MATHEMATICS ANXIETY IN THE CLASSROOM: DEVELOPING A PROFESSIONAL LEARNING PLATFORM FOR TEACHERS

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ABSTRACT

The last decade has seen an ever-increasing body of empirical research around Mathematics Anxiety specifically from psychology and educational neuroscience perspectives. However, findings from current research have not been effectively translated into classroom practice. This study seeks to ameliorate this gap by developing a professional learning platform to bring this knowledge into the classroom.

Using Mathematics Anxiety as a platform, this research explores working relationships between specialist intermediaries and classroom teachers, as a basis for teacher professional learning. A specialist teacher (the researcher) worked in the middle school classroom to demonstrate strategies to increase student engagement interactive positive self-talk, and reflection of students with mathematics anxiety to the classroom teacher. This study will endeavour to fill the void in the literature regarding effective use of strategies to support students with Mathematics Anxiety but also further develop the role of dyadic professional learning for teachers.

DECLARATION OF CANDIDATE

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief that it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed,

Mr Simon Fuller

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LIST OF ABBREVIATIONS & ACRONYMS

ABS	Australian Bureau of Statistics
ANT	Actor Network Theory
DECD	Department for Education and Child Development (for South Australia 2011-2017)
DfE	Department for Education (for South Australia 2018-)
OECD	The Organisation of Economic Cooperation and Development
MUSEC	Macquarie University Special Education Centre
PLN	Professional Learning Network
SPELD S.A.	Specific Learning Difficulties Association of South Australia

CHAPTER I

I. Introduction to Topic

In recent years, there has been growing concerns about teachers' knowledge and capacity to effectively support students with Mathematics Anxiety (Beilock & Maloney, 2015; Lyons & Beilock, 2015). Mathematics Anxiety is a complex condition that encompasses a variety of cognitive, affective and socio-cultural factors (Young, Wu, & Menon, 2012; Wang, Hart, Kovas, Lukowski, Soden, Thompson, Plomin, McLoughlin, Bartlett, Lyons & Petrill, 2014; Pellicioni, Nunez-Pena & Colome, 2016; Carey, Devine, Hill, Dowker, McLellan & Szucs, 2019; Skagerlund, Ostergren, Vastfjall & Traff, 2019).

However, it is the vast base of causality which includes social and cultural factors like intergenerational family and teacher affect (Rattan, 2012; Berkowitz, Schaeffer, Maloney, Peterson, Gregor & Levine, 2015; Maloney, Ramirez, Gunderson, Levine & Beilock, 2015) that can drive questions regarding its classification as a trait anxiety or a phobia type, and what should be addressed first. Recent studies from researchers like that of Carey, Devine, Hill, Dowker, McLellan, & Szucs, (2019) Carey, Hill, Devine and Szucs (2016) and Lukowski, DiTripani, Jeon, Wang, Schenker, Doran, Hart, Mazzocco, Willcutt, Thompson, and Petrill (2016), look beyond this conundrum and state that any interventions need to focus on the specific interplay that mathematics and anxiety may have on each other within an individual.

Mathematics Anxiety was first identified in the 1970s using a measurement scale (Richardson & Suinn, 1972) to diagnose the severity of the condition. Some meta-analyses of Mathematics Anxiety started to come out during the 1990s describing key psychological features of the condition (Hembree, 1990; Ma, 1999). During this time, educational strategies also began to emerge to address Mathematics Anxiety (Parmar & Cawley, 1991; Tobias, 1993).

Despite significant findings from the learning sciences, over the years, regarding causality and recommendations for dealing with Mathematics Anxiety the incidence of the condition, has not waned (Young, Wu & Menon, 2012; Wang, et al., 2014; Lukowski et al., 2016). During the time of these findings, there has been commentary from the Learning Sciences stating that these recommendations are not necessarily being taken up by teachers (Lyons & Beilock, 2011; Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Beilock & Willingham, 2014; Koch, 2018). This highlights a theory to practice issue of which both the Education and

Learning Sciences fields may have contributed to. In addition, there is the possibility that teachers simply do not have the expertise to discern and understand this information (Ansari & Coch, 2006; Gardner, 2008; Beilock & Willingham, 2014; Immordino-Yang, 2015 & 2016; Koch, 2018).

This investigation used a model of professional learning in which the researcher (who takes on the duties of a specialist teacher) works alongside a classroom teacher to implement strategies to lessen the impact of Mathematics Anxiety in a classroom setting. Appraising the working relationship between the teacher and specialist over an extended period, and considering the framework surrounding this relationship were the key factors in determining the study's model as a viable option for future professional learning. Coupling ethnographic research with participant observational research allowed both teacher and specialist to observe, record, and direct teaching and learning practices with each other within the classroom.

The professional learning platform brought in a complementary perspective to professional learning that catered for the specific needs of teachers. The teacher participant was given the opportunity to - learn from the specialist directly, to observe and review the work of the specialist, and contribute to improving the learning of all within a collaborative space.

A study of the literature indicates that Mathematics Anxiety is a contemporary issue which existing pedagogies and practices are not addressing. Beilock and Willingham (2014), Koch (2018), Ramirez, Shaw & Maloney (2018) suggest that there is a degree of confusion in the education community regarding how to address Mathematics Anxiety, and that not enough is being done at the early intervention level of education to prevent the onset of this condition. This makes Mathematics Anxiety an ideal topic for the professional learning platform (Sorvo, Koponen, Viholainen, Aro, Raikkonen, Peura, Tolvanen & Aro, 2019).

II. Research Objectives and Questions

This investigation sought to answer the following key question:

> How can the gradual presentation of new knowledge and skills that has been introduced by an educational specialist (the researcher) into a classroom impact teachers' knowledge and pedagogy?

To answer this question, a professional learning model was set up to determine the capacity of a professional learning relationship between a classroom teacher and specialist teacher.

Three key strategies for reducing Mathematics Anxiety (the intervention package) were introduced into the classroom by the specialist as the main source of professional learning for the teacher.

III. Significance of the Study

The last fifty years has seen a significant increase in literature outlining professional learning in Australia and overseas. During this time, a reasonably strong delineation between effective and less effective professional learning types have emerged. Some of the less effective types emerge out of poor pedagogical attributes but also out of the demands from the growing professionalisation of not only teaching, but of the professional learning apparatus itself (Bradbury, Frost, Kilminster & Zukas, 2010). For example, globalisation means that teachers now must hold a world-wide reference point to effectively teach. The continual generation of information means that their levels of expertise and knowledge will always need to be updated. Consequently, the modern teacher's access and use of professional learning is now hindered by the following factors:

- The modern teacher's need for professional learning is constant, but in practice it is temporary and short-lived.
- The modern teacher is surrounded by an overload of information.
- The modern teacher now works within a profession governed by increased managerialism which itself requires professional learning for teachers to understand and follow.
- The modern teacher's capