledge and strategies in authentic contexts, but also the development of positive dispositions and mathematical identities (Anthony & Walshaw, 2007).

Teachers are the most important resource in any classroom (Anthony & Walshaw, 2007; Boaler, 2016). The ability of teachers to access and adapt resources, provide appropriate tasks for students, and make the most of teachable moments is dependent on teacher knowledge (Anthony & Walshaw, 2007). Hattie (2002) agrees that expert teachers are able to identify essential representations of their subject, guide learning through classroom interactions, influence student outcomes, monitor learning, and provide feedback. However, he also argues that they attend to affective attributes (Hattie, 2002). They have the power to make decisions and create a positive classroom environment that promotes curiosity and interest in mathematics (Boaler, 2016). Indeed, teachers account for 30 percent of the variance in student achievement (Hattie, 2002). Perhaps surprisingly then is the point raised by Patterson (2015) that there has been little research conducted into the mathematics proficiency of primary school teachers apart from that of Young-Loveridge (2010) and Young-Loveridge, Bicknell and Mills (2012).

Many primary mathematics teachers tend to have a more general teaching qualification, with no specific qualification in mathematics. In addition, there are minimal expectations placed on mathematical achievement requirements for

entry into primary teaching qualifications (Beilock et al., 2009; Patterson, 2015; Young-Loveridge et al., 2012). To compound matters further, those completing an elementary school major have been found to have the highest level of maths anxiety compared to all other majors (Beilock et al., 2009).

Beswick et al. (2016) discuss the need for practising teachers to have ongoing professional learning within the context of their mathematics teaching, suggesting that it is, in fact, a form of applied mathematics. Recent discussion has emerged in New Zealand as to whether teachers should be encouraged to gain an optional certification of their mathematics understanding and mathematics teaching proficiency (Patterson, 2015). This centres particularly around the argument that teachers in the middle years of school require deep mathematical content knowledge beyond that provided within primary university preparation programmes (Bishop, 2008; Ministry of Education, 2010).

However, some have argued that the understanding of mathematical concepts and how to represent these is far more important for student achievement than the need for a teacher to have a degree in mathematics (Patterson, 2015).

Indeed, in his seminal work, Shulman (1986) identified the need for teachers to develop all aspects of content knowledge, which he broke down into subject-matter content knowledge, pedagogical content knowledge, and knowledge of curriculum. In other words, for Shulman, simply knowing mathematics content would not be sufficient. Instead, he argued that it must be accompanied by the specialised knowledge of how to effectively teach this content to others. In this sense, holding a degree in mathematics is not important if it occurs in isolation from a knowledge of pedagogy. Therefore, professional learning in mathematics should take into account the need to focus on in-depth exploration of a knowledge of mathematics in tandem with an in-depth exploration of pedagogical knowledge (Ball et al., 2001; Ball, Hill, & Bass, 2005; Bobis, Higgins, Cavanagh, & Roche, 2012).

Ball et al. (2008) further developed Shulman's model to consider the components that make up subject-matter knowledge and pedagogical content knowledge.

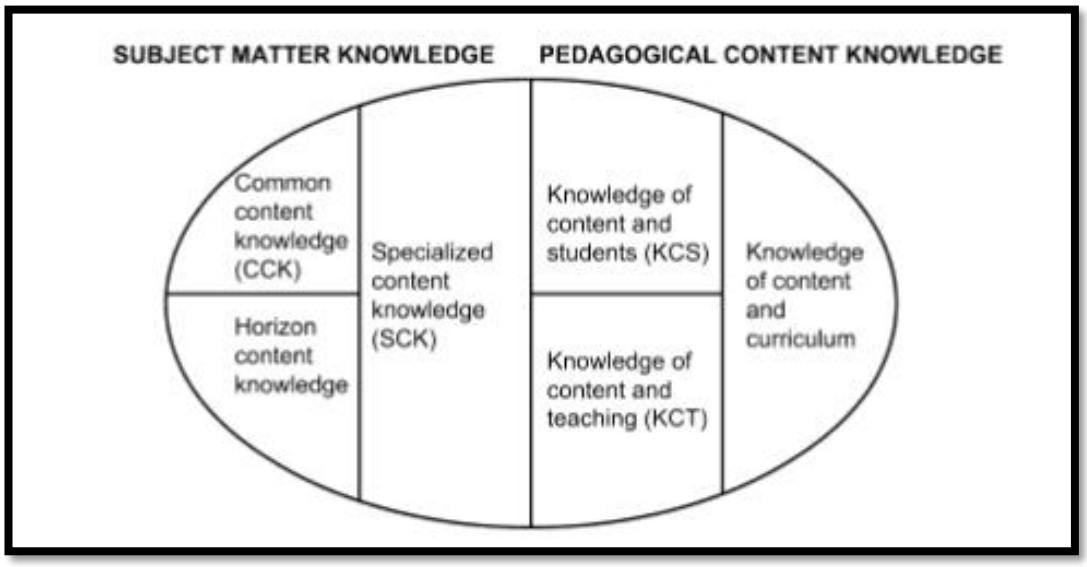

Figure 2: Ball et al.'s (2008) Framework of Mathematical Knowledge (p. 403).

According to this framework, it is important for a teacher to have a knowledge of the subject which includes common knowledge and specialised knowledge, as well as knowledge of what comes next (Ball et al., 2008). This may be an important consideration for teachers who become familiar with the knowledge required for the level of students they are currently teaching but fail to make sense of how this fits with the ongoing learning journey of their students in mathematics. Ball et al. (2008) also break down pedagogical content knowledge into the three aspects of students, teaching and, curriculum

This framework has strong links to the aspects of teacher knowledge proposed by Zhang and Stephens (2013). They too highlight the need for teachers to develop both math-specific knowledge and general pedagogical knowledge. The similarities continue, as they further break teacher knowledge down into a knowledge of mathematics, interpretation of the curriculum, understanding of students' mathematical thinking, and the design of teaching and learning experiences.

In further alignment, within their ten components of effective mathematics pedagogy, Anthony and Walshaw (2009) also espouse the importance of the development of teacher knowledge, along with their ability to build on student thinking and use assessment to promote learning.

Alongside this development of these components of teacher knowledge, Zhang and Stephens (2013) argue that without the development of teacher skill, a gap develops between what a teacher knows they should do and what they are actually capable of doing.

As indicated within this literature, teacher knowledge and skill comprise many components which require a significant amount of time on an ongoing basis to develop and refine. Addressing all of these aspects at once at occasional mandated professional development days may assist to a certain degree. However, it is argued that ongoing professional learning occurring on a *just-in-time* basis may be more effective.

Just-in-Time

Just-in-time is a term which has its origins in the manufacturing industry (Aradhye & Kallurkar, 2014; Iannarelli, 2009). Within the manufacturing industry's *just-in-time* approach there is a focus on process, not product, in order to decrease cost and waste in relation to inventory. *Just-in-time* learning then may be considered as an approach to learning which is more efficient and avoids wasted knowledge delivery.

Just-in-time is certainly a term that has become popular within the field of education following on from a change in the way in which knowledge is viewed (Bolstad & Gilbert, 2012). Whereas, traditionally, knowledge was seen as a set of critical information or skills to be attained and then saved to be reproduced at some point in life, knowledge is now seen as only useful when it is being used to create new knowledge or find solutions to new problems. This means that,

although a strong base of knowledge may still be desirable, the true power of knowledge may lie in learning *just-in-time* to solve relevant problems.

Professional learning can more readily provide for this *just-in-time* learning than the professional development model. The professional development model sees knowledge as a predetermined set of content to be given to participants in a linear structure (Webster-Wright, 2009). On the other hand, a professional learning model is more dynamic, allowing participants to access the front-loading of new learning *just-in-time* and on a continuous basis, either before or after implementation in the classroom, as shown in the professional learning sequence diagram (Figure 1, p. 10).

Therefore, the provision of continuous *just-in-time* opportunities for the development of a teacher's ability to respond to a range of learning needs and situations is perhaps more important than the provision of a prescribed programme to implement (Timperley et al., 2007).

In this model professional learning does not fit neatly into a set timeframe or structure, but rather requires easy access to robust, wide-ranging, useful material in order to develop crucial teacher knowledge as and when it is needed. This may indeed pose a challenge to this method of professional learning. However, if achieved, it is argued that this method has the potential to more adequately improve teacher dispositions by more readily allowing for teacher agency, which may in turn lead to a growth in self-efficacy and a lowering of maths anxiety. These teacher dispositions are discussed in the next section of this chapter.

Teacher Dispositions - The Affective Domain

Self-Efficacy

Self-efficacy is one component of social-cognitive theory first introduced by Bandura in the 1970's (Siegle & McCoach, 2007). It is the most consistently

defined motivational construct and has been further explored and developed by Bandura over the past four decades.

Self-efficacy is the confidence with which a person believes that they will be able to successfully plan and carry out a task (Isikal & Askar, 2005; Schunk, 1982; Siegle & McCoach, 2007; Zimmerman, 2000). Self-efficacy is developed based on mastery experience, vicarious experience, verbal persuasion, and physiological states (Bandura, 1994). The most influential factor in the development of self-efficacy is mastery experience, which is based on the individual's past performance (Siegle & McCoach, 2007). This is followed by the less stable vicarious experience, which involves observing the success or otherwise of peers. The third factor is verbal persuasion, which is based on the verbal feedback or feedforward received by others, with its level of influence being dependent on the credibility and trustworthiness of the persuader. Verbal persuasion must also be accompanied by some actual success for it to have impact. Finally, physiological states can influence the development of self-efficacy as the individual receives feedback from bodily reactions to situations.

This judgement, in turn, affects choice, effort, persistence, and anxiety or other emotional reactions when difficulty is experienced or anticipated (Isikal & Askar, 2005; Schunk, 1982; Zimmerman, 2000). Those with high self-efficacy more readily choose difficult or challenging tasks, set more challenging goals, and demonstrate greater persistence when experiencing difficulty (Schunk, 1982; Siegle & McCoach, 2007; Zimmerman, 2000).

Conversely, low self-efficacy can lead to a range of negative outcomes. Those with low self-efficacy tend to avoid difficult tasks which they perceive to be personal threats (Bandura, 1993). In addition, they tend to visualise failure, have low aspirations and weak commitment to goals, maintain a self-diagnostic focus, dwell on personal deficiencies and obstacles, lack perseverance, can be slow to recover from setbacks and are prone to stress and depression. Those with low self-efficacy may have the skills or capabilities needed to be successful but they

may fail to use these under the taxing conditions. This becomes a vicious cycle as this low level of performance is incorrectly interpreted as a low level of ability, which further entrenches low self-efficacy.

Self-efficacy is domain-specific rather than a global trait (Bandura, 2006). Hence, for the purpose of this study, the focus is on self-efficacy in relation to mathematics. Mathematics self-efficacy can be defined as the beliefs people hold in relation to their mathematical capabilities and their confidence in their ability to successfully plan and accurately solve mathematical problems and it can determine feelings, thoughts, motivations and behaviours (Bandura, 1994; Isikal & Askar, 2005; Schulz, 2005). Finney & Schraw (2003) then go further to argue that self-efficacy is more precisely, task-specific. This highlights the fact that a teacher may feel confident in certain areas of mathematics, but lack confidence in others.

Mathematics self-efficacy has a positive correlation with self-concept and a negative correlation with maths anxiety (Schulz, 2005). In addition, self-efficacy has been found to be the most reliable predictor of mathematical achievement (Attard, Ingram, Forgasz, Leger, & Grootenboer, 2016; Bandura, 1993; Beilock et al., 2009; Isikal & Askar, 2005; Siriparp, 2015; Thomson, 2014; Zimmerman, 2000). It is a more useful predictor of problem solving success than self-concept, perceived usefulness of mathematics, prior experience, or gender (Zimmerman, 2000). Therefore, it would seem crucial that any attempt to raise mathematical achievement should also work to improve self-efficacy in mathematics.

Unfortunately, low self-efficacy in mathematics is not a condition limited to a small section of the community. Teachers are certainly prone to this condition. Many primary school teachers have been told at some point in their life that they were unable to do mathematics or that mathematics was just not for them (Boaler, 2016). Indeed, Biddulph (1999) found that over half of the students in Primary Education programmes had negative feelings towards mathematics. These negative feelings are known to manifest themselves in low self-efficacy in

mathematics and maths anxiety amongst many primary school teachers (Boaler, 2016; Vale, Atweh, Averill, & Skourdoumbis, 2016). Even more concerning is the reality that these feelings are often passed on to the students being taught, thus continuing the cycle (Boaler, 2016).

To add to the complexity is the consideration that a teacher may possess a mathematics self-efficacy, as well as a mathematics teaching self-efficacy (Briley, 2012). This is an important consideration as a teacher's beliefs about mathematics are not always the same as their beliefs about mathematics teaching (Attard et. al., 2016). Whilst mathematics self-efficacy relates to the confidence a person has in relation to their own ability to successfully engage in mathematical pursuits, a mathematics teaching self-efficacy relates to the teacher's confidence about their ability to teach mathematics effectively. This involves the creation of conditions for the improvement of student learning and engagement outcomes.

Mathematics teaching self-efficacy affects choices about environments and activities (Bandura, 1993). Teachers with low mathematical teaching self-efficacy tend to spend more time on non-academic pursuits, they tend to give up on students more quickly when results are not apparent, and they criticise students for their failures (Bandura, 1993). This has a negative impact on the classroom environment.

A final consideration relates to the way in which modern learning environments have increased the possibility of social comparison for teachers due to their ability to constantly observe peers. Bandura (1993) identifies social comparison as an additional factor in the development of the self-efficacy of teachers. To guard against this constant availability of social comparison, Bandura (1993) highlights the need to ensure that feedback is given to teachers based on self-comparison of progress and personal accomplishments, rather than peer comparison. He also recommends promoting amongst teachers the understanding that, as in many other pursuits, teaching ability is something that

is acquired and that any attempts to change the current situation are worthy of time and effort.

The next section of this chapter will focus on maths anxiety due to the link that has been found between self-efficacy and anxiety (Attard et al., 2016; Schulz, 2005). Indeed, those with strong self-efficacy tend to be less anxious and more confident when approaching challenging situations (Siriparp, 2015). Hence, it would appear that improving mathematics self-efficacy is worthwhile due to its potential to decrease maths anxiety.

Maths Anxiety

Anxiety can be described as an unpleasant, future-oriented, emotional response that is disproportionate to the actual level of threat and brings about feelings of fear, dread, uncertainty, and helplessness (Hembree, 1990). It often emerges when a person feels that they are unable to control these perceived threats, which can lead to a magnification of the situation and impairment in functioning (Bandura, 1993). People tend to avoid situations that they perceive are beyond their coping capability.

Following on from this definition, maths anxiety is an unpleasant emotional response which arises from engaging with, or from the possibility of engaging with, mathematics (Beilock et al., 2009), thus threatening participation and achievement in mathematics (Hembree, 1990). As a result, those who suffer from this condition often avoid mathematics courses or mathematics-related career pathways (Beilock et al., 2009). When forced to engage in mathematical pursuits, those who suffer from maths anxiety often fail to perform to their ability due to the self-doubt and worry they experience (Beilock et al., 2009).

Maths anxiety is a learned condition that is not necessarily related to past performance in mathematics (Beswick, 2008; Hembree, 1990). It can originate from home, school, or society (Boaler, 2016; Whyte & Anthony, 2012).

Many teachers within primary school settings report low self-efficacy and high anxiety in relation to mathematics, often dating back to their own schooling experiences (Anderson, 2017; Attard et al., 2016; Flanagan, 2017; Young-Loveridge et al., 2012). These beliefs can have an impact on teaching practice as beliefs inform what is done within the classroom situation (Beswick, 2008). It has also been found that student achievement in mathematics is lower when taught by a teacher with low confidence and qualifications in mathematics (Vale et al., 2016).

In addition, teachers who are maths anxious often pass these feelings on to the students whom they teach (Anderson, 2017; Flanagan, 2017). Through their interactions, teachers are creating and moulding a student's mathematics identity (Grootenboer, 2013). Once negative attitudes have been established, although fluctuations are still possible, they can be very difficult to change and persist beyond school, often resulting in an avoidance of mathematics when it becomes voluntary (Attard, 2011). Leaving school with a negative mathematics identity can affect the options available to students and, as a result, Grootenboer (2013) argues that teachers must see their involvement in the teaching of mathematics as a highly ethical undertaking.

Female teachers have a particularly strong influence on the girls within their class (Beilock et al., 2009). Any maths anxiety of the female teacher can result in negative attitudes towards mathematics within the girls in the class, as well as reinforcing stereotypes that boys are better at mathematics and girls are better at reading. This is important due to the disproportionate numbers of female primary school teachers.

A teacher has a substantial influence on the development of positive engagement with mathematics, so it is crucial to develop a positive disposition within teachers themselves (Attard et al., 2016). For teachers who experience maths anxiety this means changing emotions, alongside knowledge and skill development (Flanagan, 2017). Some teachers may need to create completely

new mathematics identities, which can be an ongoing, challenging, and complex struggle due to the historic development of these identities inside and outside the classroom over a long period of time (Walshaw, 2013).

Perhaps one of the greatest challenges for professional learning is to transform maths anxious teachers with low self-efficacy in mathematics, as well as in mathematics teaching, and instil in them a sense of teacher agency.

Teacher Agency

Teacher agency in a professional learning context "…is the capacity of teachers to act purposefully and constructively to direct their professional growth and contribute to the growth of their colleagues" (Calvert, 2016, p. 52). It has the potential to shift a teacher from taking a passive role in their professional growth to a far more active one, leading to a higher degree of satisfaction. Professional learning then promotes teacher agency in a way that was not possible in the professional development model.

Traditionally, professional development placed requirements on teachers to engage in courses that were created based on assumptions about current teacher capabilities and necessary or desired capabilities (Beswick, 2016). The catalyst or rationale to engage, as per Figure 1 (p. 10), was created by schools, districts, or Ministry of Education requirements.

In professional learning the focus changes to the assumption that participants are capable of self-directing their learning journey (Webster-Wright, 2009). In other words, it assumes that teachers are capable and, in fact, encouraged to have agency over their learning needs. In this case Timperley et al.'s (2007) catalyst or rationale for engagement comes from the teachers themselves. Therefore, it would appear important for professional learning to be differentiated to meet these self-determined needs (Paterson, 2009; Schwartz, 2017).

The degree of teacher agency relies on both internal and external factors (Calvert, 2016). Internally, a teacher must be intrinsically motivated to engage in the professional learning and, externally, the school environment in which the teacher exists must promote the agency of the teachers through shared decision-making, time, and enabling structures. Simply providing choice to teachers does not directly lead to agency. Rather this choice needs to be supported and teachers need to be shown that this is a genuine opportunity to regain control of their learning journey within the profession.

Professional learning provides opportunities for teachers to receive new information that creates dissonance with their current beliefs and understandings about mathematics (Timperley et al., 2007). Indeed, changing beliefs and practices is the point of professional learning (Beswick, 2008). Therefore, for professional learning to be effective a teacher must feel comfortable about engaging in a process of re-establishing beliefs regarding the teaching and learning of mathematics, the effective conditions for teaching and learning mathematics, the role of the teacher, and the capacity for all students to learn mathematics (Beswick, 2014). This can be a challenging process and therefore significant support may be required in order to achieve long-term change (Timperley et al., 2007). For this to occur, a relationship of trust needs to be established, because changes to deeply-held beliefs can be emotional, challenging, and confronting (Beswick, 2014). If this relationship is not developed, resistance can occur.

In order to achieve improvement in teacher capacity through professional learning, teachers must be encouraged to step outside their comfort zones and be empowered to identify gaps in their current knowledge, skills, and dispositions (Paterson, 2009). Indeed, it has been found that when teachers recognise their gaps, they are more willing to engage in learning (Bobis et al., 2012).

However, teachers want to be seen as competent and therefore identifying learning needs can lead to feelings of vulnerability (Beswick, 2014). An ongoing relationship of trust has the potential to encourage teachers to identify and share all three categories of professional learning needs: those that they are aware of and are happy to share; those that they are aware of and are reluctant to share; and those that are initially unknown. This open communication, that can result when positive relationships have been formed, has the potential to result in increased learning for the teachers involved (Beswick & Jones, 2011).

It is proposed that one less-threatening method of allowing for teachers to have agency and to engage in *just-in-time* learning is through the use of a flipped professional learning model. This will be explored in greater depth in the following section.

Flipped Professional Learning

Flipped learning is a teaching and learning model that has gained popularity in recent years (Zainuddin & Halili, 2016). This may be due to the advances in technology that make the implementation of this model increasingly possible. Colorado teachers, Jonathan Bergmann and Aaron Sams, are often credited with beginning the flipped learning model following on from their creation of screencasts for their students in 2006 (Milman, 2012). However, others argue that the model dates back to the 1990's (Bailey, 2015).

What is undisputed is the premise of the model - that students watch instructional videos in their own time, outside of class, and then come ready to apply the learning within class time. This allows students to access teachers when they experience challenge during the application of the content (Bailey, 2015). It is a student-centred approach (Zainuddin & Halili, 2016) and allows for a far more personalised approach to learning that focusses on individual student learning needs (Bailey, 2015). The role of the teacher then shifts from knowledge imparter to that of coach (Goodwin & Miller, 2013).

Anecdotal results have indicated that this flipped learning model leads to improved student outcomes (Bishop & Verleger, 2013; Milman, 2012). In addition, Goodwin and Miller (2013) report improved teacher and student interactions, increased opportunities for real-time feedback, increased student engagement, improved opportunities for self-paced learning, and more meaningful use of homework time.

However, challenges have also been identified with the flipped learning model. At the core, these challenges may stem from a lack of understanding of the flipped learning process (Lo & Hew, 2017). A lack of technological equipment and knowledge by teachers and students could also prove problematic (Lo & Hew, 2017; Zainuddin & Halili, 2016). In addition, whilst the flipped model may mean more meaningful homework time, caution has been suggested in relation to increased workload of students due to the length of videos and the time required for viewing (Lo & Hew, 2017). Increased workload for teachers in creating the videos has also been identified as a concern. These challenges are worthy of consideration prior to making use of this teaching and learning model.

A flipped learning model acknowledges that lectures are not inherently evil; in fact, they are often an extremely effective way of teaching new knowledge (Goodwin & Miller, 2013). The issue is more to do with the relevance and pacing of the lectures. Flipped lectures allow students to have control over the pacing of the lectures, rewinding and re-watching if necessary. Many universities have begun creating videos of their course lectures and Khan Academy has an ever-expanding library of video tutorials for a range of subject areas (Bishop & Verleger, 2013). These could be useful for a flipped learning model, but the video itself does not make up the model. A flipped learning model also requires the supported application of the content alongside the video lectures, thus ensuring that each component complements (rather than supplements) the other (Lee, Lim, & Kim, 2017). The video content should be minimised, and the in-person application time should be maximised (Lee et al., 2017).

In addition, it has been suggested that teacher self-created videos can be more engaging and meaningful to students than those produced by others (Bergmann & Sams, 2015). It is recommended that these videos have good audio quality and that the length of the video be kept to ten minutes in duration if possible, but certainly no longer than 20 minutes, particularly when the face of the lecturer is not seen (Lee et al., 2017). Therefore, chunking the learning into shorter videos may be more effective than recording long videos that include multiple topics (Bishop & Verleger, 2013; Burns, 2016; Lee et al., 2017; Milman, 2012). It is advised that the videos begin with a basic overview to introduce the topic, highlight prerequisite knowledge requirements, and list the main points to be covered in the video (Lee et al., 2017). The videos should also include interactive elements where the viewer is required to pause the video, think, and answer some questions to check understanding (Lee et al., 2017).

It is interesting to consider the application of this flipped model within a professional learning programme. 91% of professional development in the United States of America is conducted using a workshop model (Burns, 2016). This may well be the case in New Zealand also. Many of these workshops are quite traditional in their approach, often theory-based with a focus on the acquisition of knowledge. Teachers who attend these sessions are left to puzzle over the application of the theory to their own practice outside of the professional development session. Even workshops that attempt to be more "hands-on," providing practical activities may become one-off sessions back in the classroom as the teacher is again left to their own devices to design further suitable activities. In addition, the enthusiasm experienced at the workshop can be quickly lost amongst competing demands experienced upon the return to the classroom (Shaffer, 2017). Indeed, many teachers feel that professional development is a waste of time and question whether it models effective teaching practice (Burns, 2016).

An alternative to this approach is the use of the flipped model of professional learning. In this approach, theory and knowledge are conveyed to teachers using

a video prior to a meeting to focus on the application of this theory and knowledge in the teacher's own classroom situation (Burns, 2016). This allows for individual scaffolding, assistance, inspiration, and coaching (Lee et al., 2017). It is a three-phase process as shown in Figure 3.

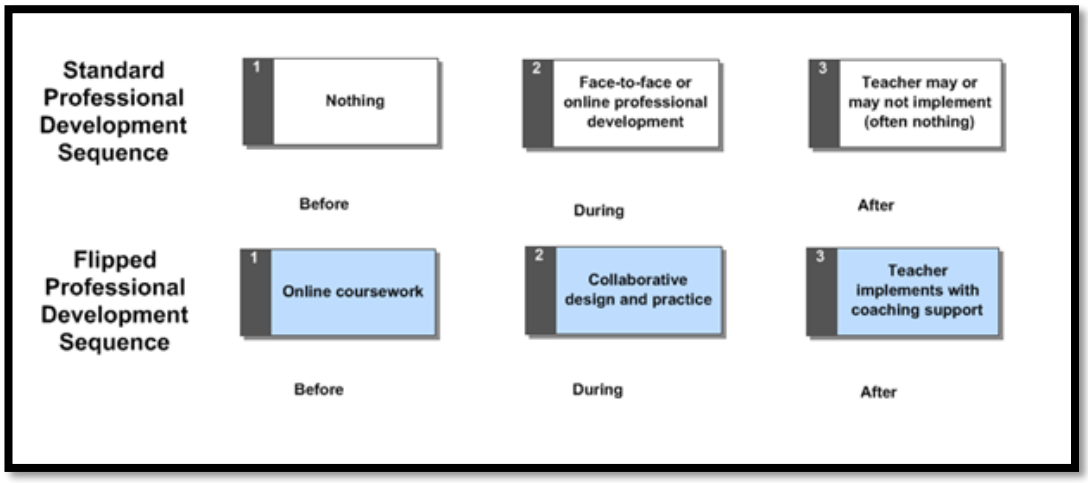

Figure 3: Burns' (2016) A Standard Versus Flipped Professional Development Sequence

The benefits that have been found with a flipped professional learning model are in its ability to provide cost efficient, *just-in-time*, in-school, professional learning support to teachers (Burns, 2016). Within this model facilitators of the professional learning are freed up to support teachers with the challenging task of applying the new knowledge and theory to their individual classroom situation. In addition, the video delivery method is perhaps more flexible to fit within the many competing demands on time that are experienced by teachers (Bailey, 2015).

Additional benefits that have been found with video-based professional learning are the potential to reduce anxiety, improve mathematical content knowledge and mathematics pedagogical content knowledge (Larkin & Jamieson-Proctor, 2013), address deep-seated math-phobia (Biddulph, 1999), promote open-ended investigations (Bailey, 2015), and provide an effective way of reaching remote and rural communities (Vale et al., 2016). Most of these benefits have been

highlighted throughout this chapter as crucial to the development of effective school mathematics programmes.

The challenges for this approach to professional learning relate to the time needed to create high quality and motivating videos and in ensuring that these videos are viewed prior to the crucial face-to-face meeting phase (Burns, 2016). The availability of the appropriate level of support following the viewing of the flipped video is potentially another barrier to the method.

A consideration of the literature regarding professional learning, regarding the development of teacher knowledge and skill, regarding the development of helpful teacher dispositions, and regarding the use of a flipped professional learning model has provided a useful basis for this study. The methodology used for this study will be explored in the next chapter.

Chapter Three

Methodology

Introduction

In order to do justice to this study and best examine the research question, it was important to consider the most appropriate research approach and resulting methodology. The research question indicated the intent to challenge the status quo of professional learning in mathematics, particularly for teachers who may be less likely to engage due to their low self-efficacy. As a result, a critical research paradigm was adopted. Flowing from this, an action research methodology was deemed to be the most suitable and qualitative data was collected and analysed in order to answer the research question:

> *In what ways might a flipped professional learning model provide a method of increasing teacher capacity in mathematics for Year Seven and Eight teachers in a provincial city school, particularly those with low self-efficacy in mathematics?*

The choice of methodology, research design, and rationale for decisions made, will be the content of this chapter.

Theoretical Rationale

The research paradigm is an important consideration for the study as it highlights the stance from which the research will be explored (Asghar, 2013). It is informed by ontological, epistemological, and methodological beliefs of the researcher. Ontological beliefs are based on the interpretation of the nature of reality (Guba, 1990). Epistemological beliefs relate to the way in which the knower and knowable interact. And finally, the ways in which the inquiry are conducted are determined by the methodological beliefs.

The critical research paradigm informed the approach taken to answer the research question in this study. This was due to the desire for the research to challenge the current reality of professional learning in the area of mathematics

education and to suggest new solutions, particularly for those with low self-efficacy who may feel powerless to make the change themselves (Asghar, 2013). This was done through enlisting and empowering participants to assist with the transformation (Guba, 1990). Therefore, ontologically, the reality of the situation was viewed to be socially constructed as it was influenced by the lens of the researcher (Asghar, 2013). This was important to acknowledge at the commencement of this study. From this socio-constructivist approach flowed an epistemological view that the knowledge gained from the study would be interpreted in order to attempt to understand the reality of the participants from their own point of view. This research approach allowed the researcher to acknowledge a lens through which the reality would be viewed and interpreted.

The methodological approach taken to attempt emancipation for participants was action research. The next section explores the action research model in greater depth.

Action Based Research

The action research model was the approach chosen to investigate the research question.

The action research approach is appropriately named, as it involves a combination of both action and research (Dick, 2000; McAteer, 2013). It encourages the researcher to engage in learning by doing due to its simultaneous focus on theory and practice (Kemmis & Wilkinson, 1998). Furthermore, it could be argued that the primary aim of action research is to change practices (Kemmis & Wilkinson, 1998). These practices could include actions, interactions with others and the world, meanings and values, and the discourses utilised to interpret and understand the world. Therefore, whilst action research may build a knowledge base and help develop theory, it is argued that the focus for action research should be on what is changed as a result of the research (Kemmis, 2010). Kemmis (2010) goes so far as to say that action research should be conducted "…for the sake of history" (p. 423). This challenges the researcher to

consider the relevance, the potential for social change, and the validity of the research they undertake (Brydon-Miler, Greenwood, & Maguire, 2003). In this way this research method aligns with the critical research paradigm adopted for this study.

These characteristics of action research may indeed result from the historic beginnings of the action research model. The creation of the action research model is often attributed to Kurt Lewin in the 1940's (Adelman, 1993; McAteer, 2013). The model emerged from Lewin's concern with the need to raise the esteem of those in minority groups. Lewin believed that this could be achieved through the active participation of these people at all stages of the research by including them in the discussion of problems, in the decisions about next steps, and in the monitoring of the consequences of these decisions.

Reason and Bradbury (2001) define action research as:

> *"…a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities." (p. 1)*

Aligning with this definition, Kemmis and Wilkinson (1998) suggest that there are six key features of the action research model.

The first three features relate to the social, participatory, practical, and collaborative nature of the action research model. Action research is a collaborative model based on the view that, since practice exists within social situations and changing practice is a social undertaking, research should also be a social pursuit (Kemmis & Wilkinson, 1998). Therefore, action research can be seen as the social construction of knowledge within a particular context (Brydon-

Miller et al., 2003). As a result, action research involves the active participation of those being researched to the extent that they are treated as co-researchers rather than subjects to be investigated (Dick, 2000). This requires agreement and commitment from the participants.

The next two features of action research, as described by Kemmis and Wilkinson (1998), are that action research is emancipatory and critical. From this perspective, action research can be seen as having the potential to challenge unjust situations (Brydon-Miller et al., 2003). As a result, the outcomes of action research should help free participants from constraints that limit their self-development and self-determination whilst also critiquing unhelpful practices, discourses, and relationships (Kemmis & Wilkinson, 1998).

Kemmis and Wilkinson's (1998) final feature of action research is that it is recursive, reflexive, and dialectical. They argue that action research not only involves "investigating reality in order to change it," but also involves "helping people change reality in order to investigate it" (p. 21).

Action research is highly reflective, with critical reflection being required at each stage of the cycle to inform next steps, resulting in its cyclic nature (Dick, 2000). The model can be seen as a spiral of planning, acting, observing, and reflecting, as depicted in Figure 4 (Kemmis & Wilkinson, 1998).

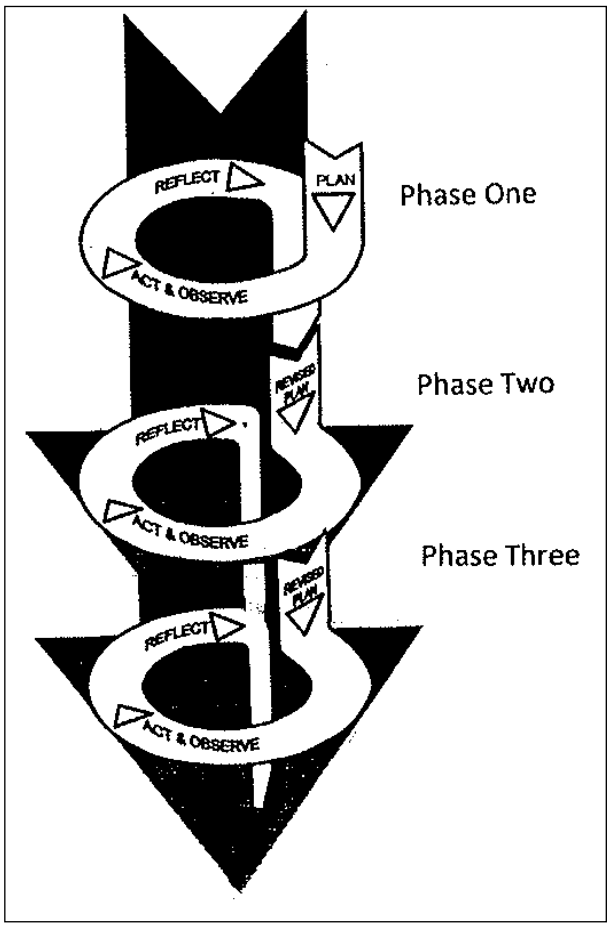

Figure 4: Participatory Action Research Cycles adapted from Kemmis and Wilkinson (1998)

The action research cycles begin with determining and clarifying the focus of the research through the creation of the research question (McAteer, 2013). During Phase One the current situation is determined. An action plan is then developed. This is then implemented (actioned) and monitored (observed). The effects of the changes are then reflected upon and evaluated. At this point, the findings are viewed in light of the research question. In addition, the research question may be further refined, prior to entering into the next phase. The process of planning, implementing, monitoring, evaluating, and question refinement is repeated through the subsequent phases, with the view to developing increased understanding and answering the research question. As a result, each phase in the action research approach is reliant on the phase prior, which in turn influences the phase which follows (McAteer, 2013).

Due to the iterative nature of this research approach, action research tends to be less prescribed, allowing for greater flexibility, emerging and responding as the research progresses (Dick, 2000). As a result, action research could indeed be thought of as a work in progress (Brydon-Miller et al., 2003).

Alignment of the present study with the action research method was determined utilising the reflection questions suggested by Kemmis and Wilkinson (1998).

Firstly, the study was well-suited to the use of the research cycles which characterise the action research model. The study was made up of three phases.

Phase One occurred prior to the commencement of the intervention. It utilised individual interviews and a cluster meeting to determine the baseline situation for the participants prior to their involvement in the intervention. The reflection within this phase was used to personalise the intervention for each participant.

Phase Two of the study was the intervention itself. This phase included involving participants in the intervention, viewing researcher-created video lectures, and engaging in face-to-face planning meetings with the researcher. Also included in this phase was the use of blog prompts to allow participants to reflect on the process in order to inform future implementation of such an approach to professional learning.

Phase Three of the study occurred following the intervention. It was again comprised of the use of individual interviews and a cluster meeting to determine what changes, if any, had occurred as a result of the intervention. This then led to reflections in the form of conclusions and implications, as well as to inform future study in this area.

The goal of action research - to change practice - aligns well with this study which has a focus on professional learning and on improving the self-efficacy of participants within self-determined areas of mathematics. This research also had

the aim of beginning to address unhelpful, socially-accepted, stereotypical beliefs that people are either "maths people" or they aren't and that they are helpless to change this situation. The individualised professional learning focus of this research aligned with the emancipatory nature of action research in freeing people from social structures that are irrational, unproductive, unjust, and unsatisfactory in order to promote self-development and self-determination (Kemmis & Wilkinson, 1998).

The action research model enabled collaboration between the researcher and the participants (Bradbury, 2015). This provided for the opportunity to gain useful insights into the feelings and experiences of the participants in order to grow a knowledge base and inform appropriate actions. This aligned with the recursive nature of action research.

The use of the face-to-face planning meeting, following the viewing of the flipped video, acknowledged the importance of the social situation to the individual and allowed for the design of learning experiences specifically tailored to that social situation and the individuals involved.

Ethical Considerations

Ethical approval was obtained from the University of Waikato Human Ethics Committee (FEDU075/17) before the research commenced.

Permission from the Principal (Appendix A) was gained, along with the recruitment and informed consent of the volunteer participants (Appendix B).

Of particular note within the ethical considerations was the care that was required in terms of the use of the interview method of data collection due to the sensitive nature of exploring aspects of a teacher's professional practice. Due to the potential of working with participants with low self-efficacy, the possibility of participants experiencing anxiety during the interview was taken

into consideration and great care was taken to ensure the professional integrity and protection of the privacy of the participants.

Pseudonyms were used within the transcripts to ensure the anonymity of the participants and only the researcher was privy to listening to the recordings in order to transcribe the interviews and meeting conversations. All identifiable data collected in gaining consent, interviews, meetings, audio recordings, observations, and blogs were stored securely on a password-protected computer and only the researcher had access to this information. All data collected will be stored for a period of five years in a locked office and the password-protected computer and will be destroyed at the end of this time period.

Whilst the identities of the participants remain confidential, the data shared by participants were collected with the intention of being reported on within the study. In addition, although participants were reminded about issues relating to confidentiality, it was not possible to determine what participants might share of the study with others, nor was it possible to prevent other staff from observing the meeting of the participants with the researcher. Therefore, whilst every effort was made to maintain anonymity this could not be guaranteed.

In addition, whist the teachers who volunteered did not include any from the researcher's immediate working environment, care was still required due to the power relationship between the researcher and the participants, as the researcher held a management position at the participants' school. However, as the management position held by the researcher was one of coaching and mentoring, trusted, professional relationships had already been established and observations and individual discussions with all teachers were already part of the normal processes within the school. The participants volunteered to take part in this research and their willingness to participate was acknowledged as an indication of their confidence in the discretion of the researcher. This was reinforced by their signing the participation agreement form.

The Participants

The School

All of the participants were teaching at a provincial school comprising of students from Year Seven through to Year Thirteen. The school operates as three smaller schools - the first made up of Years Seven to Eight students, the second of Years Nine to Ten students, and the third of Years Eleven to Thirteen students.

The school buildings consist of open plan spaces termed "Learning Commons" and the students in Years Seven and Eight are divided into four different Learning Commons to create learning communities. Within each learning community, there are four teachers (currently only three in the newest learning community), who work collaboratively with the four composite classes of Years Seven and Eight students who make up that community. These teachers have primary and intermediate teaching backgrounds. One of the teachers has the additional role of being the Leader of the Learning Commons.

The Teachers

Purposeful sampling was used for this study to attempt to access information-rich participants to inform the research question (Palinkas, Horwitz, Green, Wisdom, Duan, & Hoadwood, 2015). The participants were accessed on a voluntary basis following an open invitation to all 15 full-time Years Seven and Eight teachers within the chosen school (Appendix B). The invitation included an indication of what participation in the study would require.

Kemper, Stringfield, and Teddlie's (2003) seven sampling principles were also considered. Inviting participants from only one school allowed for efficiency and feasibility. The voluntary nature of the participation adhered to ethical practice. However, relying on volunteers limited the sample size. The teachers were chosen on their willingness to be part of the study, with the only criteria for selection being that they were currently teaching in Years Seven and Eight at the chosen school. Despite this, it was determined that the four voluntary participants were sufficient in sample size to gather in-depth data, which would

lead to inferences and explanations that were relevant to the research question and conceptual framework. However, the ability to generalise these findings to other settings and populations was considered to be a limitation of this ethically necessary self-selection process.

The four teachers who participated in this study were therefore Years Seven and Eight teachers. Two of the four teachers co-taught in one of the four Learning Commons and the other two teachers taught in two of the other Learning Commons. Participants are referred to by their pseudonyms.

The first participant was Anna. Anna had been teaching for seven years. She had taught at three schools and worked with students in Years Two and Three and Years Seven and Eight. She had been a Curriculum Leader for mathematics and spent two years as a Mathematics Support Teacher (MST).

Eva was the second participant. Eva had been teaching for ten years. She had taught at two schools and worked with Years Seven and Eight students. She had been a Whanau Leader, Dean, and Leader of Learning Commons.

The third participant was Liam. Liam had been teaching for ten years. He had taught at four different schools and had worked with students in Year Five to Year Eight, including six years as a specialist science teacher at an Intermediate School. He had been a Science Curriculum Leader and a Pedagogical Leader.

The final participant was Yvonne. Yvonne had been teaching for 15 years. She had taught at three different schools, including two years teaching in the United States of America. She had taught Fourth Grade and Years Seven and Eight. She had been an ICT/Technology Team Leader, Mentor Teacher, and Leader of Learning Commons.

As per the action research model, the participants were viewed as co-researchers. As a result, their input within each phase influenced each

subsequent phase. The role of the researcher then was to obtain the data from the co-researchers, interpret this data, and make decisions about the direction based on their feedback and feedforward.

Data Gathering Techniques

As this study adopted an action research approach, qualitative methods were used to gather data (Dick, 2000). These methods included interviews, semi-structured cluster group meetings, and a reflective blog. Each participant was involved in data collection using all three tools.

Phase One

Prior to commencing the intervention, all participating teachers were involved in an individual interview using the questions found in Appendix C.

The term "interview" can be traced back to the 17th century and the use of interviews as a technique for gathering qualitative data gained popularity in the 20th century, particularly in the area of social sciences (Kvale & Brinkmann, 2009). Indeed, in more recent times, the interview has come to be viewed as a valid way of collecting data, including having its own body of literature to more deeply describe its methodology.

An interview, at its most basic, is a structured and purposeful conversation (Kvale & Brinkmann, 2009). However, this conversation is one that occurs between unequal partners as the situation is defined and controlled by the researcher. Through the process of an interview there is interaction between both parties and new knowledge is subsequently created. However, despite the initial perception, the goal of the interview technique of expertly listening and questioning in order to gain an understanding of the world of the interviewee is far from a simple technique. Indeed, Kvale & Brinkmann (2009) go as far as to describe expert interviewing as a craft.

Despite the complexity, the interview method of data collection was chosen due to its ability to help gather detailed information regarding the thoughts and attitudes of the participants, as well as providing the flexibility to probe further to ensure that the meaning of the answers was understood (Menter, Elliot, Hulme, Lewin, & Lowden, 2011). This data collection method was well-aligned, particularly with the epistemology of the research approach chosen. The time taken to complete the interviews was a possible limitation of this method, however, with only four participants, this was not considered a barrier.

During the initial interviews information was collected on the self-efficacy of the teachers prior to the intervention. The questions focused on the teachers' confidence to accomplish various aspects of mathematics, including questions about their confidence in their ability to accurately solve a question from each strand of the Level Five New Zealand mathematics curriculum (Ministry of Education, 2007), as well as questions about their confidence in their ability to teach various aspects of mathematics, to teach specific groups of students, and to attend professional learning opportunities. This variety of questions was due to the recommendations of Finney & Schraw, (2003) who highlight that whilst self-efficacy is often thought of as domain-specific, this consideration of mathematics self-efficacy is still too broad. They argue that self-efficacy is, in fact, task-specific. In addition, each question was phrased using the word "can" rather than "will," in order to ensure that participants were encouraged to judge their capability rather than their intent (Bandura, 2006).

The participants were shown the rating scale of 0 to 100 and were asked to state a number to indicate their self-efficacy in response to each question. They were also asked to give an explanation for the number they chose. The rating scale used was based on the 100-point scale suggested by Bandura (2006) and was divided into ten unit intervals from 0 - "Cannot do at all" to 50 - "Moderately can do" to 100 - "Highly certain can do," as shown in Figure 5.

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

Figure 5: Self-efficacy Unipolar 100-Point Scale adapted from Bandura (2006)

Bandura (2006) contends that this unipolar 100-point scale is a stronger predictor of performance and achieves greater sensitivity and reliability due to the greater range of possible numerical options for participant self-assessment. This is due to the fact that the extremes of the scale are often avoided, leaving very few steps for the participant to choose if only a ten-point scale is used.

The interview was audio-recorded and transcribed by the researcher. Each interview took approximately 20 minutes. The participants were then given the opportunity to review the transcription of the interview and to make any amendments they deemed necessary. This review took, on average, an additional ten minutes.

All of the participating teachers were also involved in a semi-structured cluster meeting prior to the commencement of the intervention. This data collection tool was chosen due to its ability to give a general overview of the scope of the discussion along with the freedom to follow and explore responses given by the participants (Menter et. al., 2011). In addition, having the participants meet together provided the opportunity for interaction and discussion between the participants in order to gain more in-depth understandings of their experiences and feelings linked to the prompts (Appendix D).

The initial cluster meeting was used to gain background information from the teachers and to gather their input, as co-researchers, into the creation of the flipped professional learning videos. The cluster meeting was useful for gaining a

sense of the similarities and differences in the thoughts, opinions and experiences of group members.

This meeting also focused on aspects of teacher knowledge within the construct of teacher capacity, as defined by Zhang and Stephens (2013). This included knowledge of mathematics, interpretation of the curriculum, understanding of students' mathematical thinking, and the design of teaching and learning experiences.

The meeting took one and a half hours and was audio-recorded and transcribed. Again, participants, as a group, had the opportunity to review the transcription of the meeting and make any amendments they required. This review took an additional 20 minutes.

Phase Two

During Phase Two of the intervention participants reviewed a researcher-created video to address an area of need which had been self-identified by the participants within their initial interview. The video also took into account suggestions made by participants during the semi-structured interview. Each video was created using a similar structure based around the teacher knowledge and skill components of Zhang and Stephens' (2013) concept of teacher capacity. The videos contained relevant content knowledge, appropriate curriculum links, and consideration of the range of student responses. The aim of the video then was to also improve the third component - teacher dispositions - particularly mathematics self-efficacy, maths anxiety, and teacher agency.

As previously mentioned, it was decided that the creation of the various flipped videos should follow a similar structure (Lee et al., 2017). It was thought that this would lead to familiarity if teachers were to engage in the viewing of a range of different videos in the future. In line with the recommendations of Lee et al. (2017), the researcher was careful to consider the physical features, content features, and logistic features outside of the video.

In relation to the physical features, the topics were partitioned in such a way as to ensure that each video was kept to a time limit (Lee et al., 2017). Whilst a ten-minute time frame was the initial aim, this proved difficult due the range of content included in the videos and therefore a time frame of less than 20 minutes was considered more realistic and acceptable. The audio quality was also considered, and every effort was made to avoid background noise.

When considering the content features, the researcher ensured that each video began with a welcome section which enabled the viewer to see the talking head of the presenter (researcher) in order to make the initial personal connection. The talking head did not appear during the remainder of the video. Following this, an introduction was given, as well as an overview of the learning intentions for the session and any other important links to prior knowledge or other sessions (Lee et al., 2017). Each video then delivered some background information about the topic of the video, including definitions and links to the real world. Following this, the topic was explored in light of the relevant strand of the New Zealand mathematics curriculum (Ministry of Education, 2007) and possible student responses were considered.

The videos also incorporated interactive elements where viewers were encouraged to pause the video, think, and answer, prior to moving on. Participants were also encouraged to take notes regarding any questions, points of interest, or disputes they identified so that these could be discussed at the face-to-face meeting.

The researcher gave strong consideration to the links between the video session and the face-to-face session to ensure that there was a complementary relationship rather than a supplementary relationship so that the face-to-face session added depth but required the content from the video (Lee et al., 2017). Therefore, following the viewing of the video the researcher scheduled a suitable time to work with each participant individually to clarify any aspects of the video

and to assist in designing teaching and learning experiences for each participant's specific students, linked to the video content.

The participants were asked to keep a blog during the intervention. This recording method was chosen as it gave insights into the thoughts, feelings, and questions that the participants encountered during the intervention (Menter et. al., 2011). Blog prompts were given to help guide the reflections, but participants were able to record their reflections in their own words and format. These prompts can be found in Appendix E. These blogs were shared with the researcher.

Phase Three

Following the intervention, all participating teachers were involved again in an individual interview (Appendix F). The teachers were once again shown the rating scale of 0 to 100 and were asked to state a number to indicate their self-efficacy in response to the questions that related to their particular intervention. The participating teachers were also asked to give reasons for the number given. The interview was again audio-recorded and transcribed. The interview took approximately 20 minutes. Again, an opportunity was given to the participants to review the transcription and make relevant amendments, which took approximately ten minutes.

All of the participating teachers were also involved in a semi-structured cluster meeting following the intervention. The prompt questions for this meeting can be found in Appendix G. The meeting took one hour. The meeting was audio-recorded and transcribed. Again, an opportunity was given to the participants, as a group, to review the transcription and make relevant amendments, which took approximately 20 minutes.

Following each stage of data collection, the transcriptions were used to identify common themes. These themes informed future stages of the study.

Validity and Authenticity

In order to achieve validity and authenticity in the data, a number of strategies were used.

Firstly, within-method triangulation was achieved within this study by using three different qualitative data collection methods (Thurmond, 2001). The aim of the use of the three methods - interview, semi-structured cluster meeting, and blog - was to discover a range of information that may not be discovered through the use of only one method. In addition, the three data collection methods were used in order to gain a more thorough understanding, and also achieve a greater validity, of findings (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014).

Secondly, all transcripts were reviewed by the relevant participants in order to ensure that reliable records of the interviews and meetings were utilised.

Despite the attempts made to ensure validity and authenticity of the data, due to the small sample size, the results should be viewed with caution. However, the results found provide an insight into generalisations that might also be attributed to the larger population.

Approach to Data Analysis

The approach to data analysis used was a thematic approach based on grounded theory. In other words, the approach to data analysis was grounded in the views and experiences of the participants (Creswell, 2012). In line with the grounded theory approach, the data collected were considered with no preconceived inferences, frameworks, or hypotheses (Kvale & Brinkmann, 2009). Instead, themes were systematically and strategically uncovered as the data were analysed.

The first step taken to uncover themes was to undertake a preliminary exploratory analysis where transcripts were fully read several times in order to gain a general sense of the data (Creswell, 2012). Notes were also recorded. The

data were then colour coded to identify themes. These themes were then reduced to the three themes that best related to the initial research question and that occurred most consistently in the data. It was important to ensure that the themes also had multiple perspectives from the various participants.

The three themes that emerged through this process of data analysis were mathematics self-efficacy, teacher agency, and the importance of *just-in-time* professional learning opportunities. These three themes will be discussed in-depth within the next chapter which shares the findings of the research.

Chapter Four

Findings and Discussion

Introduction

This chapter explores the results of the study following the analysis of interviews, cluster meetings and blogs over the three action research phases. Whilst each phase was influenced by the phase which preceded it, three clear themes emerged across the entire study, in response to the research question. These themes were mathematics self-efficacy, teacher agency, and the importance of *just-in-time* professional learning opportunities, as ways in which the flipped professional learning model could increase teacher capacity.

Throughout this section, participants' pseudonyms will be used, and participant voice is indicated with italics.

Phase One

During Phase One of the study the current situation of the participants was investigated through the use of interviews and a cluster meeting. The aim was to ascertain current levels of self-efficacy in mathematics and in the teaching of mathematics. In addition, this phase allowed the participants to influence the professional learning programme in which they were participating.

Mathematics Self-efficacy

Variations in mathematics self-efficacy was a clear theme that emerged from the responses to the prompting questions during the interviews. The interviews were structured in such a way as to obtain a mathematics self-efficacy rating in relation to each participant's own ability to engage in various mathematics strands, to teach the various strands of mathematics, to work with particular groups of students, and, finally, to attend professional learning courses in mathematics.

The mathematics self-efficacy of the group was generally higher at the start of this study than had been anticipated. This should not have been surprising based on the research that suggests that it is those with high self-efficacy who more readily engage in challenging situations (Schunk, 1982; Siegle & McCoach, 2007; Zimmerman, 2000). Volunteering to participate in a mathematics research project could well be viewed as a potentially challenging situation for those with low self-efficacy in mathematics.

All of the participants had been trained in the Numeracy Project, which possibly accounts for their strong sense of self-efficacy in certain areas of mathematics. Indeed, all of the participants gave a self-efficacy rating of 90 and above in response to the question about their confidence to engage with and teach the number strand. All participants were grateful for the learning that they achieved through the project, as articulated by Yvonne below:

> *…the Numeracy Project… was the best PD I ever did, not because I like the Numeracy Project, I think that we're past that, but it made me understand how I did maths.*

Liam and Yvonne entered the intervention with a high level of self-efficacy, rating themselves between 80 and 100 on the 100-point scale for each question. The participants attributed this strong self-efficacy in mathematics to past success, otherwise known as mastery experience (Bandura, 1994).

In his comments, Liam attributed this high self-efficacy to a good working understanding and confidence in the various mathematics strands. He also referenced his university study, past teaching success, and his successful use of mathematics in everyday life as reasons for his high level of confidence.

Yvonne referenced her past teaching success as one of the main reasons for her strong self-efficacy. She also commented that she is quite stubborn and has *"quite a mathematical mind,"* along with useful strategies. These reasons, combined with real-world experience of camps, DIY, and managing money have

contributed to Yvonne's strong confidence in approaching mathematics. This high level of self-efficacy is apparent in her comment:

> *I haven't come across anything I haven't been able to solve yet.*

Eva had a moderate level of self-efficacy prior to the start of the intervention. Her ratings were between 70 and 100, with the notable exception of a rating of 10 in relation to her confidence in teaching algebra. This rating was in conflict with what she knew was reality:

> *So, my mind says 10, but I know I can.*

This demonstrates the pervasive power of previous lack of mastery experience over her own internal verbal persuasion (as defined by Bandura, 1994), as well as the prevailing power of the maths anxiety acquired during these past experiences. Indeed, when explaining this rating, Eva referenced a negative high school experience:

> *… I wasn't good at school with algebra and I failed algebra… in Year 11, Level 1 NCEA and I had tutoring pretty much just around algebra and then because I was the second year of NCEA, I don't know if it is still like this, but… the rule was if you failed algebra, the algebra standard in the exam, you couldn't do Level 2. So, I had 21 credits in maths and didn't get the last 3 or 4 for algebra and I was like, I have 20 something credits, how are you not letting me go through? So, they made me redo the whole year of Level 1 maths again… I had to redo the ones I already had and then do the algebra again. So why couldn't I just move on and just do the algebra again at the end of the year. Then that brings in the negative talk with students as well, like, I'm totally guilty of saying to them, "Yeah I found algebra's always been really hard for me too. You don't use it a lot in real life contexts," and that type of thing and so I am definitely guilty of that…*

Despite this low self-efficacy in algebra, Eva was confident with her personal use of mathematics in the real world, as well as her number knowledge and problem-solving strategies.

Anna awarded herself a wide range of self-efficacy ratings prior to the start of the intervention. Her highest self-efficacy ratings were in her ability to successfully solve problems and teach within the number strand (self-efficacy rating of 90) and in her ability to help students who struggle with mathematics (self-efficacy rating of 100). In relation to her confidence to work with students who struggle with mathematics, she articulated her ability to relate to the difficulties they have:

> *I'm a slow processor and generally kids who struggle with maths are slow processors. So, they need time, they need to be able to explore, understand and a huge amount of repetition… and patience…*

Her lowest ratings were 30. These related to her low level of confidence around her ability to solve measurement and geometry problems.

Anna also referenced negative schooling experiences and the resulting maths anxiety when discussing her confidence in attending a professional learning course:

> *I'm always scared… the presenter is going to go, "Give me the answer," when I am not one of those people and I suppose that's my own personal experience from school and from other teachers that I've worked with.*

In line with Bandura's (1994) research, mastery experience appeared to be the most influential factor in determining the mathematics self-efficacy ratings given by all of the participants during this phase of the study. What was notable was the strong influence that a negative schooling experience can have so many years later, regardless of any self-talk that attempts to verbally persuade the self otherwise. Any change in self-efficacy ratings over the course of this study will be of particular interest.

Despite the lower self-efficacy ratings of Anna and Eva, both identified their comfort in seeking help and persevering at difficult tasks, indicating an apparent

dissonance between their low rating and high motivation and determination to address their lower confidence. Perhaps, for these two participants, the higher self-efficacy ratings within some aspects of mathematics resulted in a greater willingness to address these areas despite their lower confidence.

Also worthy of consideration is the power relationship that was at play within this study and the possibility of a perceived need for these participants to assure the researcher (their Mathematics Lead Teacher) that they are active in addressing these areas of concern. However, the researcher was on leave from this position during the data collection phase in order to attempt to avoid concerns such as these. In addition, it was important to emphasise to the participants that the comments and ratings during the interviews were not part of any appraisal process.

Therefore, despite this possible explanation, the voluntary participation in the study and the follow through necessary within the study may indicate that this was less likely to be the case. On the contrary, this determination to address areas of lower confidence may also be linked to the degree of teacher agency that these teachers possess, which possibly indicates that strong teacher agency has the power to override low self-efficacy in mathematics. Teacher agency will be explored as the next theme within this chapter.

Teacher Agency

Despite variation in the mathematical self-efficacy of the participants during this phase of the study, all four shared something in common. Each participant articulated during the interview their determination to learn and find out information in areas where they lacked confidence prior to teaching their students. Their desire to take an active role in their professional growth suggests that each of these participants had a strong degree of teacher agency.

Indeed, despite his high self-efficacy in mathematics, Liam identified that there is always more to learn and mentioned his willingness to engage in this new learning, highlighted by his comment,

> *I know that there are other tricks and techniques out there to help students learn them that I still need to learn myself.*

Yvonne identified the importance of knowing vocabulary and mentioned the usefulness of school-made resources in giving her confidence in her teaching. When giving herself a lower self-efficacy rating she tended to comment that she could be successful by taking her time, figuring things out, having a refresher, or asking for help. This is exemplified by her comment:

> *… I could do with a bit of a refresher, you know, go and figure it out, find the rules… and reteach myself…*

Eva also identified multiple times that it is the language of mathematics that is sometimes the stumbling block but expressed a willingness to persevere and to clarify language and concepts that are less certain prior to teaching. She also had a strong understanding of herself as a learner, commenting:

> *… I know how to change a problem to make it work for my brain.*

Despite Anna's tendency to give herself moderately low self-efficacy ratings, within the interview her comments usually included a statement that indicated that with some time and some self-learning she would be successful, for example:

> *… it would just take me time to process it and just remember how to work it out… whenever I come across problems like this where my confidence is not high I will generally do a bit of work and make sure before I go into teach it.*

Indeed, some of the self-efficacy ratings and explanations for these ratings appeared to be in stark contrast to each other. A person with low self-efficacy would tend to avoid situations that they perceive to be threatening (Bandura,

1993), as opposed to making a conscious choice to work to improve their teacher capacity. Following on from this, perhaps it could be suggested that a teacher's self-efficacy is less important when strong teacher agency is present.

However, despite this strong indication of teacher agency in the comments made within the interviews, during the cluster meeting a clear divide was apparent between the participants. Two of the participants were very satisfied with their current mathematics programme and the other two were frustrated. This appeared to stem from the degree of agency that they felt they had in creating a mathematics programme within their Learning Commons that they believed would be beneficial for students, rather than having to use a mathematics programme where students were cross-grouped or streamed.

Liam and Yvonne were very positive about their mathematics programme. They explained that they had been team teaching this year and discussed the benefits that they had observed for a range of different students at varying ability levels.

> *Y: And so, we've been doing collaborative teaching. So, we have two classes where we sort of workshop and when one's workshopping the other is roaming, so we're then able to work with the high flyers a bit better and… trouble spot and get the kids just as they need their learning rather than having your standard sort of three groups, rotating them through and then never being able to… work with those kids as they need it.*
>
> *L: And having warm ups on the board that are differentiated in skill, so related to what the workshopping is going to be over that day or the next ones and that helps us see where the students are at, but mostly it helps them work out whether they need to be at the workshops or not so they can self-manage that a lot better because they can go "ah, I struggled with that I need to be there" or "no, I got it, I can actually just carry on."*

They mentioned their focus on enabling students to take ownership of their learning through the provision of diagnostic questions at the start of the block that would help students identify the optional workshops that they would attend. It is interesting to note here that these teachers with a high degree of teacher agency were also working hard to develop student agency in their learning community. However, they did acknowledge that this ownership and change of mind-set with the students took time to develop:

> *L: There's a bit of a stigma. That's sort of the thing you need to get rid of. I'm not a dumb kid, it's just that I need some help and you'll give it to me and it's not a big deal if I just hang out with the teacher and have success.*
>
> *Y: Yeah and for the Year 7's it was much harder cos they were so used to being told, 'You're a Triangle. You'll meet with the teacher on Tuesday," and pretty much won't be seen again and so they had so much time where they could just faf around in maths, because you know as a teacher, you've got to be focused on that group at once. So, we've found that the majority of kids are engaged in maths for the majority of the block and I could not have said that, like actively engaged in their learning, not just busy work, actively engaged and progressing. So that's been pretty cool.*

Finally, they discussed their success with challenging high achieving students in mathematics. Yvonne explained:

> *And we often have an extension activity for the week…. we kind of have a task sheet… and one of those will always be an extension activity. So often the kids who are high flyers will go straight to that and then revert back to something else, because maybe it was a bit hard. But I haven't had the "I'm bored," in maths since we've started doing that…*

Anna and Eva were less positive about their mathematics programme and their reasoning for that seemed to be their frustration with the streaming that was used within their Learning Commons. They indicated a belief that this is not the

most effective way of teaching students and differed from more successful experiences in their previous mathematics programmes. However, they seemed to lack the agency to make changes.

A: I don't have much positive to say unfortunately at the moment.

E: Yeah, I'm feeling a bit disheartened by my maths teaching at the moment and the learning that's going on… I've got the second to lowest group… they're probably the toughest group I've ever taught maths to and I'm kind of like, "I don't know what to do. Where do I go next?" because I used to do the sign-up workshops and rich learning tasks and things. Yeah, high motivation and participation and the kids really understanding where they were at was fantastic…

Y: Do you think because you've streamed that they are all in that box?

A: I agree, cos that's what we're doing in our commons and… I've done a huge amount of PD on maths… and streaming kids is not the best way for our low flyers… which is what all research shows and so that's what frustrates me, because I've got a middle group as well and it really frustrates me with the group I've got because… everything I've done in my research in my teaching over the last four years is that streaming kids is not the best… for them and… that's my… personal frustration.

Yvonne agreed with Anna and Eva that she had been very satisfied with her change from her previous method of streaming within her Learning Commons mathematics programme:

… last year we did groups and I had the low group… that felt uncomfortable… we weren't seeing as much growth as what we're seeing… a big part was because it was streamed I think.

Both Anna and Eva commented that they would prefer to make changes to their programme to make it more similar to the programme offered by Liam and

Yvonne. When asked what changes they would make to their mathematics programmes, Anna immediately responded:

> *Doing what they're doing.* (Pointing to Yvonne and Liam)

When asked to provide clarification Anna discussed the benefits that she had experienced in the past with students of varying levels of ability in mathematics, replying:

> *Well that's how I've taught maths for the last four years. So… everything that they do… that's exactly how I would want to be… cos it is, just gives those kids that boost… it also makes the high flyers actually think about their learning, because sometimes they're so quick that they actually need to… process and record their thinking process.*

Eva explained that coming into a Learning Commons part way through a year had posed difficulties for her due to the fact that the ways of working had already been established. However, she had a desire to make changes for next year now that she had tried what was already in place:

> *I think that… coming into a Commons half way through the year when structures are already in place… that's been quite difficult, in terms of… if I was wanting to make changes it was… kind of ingrained for my Commons this year and I kind of just wanted to… continue with what they were doing, because it seemed to be working. But, going forward… I would like to go back to having… either own classes or… just a slightly different Commons-wide structure. Sometimes as a teacher, when you get stuck with the same group… you get into a bit of a funk.*

Therefore, it would appear that whilst individually each participant had strong teacher agency when it came to their confidence to improve their mathematics understanding, this was not the case for Eva and Anna when it came to making changes to the mathematics programmes with their Learning Commons. Eva also highlighted this feeling within her comments regarding her confidence when attending a Mathematics Professional Learning course:

… trying to tell them that I didn't agree, I would feel nervous…. I guess one thing that would make me nervous is that in the back of my head, I don't, I couldn't, bring out like research to back it up and like quotes and people to reference. If I got cornered, and they were like, well tell me is there research to back you up, yes, but I don't know. So, I can definitely back it up based on what I see in the classroom and what kids tell me. But I kind of wish I had that research. Here you go. Here's something I prepared earlier…. I am happy to talk about it and fight for it, I guess. But I just need that extra little something in my kete.

Based on these comments the question arises as to how a professional learning programme can help to promote teachers' confidence to not only address their personal gaps in mathematical understanding, but also to address the gaps in mathematical programmes that involve other teachers. Perhaps one of the outcomes of professional learning also includes the development of teachers' confidence to enable them to stand up for changes in practice that are ingrained within their setting and the provision of research support to give them this confidence. It is also interesting to consider whether it is, in fact, the attainment of a general degree of teacher agency that can ultimately address lower self-efficacy in a specific area.

Just-in-time

The previous theme, which highlighted the importance of teacher agency, then leads on to the idea that professional learning should be provided *just-in-time*. This is so that teachers can access the professional learning they self-identify, at the time that they need it in order to grow their teacher capacity.

It was agreed by the participants that professional learning now needs to move on, there is little place for generic professional learning courses. Liam summed it up:

…the generic ones, that sort of PD is becoming less and less useful…

Eva added:

> *…the most beneficial PD now for me is in-house stuff that is relevant to our environment, our kids, and our beliefs as teachers in this… situation…*

Following on from this, all of the participants acknowledged the ongoing *just-in-time* professional learning that they believe they receive by working in a collaborative learning environment.

Eva commented:

> *I mean… the whole environment is really cool, like… something came out of the photocopier this morning and I said, "Oh, who's is that?... that looks really cool… can we talk about that," and so like over the photocopier we have conversation about the Scooby Doo lesson that he's going to do with algebra tomorrow, or whatever… so that fact that I've actually got a person who is there to have a conversation with, because we're in this environment, is fantastic… the sharing of resources, the constant chat about kids, assessment, programmes, that is all professional development.*

Anna agreed:

> *… also, being in that open space… it's nice to be able to have those conversations, because when you're in a classroom on your own, there's nobody there except you and you can't talk to the kids and you can't bounce that idea off, or Yvonne's walking past and she sees something, and she suggests something, and you think, "Yeah, I could do that." But you can't do that when you're in a single cell classroom. So that is a really, really, good advantage.*

Yvonne added to the comments about the positive benefits from the *just-in-time* professional learning when working in a collaborative working environment:

So, when we were doing measurement and I was like, uuuhhh you're doing negative numbers or integers because I get myself so confused and now that I've watched how Liam's taught it, I'm much more confident as well… I feel really supported, I think. When I did maths on my own it was always just you, those kids, whatever and if you got to an area you weren't that comfortable with, you just avoided it… I think when you're a competent mathematician and you're an experienced teacher the best thing that you can do is question yourself and reflect on your own practice. So, for me that's probably been this year, reflecting alongside somebody else. So, when you're in your own classroom with four walls, it's so lonely and you just don't know whether you're doing anything right or wrong. You might get one observation a term, if you're lucky, your kids might be progressing, or they might not be, but you know research says that kids will progress without us anyway, so is what I'm even doing effective? So, when you're constantly, like I've had some flops, where I'm like, "Oooh that was a bit interesting wasn't it?" and you know but being able to talk through that rather than just feeling like, "Oh, I'm a crap teacher. Can I even do this job? I'm letting the kids down." Talking it through in a more positive approach and having somebody say, "Oh well… we'll just do it like this tomorrow." Or often you come up with that solution yourself, by just having somebody to talk to.

Liam cautioned:

Yep. The right person to talk to though aye… If you've got the wrong person there, then you can feel potentially isolating, even though there's someone there, you know… We're really lucky… We met in January and we just clicked.

Liam mentioned that a "drop in centre" concept of professional learning dialogue opportunities could be useful.

Yvonne agreed, commenting that time is the biggest barrier for teachers becoming involved in professional learning, but suggested there might be a benefit in having the opportunity for professional dialogue:

> *…we know everybody's busy, but we want you to put this time in your mind aside…*

These comments regarding *just-in-time* conversations within the work environment of the participants have implications when considering the application of a flipped approach to professional learning in Phase Two of this study. Firstly, the availability of a video resource to provide this learning could be useful for those teachers who do not have an expert colleague to approach within their work environment for this *just-in-time* learning. Secondly, the need for a video method to be accompanied by conversation would appear to be essential from both the research literature (Burns, 2016) as well as from the comments made by participants, which can be summed up in the following comment made by Yvonne:

> *… I think the value… is that conversation. So, the video you might learn something, but the conversation's where the learning is really gonna happen.*

This is to ensure that the generic information becomes contextually relevant to the participant. It would seem important for this follow-up conversation or application of learning to occur soon after the video viewing to ensure that it remains *just-in-time*.

In addition, for this flipped professional learning method to be useful, it would appear that it is crucial for a trusted relationship to be established between the participant and the facilitator and video creator of the professional learning. This was exemplified in Eva's statement, that whilst there might be a myriad of videos on the internet:

> *…you don't want to just randomly Google.*

This professional trust would take time to establish but can be more readily achieved within a collaborative working environment. Within this study the researcher had the advantage of being a work colleague of the participants and had already established such a relationship.

If this had not been the case, Liam suggested that relational trust could also be established if the facilitator spent time observing the classroom during in the beginning phase of the intervention. This would assist the facilitator to gain a greater context for the later conversations and would ensure the usefulness of the video produced:

> *I think that it would be really well-paired if the facilitator had observed the classroom…. Or the teacher teaching that thing. So, if it was a strand, having them, watching them teach the strand and then having a conversation that involves that as well, or if it was about low-level learners, coming in and seeing what that teacher thinks low level learners in their classroom is. So… when the conversation's happening you've got an even stronger context.*

During the cluster meetings the participants discussed the potential usefulness of the bank of video resources that they could return to, when needed, following their flipped professional learning sessions. The fact that these resources would have been created by a trusted source was determined to be advantageous. Yvonne commented:

> *… And it would be a great resource just to have access to… Because those of us who are proactive in our teaching and what not, would do that…The one's that aren't, won't.*

Eva used examples to explain when the videos might be useful:

> *…it needs to be on a as needs basis… this unit's coming up so I'm gonna go and make sure that I'm up to speed with it and I've got some ideas in my head for what I can do with my planning and then if you forget, going back to it.*

Later she mentioned:

> *… So, you know, or you might be sitting at home and going, "Oh that's right I'm teaching that tomorrow and uhhh", or I didn't have time to talk to someone else today or clarify this so that's when it would be good to access those videos.*

Anna discussed the benefits of the videos in creating a supported co-learning flipped learning situation for teachers to access when needed:

> *…if there's access to videos, that is the time to go… I'm doing geometry or whatever it is and… you can say well actually we've got this bank, here's a video, how about we have a look at that… because… the two of us were wanting to do that and we can watch that video and then organise to maybe have that observation or to have that further in-depth…*

The results of Phase One of this study helped to gauge initial self-efficacy ratings in mathematics and mathematics teaching, suggested the importance of teacher agency in addressing low self-efficacy, and highlighted the need for professional learning to be *just-in-time*. The *just-in-time* learning also highlighted the importance of conversation and the development of trusted relationships. In Phase Two of the study participants were invited to engage in a self-chosen flipped professional learning episode. The episode was chosen to meet a self-determined need in order to attempt to improve teacher capacity, including teacher knowledge, teacher skill, and teacher dispositions (Zhang & Stephens, 2013).

Phase Two

In line with the intent of action research, the participants were viewed as co-researchers. As a result, the intervention that ensued during Phase Two was informed by the information gained from the initial cluster meeting combined with the information gained from the initial participant interviews during Phase One. In addition, aspects and influences highlighted in literature were

considered; these were mostly regarding format and were explained in the methodology. Throughout the discussion of this phase participant comments will be italicised and blog comments will be recorded in normal font.

Following on from the requests given by participants in their interviews, three videos were produced by the researcher. One video explored the difficulties that students have in converting between units of measure, one explored the algebra strand (this video was requested by two participants) and the final video explored the geometry strand of the mathematics curriculum.

Each video gave some background information about the topic of the video, including definitions and links to the real world. Following this, the initial plan had been to explore the topic in light of the relevant strand of the New Zealand Mathematics curriculum (Ministry of Education, 2007). This was actually done with reference to a document that was compiled by the researcher to show the movement from Level 1 through to Level 5 of the New Zealand mathematics curriculum (Appendix H). This document was compiled in response to comments by participants in the cluster meeting that they felt less comfortable with what came before, but particularly after, Level 4 of the New Zealand mathematics curriculum. This is exemplified in Eva's comment:

> *It would probably be good to have the… what's coming up next type situation, because we are not in the zone of Level 5 on the daily. We kind of don't have that in our heads. We've got a better understanding of where the kids have come from, in terms of like Level 2 and 3.*

Yvonne added:

> *So, I, in terms of strand, I probably only know Level 4 well.*

The next section of the video then explored a possible rich learning task, linked to the topic of the video, which was then followed by possible student responses. This rich learning task approach was chosen because, within the cluster meeting, Liam and Yvonne mentioned their use of rich learning tasks in

their current mathematics programmes and Eva and Anna indicated a desire to return to this approach which they had previously used. The rich task example was followed with possible ways that students could engage with the task, demonstrating the way in which one task could be differentiated for all students. This came about following Eva's suggestion:

> *I guess for me, what would be really beneficial would be if… we could clearly see within that session how you differentiated for our above Level 4 learners and then again… our below maybe. But, yeah, definitely showing that differentiation of… one task fitting all and… catering to all levels…*

The initial aim had been to keep each video to less than ten minutes, in line with the recommendation of Lee et al. (2017). However, in order to do justice to the various sections within the video, each video ended up being approximately 18 minutes long.

Once the videos were created they were shared with the appropriate participant. After viewing had taken place, the participants met individually with the researcher to discuss the video content in order to then personalise the professional learning to the teacher's context. The conversation following the viewing of the video was also considered vital following on from Yvonne's comment, previously quoted:

> *… I think the value of that is that conversation. So, the video you might learn something, but the conversation's where the learning is really gonna happen.*

Mathematics Self-efficacy

Through the flipped professional learning process, the opportunity arose for the facilitator (researcher) to provide an additional voice of verbal persuasion in order to upstage unhelpful mastery experiences.

Liam commented in his blog that the process had:

> …just reaffirmed that I am where I am… I recognize that I am doing the right things to help less confident students with their math, just need to continue breaking down the barriers.

Yvonne found the process reaffirming to her self-efficacy:

> I have realised that I am already quite confident across the Maths curriculum, this process has been a good confirmation of my own ability.

Eva stated that the following points were benefits for her through the flipped professional learning experience:

- Not feeling alone about ability to teach something I am not so comfortable with.
- Being reminded that there is more to algebra than just x.
- Given me more confidence to throw out a problem and let them go for it.
- How to get thinking in more algebraic terms.

How these comments translated to changes in self-efficacy ratings will be explored in the results and discussion of Phase Three. However, the initial self-efficacy ratings provided the participants with the catalyst for engagement (Timperley et al., 2007) and for promoting teacher agency.

Teacher Agency

Teacher agency was promoted within this phase as each participant chose the focus for their individualised intervention at the completion of their initial interview, during which they had considered their own self-efficacy in various strands of mathematics. The aim of having participants chose their own area of focus was to improve teacher capacity.

Liam identified working with struggling learners, and during the interview, had mentioned his interest in the difficulties that he had noticed that students have with converting between units. Yvonne and Eva identified the Algebra strand and Anna identified the Geometry strand for their interventions.

The participants then had control over the direction the professional learning took during the face-to-face meetings. The participants were provided with hard copies of rich tasks that were used in the video (Liam was also given two additional possible tasks). Liam commented:

> I really like the 2 rich task ideas that you brought in… these are the things that help us to teach the meaningful real-life mathematics. Having a wider range of these to use as milestones would be really useful.

Copies of the Curriculum Guide linked to the content of their video were also offered. Yvonne requested copies of Curriculum Guides for all of the mathematics strands:

> Do we have that diagram (the one that had Level 1-5) for the other strands - would be really helpful in determining what students may be missing and looking at the ZPD

The face-to-face conversation offered a chance to clarify learning and thoughts and then clarify any questions prompted by the video. It also allowed for conversations regarding implementation of the video content into the teacher's classroom. Liam, Yvonne and Anna ceased their intervention at the conclusion of this face-to-face meeting.

Eva requested that the researcher provide a modelling session following the face-to-face meeting to gain further learning from the intervention. The session modelled linked to the rich task that was suggested in the video that Eva had already begun to implement with her class. In the modelled session, the researcher used an alternative context so that the students would have the opportunity to apply new learning to the initial rich task context in order to demonstrate their level of understanding of the new concepts. Following this modelling session, Eva was satisfied to cease the intervention. Therefore, teacher agency within this phase was encouraged by the control that participants

had over the face-to-face sessions. The availability of the researcher also allowed the professional learning to be delivered in a *just-in-time* manner.

Just-in-time

Due to the encouragement of teacher agency in the self-selection of each participant's intervention focus, the professional learning also became *just-in-time* to fill a need in relation to teacher capacity that had been personally identified.

Liam identified the benefit of engaging in this professional learning in his own time, with the ability to re-watch videos as needed. Eva agreed that it was helpful to go back, and she felt that the visual and audio method was suited to her learning style. Anna also found the ability to watch the video in her own time was beneficial as it allowed for processing and reflection time, backed up by a follow-up discussion.

The importance of this conversation was again emphasised with Liam's blog comment:

> Great to talk… about the content… The greatest PD is generally from professional discussions as the content of the dialogue is led to those who want it and meaningful thoughts and ideas can be shared in the moment.

This was again reconfirmed in Anna's blog comment that the dialogue:

> …is a must as when you talk other things come out.

Yvonne agreed, stating that the flipped professional learning experience allowed the chance to share some rich dialogue. Yvonne also identified that this style of professional learning:

> …is a non-threatening way to upskill in a short period of time.

Also, with regards to this style of professional learning, Eva commented that it:

> …feels like you have an expert on call to help answer your questions…

However, she also commented that:

> If you have a burning question then and there, that it isn't live. But it needs to be manageable so having a Q&A or support group to go with it would be beneficial.

Anna's flipped learning experience, in particular, reinforced the importance of *just-in-time* professional learning. Although Anna had chosen the focus of her intervention based on a self-identified need, the fact that the strand of mathematics was not the one she was teaching at the time meant that she did not feel that she got as much out of the professional learning as she would have liked. She commented, that it may have been more useful to:

> …have it *just-in-time*. Identify at start of year what you would like to focus on or "goals" – set dates and then do and before teaching and then follow up – during and after.

Therefore, due to the nature of the timing of participation in this intervention, for some participants this professional learning occurred *just-in-time*, whereas for Anna this component was missing. This served to emphasise the importance of this aspect of professional learning.

Phase Three

At the conclusion of Phase Two of the study each participant again met with the researcher to conduct their second interview and all four participants also participated in a second cluster meeting. The changes to aspects of teacher capacity were of interest during this phase.

Mathematics Self-efficacy

The responses to the interview conducted during Phase Three were compared to those given in the initial interview to determine whether or not any change to self-efficacy was apparent. The self-efficacy ratings were broken into four

sections and placed in four tables. A colour code was used to identify increased (green), decreased (red), or unchanged (orange) self-efficacy ratings during the second interview compared to the first. In addition, participants were all asked each question during the first interview but were only asked questions that related to their intervention during their second interview. Therefore, grey shading has been used in the tables to indicate questions that were not asked a second time.

This first table compares the before and after self-efficacy ratings that related to the participants' confidence that they could successfully engage with the various strands of mathematics themselves. This was done by showing each participant a question at Level Five of the New Zealand mathematics curriculum (2007) and asking whether they felt confident that they could give the correct answer to the questions shown. They also rated themselves in relation to their confidence to solve mathematics problems and to be successful with mathematics in the real-world.

Table 1: Participants' Self-efficacy Ratings to Personally Engage in Mathematics

Question	1 Maths Problems		2a Number		2b Geometry		2c Measurement		2d Statistics		2e Algebra		11 Maths in the real-world	
Pre/ Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Anna	60	70/ 80	90		30	40	30		60		60		80	70/ 80
Eva	75/ 80	80	90's		90's		70's		80's		90's	95	98	90
Liam	95	100	100		90		100	100	100		100		100	
Yvonne	80	95	100		100		80		100		90	100	100	100

All of the participants reported improved self-efficacy in relation to their confidence to solve mathematics problems in question one. Anna reported improved self-efficacy in solving problems involving geometry, which was linked to her intervention. Yvonne and Eva also reported improved self-efficacy in solving problems involving algebra, which was linked to the intervention in which they participated. Liam showed no change in his high confidence in solving

problems linked to measurement. However, it is worth noting that Liam's intervention that focussed on measurement was not intended to improve his knowledge or ability in the subject area but was intended to improve on his strategies for working with students who struggle in a particular aspect of measurement.

Despite these improved ratings, Anna and Eva showed a slight decrease in levels of self-efficacy in their confidence to solve mathematics problems in the real world. This could be attributed to the fact that you don't know what you don't know, and following the professional learning experience, more questions and uncertainties were uncovered. Mastery experiences (Bandura, 1994) ,when solving real world mathematics problems, could perhaps re-elevate these levels.

The second table compared the before and after self-efficacy ratings that involved the confidence of the participants to teach the various strands of mathematics.

Table 2: Participants' Self-efficacy Ratings to Teach Mathematics

Question	3 Number		4 Geometry		5 Measurement		6 Statistics		7 Algebra	
Pre/ Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Anna	90		70	70	80		80		60	
Eva	95		85		100		85/ 90		10	70/ 80
Liam	80		95		90	95	90		(70) 90	
Yvonne	100		100		100		100		90	100

Again, in most cases, an increase in confidence to teach the strand of mathematics that related to the intervention of their choice was apparent. Anna was the only participant to report unchanged levels of self-efficacy in her chosen area of professional learning - geometry. She commented:

…it would just be having to look at what we're doing and what do I need to research…

Liam, Yvonne, and Eva, on the other hand, all reported increased self-efficacy in teaching the strand of mathematics linked to their personal intervention. The most notable improvement was that of Eva who went from a self-efficacy rating of 10 on the 100-point scale prior to the intervention to 70 to 80 out of 100 following the intervention. In her explanation she stated:

Definitely still not confident with higher end algebra. But have a better understanding of the progressions.

The third table compared the before and after self-efficacy ratings that related to the participants' confidence that they could teach mathematics to particular groups of students.

Table 3: Participants' Self-efficacy Ratings to Teach Specific Groups

Question	8 Students who struggle with maths		9 High achieving maths students		10 Year 9 & 10	
Pre/ Post	Pre	Post	Pre	Post	Pre	Post
Anna	100	90	80	60	70/ 80	60
Eva	100	80/ 90	90	70	80	80
Liam	80	90	100		95	
Yvonne	100	100	80	80	80	100

Liam and Yvonne showed increases that would appear to link to the intervention in which they participated. Liam's intervention was particularly focussed on ways to help students who struggle in conversion of units. Yvonne recognised her confidence in teaching algebra through her intervention which may account for her increased confidence in teaching more complex mathematics, potentially to students in Years 9 and 10.

However, conversely, Anna and Eva both showed drops in their self-efficacy in teaching various students. This would seem surprising as their confidence to engage in and teach mathematics had improved. Perhaps the complexity of mathematics learning had been highlighted to them through this process. Again, new mastery experience (Bandura, 1994) may be required to reinstate self-efficacy levels for these participants.

The final table compared the before and after self-efficacy ratings of the participants in relation to their confidence to attend mathematics professional learning courses.

Table 4: Participants' Self-efficacy to Engage in Professional Learning

Question	12 Attending a professional learning course	
Pre/ Post	Pre	Post
Anna	60	70
Eva	80	90
Liam	90	100
Yvonne	100	100

All of the participants, except Yvonne who maintained her 100 rating, reported increased confidence to attend a mathematics professional learning course. This is an important finding due to the importance of ongoing learning to the effective teaching of mathematics (Askew et al., 1997).

In order to attempt to increase teacher self-efficacy in mathematics, this intervention utilised verbal persuasion (Bandura, 1994) through facilitator encouragement. In addition, the intervention also included vicarious experiences (Bandura, 1994) through the facilitator sharing ideas that had been

successful in her experience, as well as by providing in-class modelling sessions. It would appear that this was mostly successful in relation to increasing the confidence of participants to engage in mathematics and to teach mathematics, as well as to engage in future professional learning in mathematics. This was certainly the case with Eva.

Following the face-to-face meeting, Eva requested a follow-up modelling session to gain further understanding through the real-time viewing of the researcher teaching her students. Her comments demonstrated the benefit of the vicarious experience (Bandura, 1994) of viewing the model session and also the restoration of confidence that she gained through this possible extension of the intervention:

> *I also took up the opportunity to have [the researcher] come in and do a modelling session and that was really valuable for me, because… [the researcher] and I worked together many years ago and I've seen her teach heaps and every time I see her it just kind of reignites the fire, but just… the language, like I noticed that I was using not quite the correct word for… expression/equation. I was using that incorrectly and just… watching her, is just like, "Oh yeah that's right, oh yeah I can do that" and it was like, "Okay, yep, I'm good."*

However, in relation to working with particular groups of students and engaging in mathematics in the real world some participants felt less confident following the intervention. Potentially new mastery experiences (Bandura, 1994) may be required to re-elevate self-efficacy. This also highlights the need for professional learning to be an ongoing journey and to address new areas of need, rather than being a one-off experience. Despite some drops in self-efficacy, teacher agency was still apparent. This will be explored in the next section.

Teacher Agency

Once again teacher agency was certainly a theme that emerged during the cluster meeting, as a sense of empowerment had been experienced by the participants. Yvonne commented:

> *I know more than I think I know and that I'm kind of doing a pretty good job and that's quite good, because you always, I think, question yourself.*

Anna shared similar thoughts:

> *I would agree with that and I know after… our follow-up conversation, it was like, "Oh, yeah, I know stuff."*

Liam also mentioned the reaffirmation he received as an experienced teacher:

> *…as experienced teachers a lot of what they did for us was affirm that we know what we're doing…*

Eva also expressed her increased confidence, particularly in the use of rich tasks with her students:

> *…it's increased my confidence to, kind of, just throw a problem at the kids and see what they do with it, rather than going, "Oh no, this is too hard, they wouldn't be able to do it."*

Eva and Anna also indicated that the intervention had reaffirmed for them a determination, as opposed to their previous helplessness in Phase One, to return to their former ways of teaching which involved the use of rich tasks, workshopping to needs, and the removal of cross-grouping. This sense of teacher agency to move beyond making changes within themselves to making changes in their sphere of influence was encouraging.

Following on from this professional learning experience both Yvonne and Anna identified the need to find a way to encourage teachers to develop teacher agency and to engage in professional learning:

Yvonne commented:

…it's empowering other people to feel like that's a good thing to do. I feel like that's the challenge… we've taken this on board because we're keen learners… I almost feel like every teacher needs to take that e-asTTle test and see what they come up as… actually knowing what I don't know… it's the teacher mindset almost that's going to allow that to happen… we all need to be life-long learners and what that actually means in our profession. It's easy just to say I am, but what does that mean.

Anna added comments about the need for teachers to be prepared to get into the space of struggle:

You nailed it on the head before… you said… that we teachers, if you've never, particularly once you've been teaching and you've gone through, if you're not struggling and you haven't had to do that struggle then, it's about empathising with that student in front of you who is struggling… we are all learning and exactly what you said about remembering what it's like to struggle… and we understand that thought process and the thinking and the brain power it takes and the tiredness you feel from thinking too much...

It would appear that the potential for a flipped professional learning model to encourage teacher agency was certainly empowering for teachers and was viewed as an important component of improving teacher capacity, particularly in relation to self-efficacy in the teacher disposition component.

Just-in-time

In reflecting on the flipped professional learning experience the participants commented on the benefits of this style of professional learning compared with a more traditional professional development course. Eva commented:

Definitely more powerful than a full day PD session… listening and watching somebody deliver in a manner that is… not displaying good teaching practice.

Yvonne stated:

> *I guess moving forward and using flipped, would I use flipped learning? Absolutely… it was much more useable than sitting… in a day's course...*

The participants highlighted the benefits as being the ease of access, the ability to engage in *just-in-time* learning, the personalisation of the learning, and the face-to-face follow-up conversation. Yvonne commented:

> *I think that it was nice that it was sort of personalised and that I could do it on my couch…*

However, despite this, she also noted in her blog comments the need for the videos to be shorter:

> The videos need to be kept short and sharp. We discussed perhaps having time markers for people who perhaps didn't need everything in the video.

This suggestion would further promote the *just-in-time* philosophy, as well as promoting teacher agency, by allowing the participant to watch exactly what they needed, when they needed it.

During the cluster meeting, the participants also discussed ways that they could see this flipped format working in the future.

Eva identified the benefits of using the videos as springboards into whole team professional learning:

> *…I think it would be a great tool to be used as… a team discussion tool there to access, grab it, when you need it, discuss it as a team… you said, "Hey team, here's a video. We're doing algebra next term. Watch the video and we'll discuss it at our next meeting," …that… would be as powerful for me, that conversation with my team.*

Yvonne agreed:

Would I… use it in my team? Absolutely.

Yvonne also identified the usefulness of the videos for certain teachers:

…if I had a team member joining me who had come from Year 4, say, then it might be really powerful for them to see…the different levels... Or somebody who had maybe been teaching overseas for a long time. Like, as refreshers, I think they are really good too.

Liam also suggested the benefit of having:

… a paired video system where there was the one like we all got, but then there was one that goes with it which is, so what does this look like in the classroom? Like a model, modelled lessons… So, you could have them buddied up, so if you need to learn about it you go to the first video, but if you… know it… you just go to the other video and it's just a whole lot of little mini lessons.

The face-to-face meeting that followed the viewing of the video was identified by participants as being important and beneficial, once again highlighting the importance of conversation, *just-in-time*. Yvonne noted:

I think the most power for me was in the conversation though. So, a video alone I probably wouldn't go out and watch…

Liam commented:

The benefit for what we did was … that there was face-to-face conversation… I guess the potential barrier is that in the future if there was just a bank of videos that it won't be as personalised as it was this time and then I go, "That was alright and not quite what I wanted," and so there's still that potential, which a face-to-face conversation will always fix.

In addition, Liam had also mentioned in his blog comments:

> Personal preference to the PD style is a major factor in what you gain from it. In the end, the most effective PD for established teachers is ongoing informal discussions about their teaching and student learning….

Anna elaborated on the importance of the follow-up conversation in her experience:

> *…that meeting, the follow-up, the talking, the processing, having the conversation was far more powerful than anything else and the video is just a backup or a support… there will be the small percentage of people who the conversation isn't, it's just how we all learn differently, but for most teachers… that's kind of how we process and learn.*

Later Yvonne added that the process had:

> *…definitely highlighted the importance of professional dialogue.*

This is in line with the findings of Muir (2017) who found that a flipped classroom approach may be of most benefit when it compliments practice that is already in place. In addition, it reinforces the fact that the flipped learning approach is much more than a video lecture model.

The importance of the need for the development of a respected, professional relationship with the facilitator and video creator was again highlighted during the cluster meeting. Anna suggested that it would be just as easy to find and view YouTube videos on the area of professional learning focus. Eva's initial concern was whether or not these videos would link to the New Zealand Curriculum.

Yvonne then brought up the importance of the credentials of the video creator:

> *…because I know that she's worked in this environment, I listen to what she says a whole lot more than what I listen to somebody else… So, it's actually valuing the person. So, I could probably find some clips on YouTube that might be good, but I'm a little bit of a critic, no I'm a*

massive critic, but I'm a little bit of a critic when it comes to who I want to sit down and watch in a professional learning sense. So, if you were a Joe Bloggs and I don't know you from a bar of soap, then I'm not gonna give you my view on your YouTube channel because I wanna know that you're actually a good educator. Cos there's a lot of people can stand up and be amazing mathematicians and maybe can show you how they do it, but does that relate to my learners well? So, I guess I wouldn't be as likely to just go and find a video, as I might be to use one that… somebody I know has created…. would it be great to have a resource of things… that have been created by somebody you value? Yes… Like if there was a bank of them, then I could go and find what I needed at that time. I think knowing and valuing the presenter was huge.

Eva agreed with Yvonne:

And I guess also… I know that she has a philosophy that I can only aspire to, and… I want to follow the learning, teaching style that… she's advocating, and I guess that's why, like you, I'm invested… I know what I'm signing up for, what I'm going to be watching is along the same lines. I don't waste 15 minutes watching something and then going, 'Oh well, okay'… And it didn't relate to New Zealand Curriculum and now I have to go and find another one… I don't have that time to go find other things.

This has implications for the future use of this flipped professional learning model as the comments made by these participants highlight the need for future facilitators to also create their own videos rather than rely on the pre-recorded videos of others. This is a time-consuming process initially but would seem crucial to the success of the model.

Overall, the flipped professional learning model was considered by the participants to be more useful than a traditional professional development session. They indicated that this was due to the time-efficient, personalised, *just-in-time* relevance it provided.

However, the participants indicated the crucial importance of the face-to-face conversation to ensure application within their teaching context, along with the establishment of a trusted relationship with the facilitator. Tweaks to the videos were also suggested to enable an even more useful experience, particularly time markers to enable greater personalisation of the viewing experience.

A further consideration of the conclusions that can be drawn and the subsequent implications from the results of the three phases of this study will be discussed in the next chapter.

Chapter Five

Conclusions and Implications

Introduction

The focus of this study was to explore:

> *In what ways might a flipped professional learning model provide a method of increasing teacher capacity in mathematics for Year Seven and Eight teachers in a provincial city school, particularly those with low self-efficacy in mathematics?*

Therefore, the purpose of this chapter is to synthesise the findings from the previous chapter, including linking to literature, in order to suggest conclusions, as well as implications for practice, policy, and research. The limitations of this study are also explored.

When examining the findings in light of the research question, changes to the self-efficacy ratings of the participants throughout the three phases of the study were of particular interest as an aspect of teacher capacity. In addition, the themes of teacher agency and *just-in-time* professional learning were explored as two of the features of the flipped professional learning model that were identified as useful in increasing teacher capacity.

Conclusions

The flipped professional learning approach certainly improved the self-efficacy of participants and encouraged teacher agency, *just-in-time*. These conclusions will now be explored in more depth.

Mathematics Self-Efficacy

From the outset, the aim of this study was to utilise a flipped professional learning model to raise the self-efficacy of primary-trained Years Seven and Eight teachers. This was due to the evidence of the predictive power of self-efficacy over mathematical achievement (Attard et al., 2016; Bandura, 1993; Beilock et

al., 2009; Isikal & Askar, 2005; Thomson, 2014; Zimmerman, 2000) and the concern that low self-efficacy in teachers of mathematics is often passed on to the students that they teach, thus continuing the cycle (Boaler, 2016).

However, as was also suggested in the research, those with low self-efficacy and maths anxiety are unlikely to willingly engage in professional learning in relation to an area that they may perceive to be a personal threat and beyond their coping capabilities (Bandura, 1993; Beilock et al., 2009). This was indeed the case. Hence, none of the voluntary participants had low self-efficacy across all areas of mathematics. Liam and Yvonne, in fact, had high self-efficacy, and Eva and Anna moderate self-efficacy. Despite this, over the three phases of the action research process, the self-efficacy of all of the participants improved in areas linked to their professional learning area of focus. This was most notable in the case of Eva, with her dramatically improved confidence in her ability to teach algebra over the three phases, which was the focus of her flipped professional learning programme.

Throughout this study it has been seen that mathematics self-efficacy is indeed malleable (Finney & Schraw, 2003). It would appear that engagement in a flipped professional learning programme has the potential to affirm the self-efficacy of those who are already confident and to improve the self-efficacy of those less confident. This was true for both improvements in mathematics self-efficacy with Anna and mathematics teaching self-efficacy with Eva. However, it also has the potential to reduce confidence in areas not specifically addressed within the flipped professional learning.

Having said this, self-efficacy is a highly complex construct with many factors impacting on confidence levels on a daily basis. Therefore, the various changes in self-efficacy cannot be solely attributed to flipped professional learning. Nevertheless, the flipped professional learning approach used in this particular study certainly had some influence.

Teacher Agency

The flipped professional learning model relied heavily upon and promoted teacher agency in order to increase teacher capacity. Firstly, the participants had to volunteer to participate in the research from the outset, demonstrating their willingness to access additional professional learning that was not mandated by an external source. Whilst the findings of Timperley et al. (2007) suggested that the intrinsic motivation for teacher engagement in professional learning was not critical, the teacher agency evident in the participants appeared to be crucial to the success of this professional learning experience.

Secondly, the participants had to make decisions about the area of professional learning that they wished to access to improve their teacher capacity. It should be acknowledged that this first round of professional learning most likely related to Beswick's (2014) initial category of learning needs - that is, those that the teacher was aware of and would share with colleagues. Indeed, the flipped professional learning approach provided a springboard to useful conversations around a self-identified need in relation to teacher capacity.

During the initial phase of the study it was interesting to note that all four participants made reference to the control they had over their lower self-efficacy ratings in particular. This is exemplified in the following comment made by Anna:

> *… whenever I come across problems like this where my confidence is not high I will generally do a bit of work and make sure before I go in to teach it.*

Comments such as this seemed to be in dissonance with the lower self-efficacy rating, in essence, bringing into question whether or not the participant did, in fact, have low self-efficacy in that area. Perhaps this suggests that teacher agency has the potential to override low self-efficacy.

Finally, it is important to note the impact of the flipped professional learning approach to increased teacher agency to not only take action to improve individual practice but also the practice of others in their sphere of influence.

Working in tandem with teacher agency was the potential for a flipped professional learning programme to occur *just-in-time* to meet these self-identified needs in a timely manner in order to improve teacher capacity.

Just-in-time

The flipped professional learning model allowed for the teachers to engage in learning as and when they needed, as explained again by Yvonne:

> *I think that it was nice that it was sort of personalised and that I could do it on my couch…*

In the case of Eva, it was seen that the flipped approach allowed for professional learning to occur *just-in-time* before classroom implementation. However, the approach also allowed the opportunity for ongoing *just-in-time* professional learning in the form of a modelling session following the initial implementation within the classroom. This demonstrates alignment with the professional learning model in Figure 1 (p. 10).

In addition, it was very clear throughout the three phases of the study that the professional dialogue that accompanied the videos was crucial, almost to the point of suggesting that it was, in fact, the conversation that was important, not the video. Yvonne's comments demonstrate this view:

> *I think the most power for me was in the conversation though. So, a video alone I probably wouldn't go out and watch…*

This was particularly important to ensure that questions, wonderings, and affirmations were received *just-in-time* to enter back into the classroom.

Whilst the flipped professional learning approach certainly improved the self-efficacy of the participants and encouraged teacher agency *just-in-time*, it is important to acknowledge the limitations to this study.

Limitations

The conclusions within the previous section of this chapter should be considered in tandem with the following limitations.

Firstly, the study was comprised of a small sample of four teachers, all teaching at the same school. Due to the small sample size, the intention of using this study to challenge unhelpful discourses in relation to mathematics and the resulting societal beliefs was limited. However, despite this small sample size, considerable amounts of qualitative data were gathered in order to reach the conclusions offered here. It is hoped that this study will contribute to the ongoing discussion relating to the mathematics self-efficacy of primary-trained teachers.

Another factor worth noting here is the relationship that was already established between the researcher and the participants. Whilst there was a power relationship at play, potentially influencing the way in which participants responded to questions, the established relationship of coaching and support may have also allowed for honesty and trust. This may have taken a considerable amount of time to establish had the study been conducted at another school. This would need to be considered if such a method of professional learning was trialled more widely.

In addition, all of the teachers volunteered for the study so there was no resistance from these teachers with respect to their engagement within the professional learning programme. In addition, due to the voluntary nature, there were potentially key participants missing from the study due to their low self-efficacy. These teachers may have had important insights to share.

Any improvements to student achievement, as a result of this professional learning intervention, were not measured within the present study. Rather, any changes to the mathematics self-efficacy of the teachers were of greater interest.

Finally, as this study only utilised a flipped professional learning model it is difficult to argue that an alternative professional learning approach would not have achieved the same results.

Despite these limitations, changes to teacher capacity were evident. The implications for practice, policy, and future research will be explored in the following sections of this chapter.

Implications for Practice

As mentioned in the limitations, this study only utilised a flipped professional learning approach, however, despite this, a shift in self-efficacy was apparent. Therefore, the challenge remains as to how to get teachers, particularly those with low self-efficacy in mathematics, to engage in professional learning more readily. This may then lead to growth in self-efficacy, an aspect of teacher dispositions within the construct of teacher capacity. The results suggest that allowing for teacher agency and allowing learning *just-in-time* may be beneficial and this study shows that the flipped approach to professional learning encouraged both.

If teacher agency has the potential to override low self-efficacy, then how to build teacher agency in all teachers, particularly those with low self-efficacy in mathematics, should be a significant focus to ensure greater improvements in teacher capacity.

Therefore, it would appear that any further use of a flipped professional learning programme should first focus on building teacher agency, in order to increase participation and to build teacher capacity. This is a hard shift to make, especially

if teachers have been used to waiting for a mandate from an external source before engaging in professional learning, particularly in an area of perceived threat.

One important factor in building teacher agency would appear to be the development of a trusted relationship between participants and facilitators in the professional learning programme, as expressed here again by Yvonne:

> *…because I know that she's worked in this environment, I listen to what she says a whole lot more than what I listen to somebody else… So, it's actually valuing the person…I think knowing and valuing the presenter was huge.*

This also highlights the need for facilitators of this style of professional learning to create their own videos. This would require substantial time, but would appear to be imperative, based on the findings of this study.

Indeed, Timperley et al. (2007) and Beswick (2014) highlight the power of the development of these strong, trusted relationships to achieve willing participation, to provide adequate support through confronting learning, and to achieve long-term change. These relationships take time to develop and would need to be a consideration in the provision of time and resulting cost of a professional learning programme to improve teacher capacity.

However, once established, these trusted relationships may more readily encourage those teachers to begin to explore the other two categories of learning needs described by Beswick (2014): those that they are aware of and are reluctant to share; and those that are initially unknown.

It would appear that another significant factor in building this teacher agency is enabling teachers to have more control over their professional learning journey. This was highlighted in the comments made by Liam:

> *…the generic ones, that sort of PD is becoming less and less useful…*

Eva added:

…the most beneficial PD now, for me, is in-house stuff that is relevant to our environment, our kids, and our beliefs as teachers in this… situation…

This would seem to be the intent of the Ministry of Education with its current Communities of Learning model and the opportunity for schools to apply for funding to meet self-identified needs (Ministry of Education, 2016). However, if the professional development is still mandated by the school or Community of Schools, opportunities to develop teacher agency through professional learning may still be lacking. This is due to the assumptions that are often made in these situations about current teacher capabilities and necessary or desired capabilities (Beswick et al., 2016) rather than self-identified needs in relation to teacher capacity.

Teachers must be seen as capable of self-directing their ongoing learning journey and must be given the external support of time, money, and resources to access this self-identified need (Webster-Wright, 2009). This includes time to actively engage in professional dialogue and to develop relational trust with other professionals in order to eventually become willing to address their deeper, possibly less obvious, professional learning needs. This is highlighted by Anna in her comment:

…the barrier is time, even though it wasn't long, is finding that time, but then that would be a modification of actually allocating time and is actually more directed and it becomes embedded into the philosophy and the practice within the school…

Therefore, it is important to note that simply creating a bank of videos for teachers to access in isolation may not be a suitable method for encouraging teacher agency or building teacher capacity. As highlighted by Calvert (2016), simply providing choice to teachers does not directly lead to agency. Liam commented:

The benefit for what we did was … that there was face-to-face conversation… I guess the potential barrier is that in the future if there

was just a bank of videos that it won't be as personalised as it was this time and then I go, "That was alright and not quite what I wanted," and so there's still that potential, which a face-to-face conversation will always fix.

This may require a complete rethink within schools about the way that professional learning is offered and encouraged. Beginning the school day later on certain days to allow for the meeting of professional learning communities is one such method that may be considered. If ongoing growth in teacher capacity is, indeed, valued, then enabling structures to facilitate this professional learning may be required.

In addition, ongoing access to professional learning, such as that trialled in this study, may have alleviated Anna's concern that, due to the timing of the intervention, her professional learning selection was not immediately relevant to her teaching:

"…So, benefit is the just-in-time, but that is also the modification… so it's just about identifying what needs to happen just-in-time for my teaching… same as how we teach the children, it should be just-in-time, not just-in-case…"

However, for this *just-in-time* approach to be possible on an ongoing basis, it would be vital to have a facilitator of the professional learning available whenever required. This could even be to the point of taking on Eva's suggestion of having a live discussion function that was available whilst watching the videos. Despite this suggestion, Eva also then questioned the sustainability of this form of professional learning due to the practicalities of workload for the facilitator:

However, not sustainable for somebody to deliver that kind of PL on a regular basis… as it has been for us, individualised, which has been great, personally, but individualised, I don't know… how sustainable it is…
It needs to be generic enough that it's manageable for the people, for you, to do. So, I don't think you could do it for… everybody's different classes.

This would indeed be the challenge in the provision of this form of professional learning and further exploration of a way of ensuring that teachers have access to the professional learning that they need, when they need it, warrants further consideration.

In addition, when creating flipped videos, it would appear critical to consider limiting the videos to ten minutes and provide time markers for the various sections of the videos. This is based on feedback from participants and in line with the recommendations of Lee et al. (2017). Efficient use of time is particularly important if it poses a potential barrier for teacher participation in professional learning.

Perhaps a flipped professional learning programme could be more readily achieved if videos were used as a springboard for *just-in-time* professional conversations within professional learning communities. Both Yvonne and Eva identified this possibility as a future step for the use of this style of professional learning. Eva commented:

> *…I think it would be a great tool to be used as… a team discussion tool there to access, grab it, when you need it, discuss it as a team… you said, 'Hey team, here's a video. We're doing algebra next term. Watch the video and we'll discuss it at our next meeting,' …that would probably would have been, would be as powerful for me, that conversation with my team.*

Yvonne agreed:

> *Would I… use it in my team? Absolutely.*

This study highlighted many implications for practice, particularly with regard to the need to ensure teacher agency to engage with professional learning by developing trusted relationships, by allowing teachers to take control of their learning journeys with supportive structures in place, and by ensuring feasible

methods of accessing this learning *just-in-time.* Implications for policy will now be considered.

Implications for Policy

As a result of this study, the importance of teacher agency in mathematics professional learning was highlighted. The possibility of a mandated mathematics certification, mentioned in Chapter Two, would appear to be in stark contrast to the promotion of teacher agency.

Whilst continued improvements to the mathematics teacher capacity of Years Seven and Eight teachers is crucial, finding ways to enable teachers to take increased responsibility for this through the provision of *just-in-time* resources of videos and conversations from trusted sources may be more beneficial for long-term success. Changes to funding and enabling structures may be required. Perhaps consideration should be given to the creation of a mechanism for teachers to access funding pools themselves, rather than relying on schools to use professional learning funds for the self-determined needs of teachers.

In addition, from the findings in this study it would appear that accreditation of professional learning providers should continue to emphasise the importance of the ability of these providers to build trusted relationships. This would necessarily include the adequate provision of funds to allow the time for these relationships to be created.

Suggestions for Further Research

The flipped learning approach, with its further application for professional learning, is still a relatively new phenomenon. Therefore, further research, beyond anecdotal evidence, would be valuable. Any changes to levels of student achievement as a result of this form of professional learning would be of particular interest. Future research may focus on this aspect in order to further determine the levels of effectiveness of a flipped professional learning programme. As suggested earlier, "…the success of professional learning should

be measured not just in the benefit to the teachers, but in the improved outcomes for the students" (The Australian Senate Standing Committee of Education and Workplace Relations, 2013, as cited in Beswick, Anderson, & Hurst, 2016, p. 92).

If teachers are indeed the most important resource in any classroom (Anthony & Walshaw, 2007; Boaler, 2016), it would appear useful for further research to be conducted into the level of mathematics self-efficacy and mathematics teaching self-efficacy in teachers of Years Seven and Eight within the New Zealand context. In addition, further exploration of the relationship between self-efficacy and teacher agency would also appear to warrant further research.

Further research into any difference in outcomes for teachers who are extrinsically, compared to intrinsically, motivated to engage in professional learning would also appear useful. This is due to the apparent contrast in the synthesised findings of Timperley et al. (2007) that engagement in professional learning was more important than the motivation to engage. This would appear to be at odds with the literature regarding the importance of teacher agency and the findings of this study.

Finally, further iterations of this study would be considered useful in order to attempt to allow more teachers to access flipped professional learning as a need is self-identified within their teaching capacity. In addition, this ongoing availability of professional learning and continued development of trust, may allow for all three layers of learning needs, as identified by Beswick (2014), to be explored. These include those that the teacher is aware of and is happy to share, those that the teacher is aware of and is reluctant to share, and those that are initially unknown. This would seem likely due to the increased self-efficacy of all participants to attend professional learning experiences at the completion of the flipped professional learning intervention.

Conclusion

The flipped professional learning approach used within this study allowed for *just-in-time* learning and saw increases in self-efficacy in areas of self-identified need. This encouraged the teachers to explore their teacher capacity, including their knowledge, skill, and dispositions associated with the professional learning focus area.

From the study it was seen that teacher dispositions, particularly self-efficacy, improved for each participant in relation to their area of professional learning focus.

In addition, the way in which the flipped professional learning approach encouraged conversation was particularly valued by the participants. This highlighted the fact that a flipped professional learning approach is far from an isolated video-watching method. It is a valuable springboard into robust learning-focused conversations which are relevant to the current reality of the teacher.

Ensuring the availability of a facilitator with the appropriate range of knowledge and developed trust would be the challenge to the provision of this style of professional learning in order to ensure that it could be delivered *just-in-time*.

The accessibility and non-threatening nature of this method of professional learning could well provide a solution to improving mathematics teacher capacity in New Zealand. This would seem crucial to addressing student achievement in mathematics and to prompting a rethink of unhelpful societal discourses that relate to mathematics in Aotearoa. We all have a maths brain!

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Appendix A

Principal Consent Letter

Principal

***

Dear ***,

I am writing to request your permission to invite the Year 7 & 8 teachers at *** to participate in my research project that I am completing as a Masters student at the University of Waikato, under the supervision of AProf Nigel Calder.

My study aims to investigate: In what ways might a flipped professional learning model provide a method of increasing teacher capacity in mathematics for Year 7 & 8 teachers, particularly those with low self-efficacy in mathematics? The teachers will participate on a voluntary basis and I will ensure that teachers' participation in this study will not interfere with their usual teaching and learning programmes. Data collection, including interviews, cluster meetings, video viewing, blog reflections and planning meetings will occur outside of class time.

All information gathered during this study will be kept confidential. The school and the teacher will not be identified. Students will not be directly involved in the study. Data collection sessions with the teachers participating will be audio-recorded, with their consent, to enable later reflection and analysis of the session. During the data collection sessions, the teacher participants will have the right to stop the session completely or decline to answer a question.

I would also like your permission to approach ***, as the Deputy Principal who oversees Professional Learning within the school, to have him peruse the tools that I plan to use and to request his permission to be a support person for the participating staff if the need arose.

I have attached the letters of introduction and consent forms for the teachers that explain in detail the procedures involved in participating in this study.

Thank you for taking the time to consider allowing your school to assist with this study and please do not hesitate to contact me on *** or via return email if you require any further clarification. You could also contact my supervisor: AProf Nigel Calder, if required.

Would you please advise me of your decision to participate by return email?

Kind regards,

Angela Stensness

Appendix B

Teacher Information Letter and Informed Consent

Dear Teacher,

Invitation

You are invited to participate in a study to explore a flipped professional learning model for mathematics. This study is being conducted in order to complete my Masters Thesis at the University of Waikato, under the supervision of AProf Nigel Calder.

What is the purpose of this study?

The purpose of this study is to investigate the ways in which a flipped professional learning model might provide a method of increasing teacher capacity in mathematics for Year Seven and Eight teachers, particularly those with low self-efficacy in mathematics.

Why have I been invited to participate?

You have been invited to participate in this study because you are currently teaching Year 7 & 8 students.

What will I be asked to do?

If you consent to participate in this study, you will be invited to contribute data in the following ways:

- By participating in audio-recorded interviews for up to 20 minutes at the beginning and end of the study.
- By participating in an audio-recorded cluster group meeting for up to 1 hour at the beginning and end of the study.
- By keeping a blog of your reflections during the study.
- By watching a flipped professional learning video.

- By engaging in a follow-up planning session with the researcher following your viewing of the video in order to plan specifically for your students and your class learning situation.

Audio-recorded interviews

Should you choose to participate in the study, you will participate in an interview with the researcher at a mutually convenient time at the start and end of the intervention. Each interview will take no longer than 20 minutes and will be audio-recorded and transcribed. During the interviews the researcher will invite you to respond to questions that relate to your self-efficacy in mathematics.

You will be offered the option to read and amend the transcripts of your own interviews.

Semi-structured cluster group meeting

Should you choose to participate in the study, you will also participate in two meetings with the other participating teachers that will occur again at a mutually convenient time at the start and end of the intervention. Each meeting will take no longer than one hour and will be audio-recorded and transcribed. During the meeting the researcher will generate discussion regarding your mathematics programme, the curriculum, student responses, planning and professional learning.

You will be offered the option to read and amend the transcripts of the meetings, as a group.

Flipped professional learning

Following the initial interview and cluster group meeting, you will be provided with a flipped professional-learning video to view. After viewing the video, you will engage in a follow-up session with the researcher to clarify any aspects of the video and to create a plan specifically tailored to your learners and learning

situation. You will keep a blog during this phase of the study. Some blog prompts will be provided.

Are there any possible benefits from participation in this study?

The study will give you an opportunity to reflect upon, examine, discuss and improve your own practice in mathematics.

The mathematics education research community and the teaching community may benefit from the findings of this study in terms of identifying the opportunities available through this alternative form of professional learning.

Are there any possible risks from participation in this study?

Although it is not anticipated, there is a chance that you may feel anxious during an interview or meeting. During the interviews and meetings, you can decline to answer any or all questions or ask that the interview cease at any time without any explanation or consequence.

You will be able to view and amend interview and meeting transcripts and ask that any unprocessed part of the data or all unprocessed data that you have contributed be withdrawn from the study at any point during the project. If you experience any discomfort as a result of any aspect of this research you are able to access support from ***, as Deputy Principal in charge of professional learning.

I appreciate that your time is precious and so your participation in this study will not interfere with the usual activities of teaching and learning with your class. Data collection will occur at mutually agreed times.

What will happen to the information when this study is over?

Surveys, hard copies of interview transcripts and audio files will be stored on a password-protected computer, only accessible to the researcher.

Your name and other identifying information will be removed from the data and replaced with a pseudonym.

After a period of five years from the publication of the thesis, all transcripts and field notes will be shredded, the computer files deleted, and the raw audio deleted.

All information collected by the researcher will be treated confidentially. I will remind all participants of the importance of confidentiality and while all efforts will be made to ensure confidentiality, this cannot be guaranteed.

How will the results of the study be published?

After the completion of data collection at the end of 2017, the researcher will provide a summary report of the data for participating teachers. You will be provided with the thesis in electronic form once it has been marked and published in 2018. The results of the study may also be used in journal articles and conference presentations. The names of participating teachers and the name of the school will be anonymous in all publication of results. Pseudonyms will be used when referring to quotes from interview transcripts.

What if I have questions about this study?

If you have any questions relating to this study at any stage in the process please feel free to contact myself as researcher on *** or via email ***.

Further concerns can be directed to my research supervisor, AProf Nigel Calder at the University of Waikato or via email.

Thank you for taking the time to consider participating in this research. If you would like to participate in this study, please inform me via return email and I will be in touch to come and meet with you to have the attached consent form completed.

Kind regards,

Angela Stensness

Teacher Informed Consent Form

1. I have read and understood the Information Sheet for this study.

2. The nature and possible effects of the study have been explained to me.

3. I understand that the study involves:

- Participating in an audio-recorded interview at the start and end of the study.
- Participating in an audio recorded cluster meeting at the start and end of the study.
- Viewing researcher created professional learning videos.
- Engaging in a session following the video viewing to plan teaching and learning experiences for your particular students.
- Using a blog to record reflections during the study.

4. I understand that my participation in this study involves low risk.

5. I understand that all research data will be securely stored on the password-protected computer of the researcher.

6. Any questions that I have asked have been answered to my satisfaction.

7. I understand that the researcher will maintain confidentiality and that any information that I supply to the researcher will be used only for the purposes of the research. I understand that in any public documents arising from this research, pseudonyms will be used for my own name and the names of my school.

8. I understand that the results of the study will be published so that I cannot be identified as a participant.

9. I understand that my participation is voluntary and that I may withdraw at any time without any effect. If I so wish, I may request that any unprocessed data I have supplied be withdrawn from the research.

10. I know that I can contact AProf Nigel Calder, nigel.calder@waikato.ac.nz if required.

I give consent to participate in this study.

Yes No

Participant's name: _____

Participant's signature: _____

Date: _____

Appendix C

Participant Interview – Phase One

The scale below, from 1 to 100, will be shown as a reference for the participants when stating a number to rate themselves in response to each question below.

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

1. Rate your degree of confidence that you can do well when solving mathematics problems. _____

   Explain:

2. Rate your degree of confidence that you can give the correct answer to the following mathematics questions (you don't have to actually solve them):

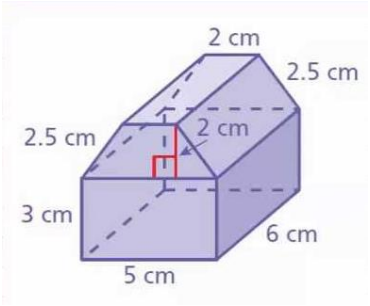
   - A recipe requires 300 grams of mince to feed 4 people. If we want to make the recipe for 25 people. How many grams of mince will we need? _____

     Explain:

   - Describe the invariant properties of translation, reflection, rotation and enlargement. _____

     Explain:

- Calculate the volume of this shape. _____



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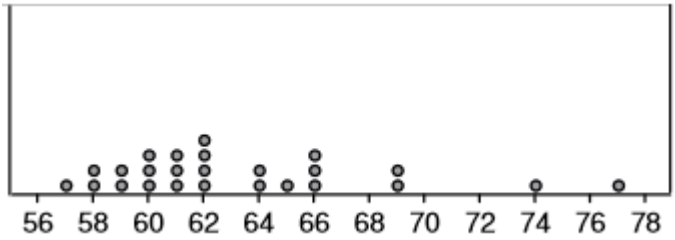
Explain:

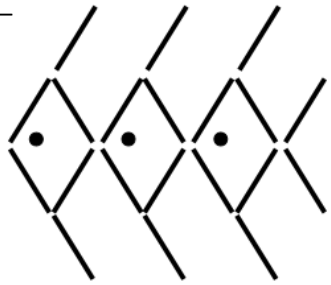
- Name the following graph type, explain what type of investigation it would be appropriate for and describe the useful analysis calculations that could be used. _____



Source of image:
https://nzmaths.co.nz/sites/default/files/curriculum/Level5StatisticsStatisticalInvestigations.pdf

Explain:

- If this pattern continued in the same way and you used 188 matchsticks to build it, how many fish would there be? _____



Source: https://nzmaths.co.nz/sites/default/files/curriculum/Level5NumberandAlgebraPatterns.pdf

Explain:

3. Rate your degree of confidence that you can teach number. _____

   Explain:

4. Rate your degree of confidence that you can teach geometry. _____

   Explain:

5. Rate your degree of confidence that you can teach measurement. _____

   Explain:

6. Rate your degree of confidence that you can teach statistics. _____

   Explain:

7. Rate your degree of confidence that you can teach algebra. _____

   Explain:

8. Rate your degree of confidence that you can teach students who struggle with mathematics. _____

   Explain:

9. Rate your degree of confidence that you can teach students who are high-achievers in mathematics. _____

   Explain:

10. Rate your degree of confidence that you can teach a Year 9 & 10 mathematics programme. _____

    Explain:

11. Rate your degree of confidence when solving mathematics problems in the real world. _____

    Explain:

12. Rate your degree of confidence when attending a mathematics professional learning course. _____

    Explain:

13. In what strand of mathematics would you most like professional learning?

    _____

Appendix D

Semi-Structured Cluster Group Meeting Prompts – Phase One

1. What is working well in your current mathematics programme?

2. What would you like to see improved in your current mathematics programme?

3. What do you believe are the most critical elements to your mathematics programme?

4. How do you go about designing and planning your mathematics programme?

5. How confident do you feel about the requirements at the various levels of the New Zealand Curriculum for each mathematics strand?

6. How confident do you feel that you can anticipate the range of student responses within a mathematics session?

7. What have been your previous experiences of professional learning in mathematics?

8. What would you like to see more of in professional learning programmes for mathematics?

9. What would you like to see less of in professional learning programmes for mathematics?

10. What are the barriers to you participating mathematics professional learning opportunities?

11. What do you think the benefits of a flipped mathematics professional-learning programme might be?

12. What do you think the barriers of a flipped mathematics professional-learning programme might be?

13. What do you think would be useful for a flipped mathematics professional-learning video to contain?

14. Other comments

Possible probing questions:

- Tell me more about that
- Can you give me an example?
- What do you mean by that?
- What makes you think that?

Appendix E

Blog Prompts – Phase Two

As you engage in the "Flipped Professional Learning Intervention" record your reflections.

Here are some possible prompts that you might like to use:

- How was the flipped video helpful?
- How could the flipped video be improved?
- How useful was the follow-up session following the video?
- What has changed as a result of your participation in the process?
- Have you experienced any change in your levels of confidence following your participation in the process?
- Have you identified any benefits from a flipped professional-learning model?
- Have you any recommendations for improving a flipped professional-learning model?

Appendix F

Participant Interview – Phase Three

The scale below, from 1 to 100, will be shown as a reference for the participants when stating a number to rate themselves in response to each question below.

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

14. Rate your degree of confidence that you can do well when solving mathematics problems. _____

    Explain:

15. Rate your degree of confidence that you can give the correct answer to the following mathematics questions (you don't have to actually solve them):

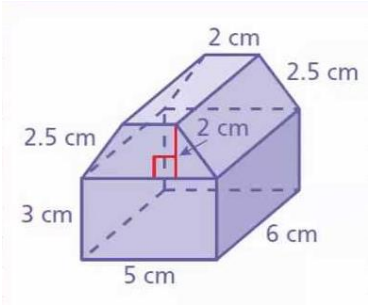
    - A recipe requires 300 grams of mince to feed 4 people. If we want to make the recipe for 25 people. How many grams of mince will we need? _____

      Explain:

    - Describe the invariant properties of translation, reflection, rotation and enlargement. _____

      Explain:

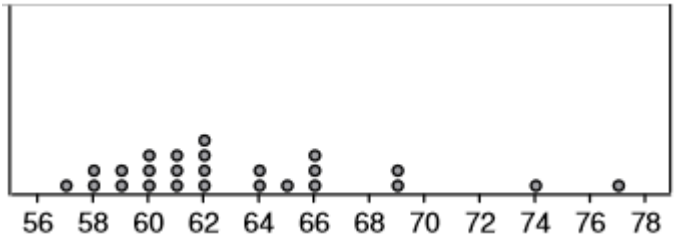
- Calculate the volume of this shape. _____



Source of image: https://i.ytimg.com/vi/TyRe9MZMziM/maxresdefault.jpg

Explain:

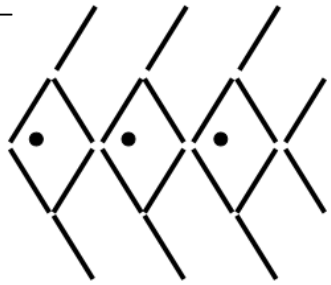
- Name the following graph type, explain what type of investigation it would be appropriate for and describe the useful analysis calculations that could be used. _____



Source of image:
https://nzmaths.co.nz/sites/default/files/curriculum/Level5StatisticsStatisticalInvestigations.pdf

Explain:

- If this pattern continued in the same way and you used 188 matchsticks to build it, how many fish would there be? _____



Source: https://nzmaths.co.nz/sites/default/files/curriculum/Level5NumberandAlgebraPatterns.pdf

Explain:

16. Rate your degree of confidence that you can teach number. _____

    Explain:

17. Rate your degree of confidence that you can teach geometry. _____

    Explain:

18. Rate your degree of confidence that you can teach measurement. _____

    Explain:

19. Rate your degree of confidence that you can teach statistics. _____

    Explain:

20. Rate your degree of confidence that you can teach algebra. _____

    Explain:

21. Rate your degree of confidence that you can teach students who struggle with mathematics. _____

    Explain:

22. Rate your degree of confidence that you can teach students who are high-achievers in mathematics. _____

    Explain:

23. Rate your degree of confidence that you can teach a Year 9 & 10 mathematics programme. _____

    Explain:

24. Rate your degree of confidence when solving mathematics problems in the real world. _____

    Explain:

25. Rate your degree of confidence when attending a mathematics professional learning course. _____

    Explain:

26. In what strand of mathematics would you most like professional learning?

    _____

Appendix G

Semi-Structured Cluster Group Meeting Prompts – Phase Three

1. What has changed in your mathematics programme following your flipped professional learning experience?

2. What would you still like to see improved in your current mathematics programme?

3. Has there been any change to your confidence in anticipating student responses within a mathematics session?

4. Has there been any change to your ability to articulate and understand the requirements of the various levels of the New Zealand Curriculum for the various strands of mathematics?

5. What changes might you make to your previous method of planning and designing mathematical experience following on from this professional learning experience?

6. Describe your experience of flipped professional learning in mathematics compared with previous professional learning experiences in mathematics?

7. What do you think the benefits of a flipped mathematics professional-learning programme might be?

8. What do you think the barriers of a flipped mathematics professional-learning programme might be?

9. What modifications would you suggest to the flipped professional-learning videos and follow up session?

10. Other comments

Possible probing questions:

- Tell me more about that
- Can you give me an example?
- What do you mean by that?
- What makes you think that?

Appendix H

Mathematics Curriculum Strand Summary Level 1 – 5

The following three Mathematics Curriculum Strand Summaries were compiled by the researcher, based on the New Zealand Mathematics Curriculum (Ministry of Education, 2007).

Algebra

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Equations and Expressions					
Communicate and explain counting, grouping, and equal-sharing strategies, using words, numbers, and pictures.	Communicate and interpret simple additive strategies, using words, diagrams (pictures), and symbols.	Record and interpret additive and simple multiplicative strategies, using words, diagrams, and symbols, with an understanding of equality.	Form and solve simple linear equations.	Form and solve linear and simple quadratic equations.	Form and solve linear equations and inequations, quadratic and simple exponential equations, and simultaneous equations with two unknowns.
Patterns and Relationships					
Generalise that the next counting number gives the result of adding one object to a set and that counting the number of objects in a set tells how many.	Generalise that whole numbers can be partitioned in many ways.	Generalise the properties of addition and subtraction with whole numbers.	Generalise properties of multiplication and division with whole numbers.	Generalise the properties of operations with fractional numbers and integers.	Generalise the properties of operations with rational numbers, including the properties of exponents.
Create and continue sequential patterns.	Find rules for the next member in a sequential pattern.	Connect members of sequential patterns with their ordinal position and use tables, graphs, and diagrams to find relationships between successive elements of number and spatial patterns.	Use graphs, tables, and rules to describe linear relationships found in number and spatial patterns.	Relate tables, graphs, and equations to linear and simple quadratic relationships found in number and spatial patterns.	Relate graphs, tables, and equations to linear, quadratic, and simple exponential relationships found in number and spatial patterns.
					Relate rate of change to the gradient of a graph.

Geometry

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Shape					
Sort objects by their appearance.	Sort objects by their spatial features, with justification.	Classify plane shapes and prisms by their spatial features.	Identify classes of two- and three-dimensional shapes by their geometric properties.	Deduce the angle properties of intersecting and parallel lines and the angle properties of polygons and apply these properties.	Deduce and apply the angle properties related to circles.
	Identify and describe the plane shapes found in objects.	Represent objects with drawings and models.	Relate three-dimensional models to two-dimensional representations, and vice versa.	Create accurate nets for simple polyhedra and connect three-dimensional solids with different two-dimensional representations.	Recognise when shapes are similar and use proportional reasoning to find an unknown length.
					Use trigonometric ratios and Pythagoras' theorem in two and three dimensions.
Position & Orientation					
Give and follow instructions for movement that involve distances, directions, and half or quarter turns.	Create and use simple maps to show position and direction.	Use a co-ordinate system or the language of direction and distance to specify locations and describe paths.	Communicate and interpret locations and directions, using compass directions, distances, and grid references.	Construct and describe simple loci.	Use a co-ordinate plane or map to show points in common and areas contained by two or more loci.
Describe their position relative to a person or object.	Describe different views and pathways from locations on a map.			Interpret points and lines on co-ordinate planes, including scales and bearings on maps.	
Transformation					
Communicate and record the results of translations, reflections, and rotations on plane shapes.	Predict and communicate the results of translations, reflections, and rotations on plane shapes.	Describe the transformations (reflection, rotation, translation, or enlargement) that have mapped one object onto another.	Use the invariant properties of figures and objects under transformations (reflection, rotation, translation, or enlargement).	Define and use transformations and describe the invariant properties of figures and objects under these transformations.	Compare and apply single and multiple transformations.
				Apply trigonometric ratios and Pythagoras' theorem in two dimensions.	Analyse symmetrical patterns by the transformations used to create them.

Measurement

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Order and compare objects or events by length, area, volume and capacity, weight (mass), turn (angle), temperature, and time by direct comparison and/or counting whole numbers of units.	Create and use appropriate units and devices to measure length, area, volume and capacity, weight (mass), turn (angle), temperature, and time.	Use linear scales and whole numbers of metric units for length, area, volume and capacity, weight (mass), angle, temperature, and time.	Use appropriate scales, devices, and metric units for length, area, volume and capacity, weight (mass), temperature, angle, and time.	Select and use appropriate metric units for length, area, volume and capacity, weight (mass), temperature, angle, and time, with awareness that measurements are approximate.	Measure at a level of precision appropriate to the task.
	Partition and/or combine like measures and communicate them, using numbers and units.	Find areas of rectangles and volumes of cuboids by applying multiplication.	Convert between metric units, using whole numbers and commonly used decimals.	Convert between metric units, using decimals.	Apply the relationships between units in the metric system, including the units for measuring different attributes and derived measures.
			Use side or edge lengths to find the perimeters and areas of rectangles, parallelograms, and triangles and the volumes of cuboids.	Deduce and use formulae to find the perimeters and areas of polygons and the volumes of prisms.	Calculate volumes, including prisms, pyramids, cones, and spheres, using formulae.
			Interpret and use scales, timetables, and charts.	Find the perimeters and areas of circles and composite shapes and the volumes of prisms, including cylinders.	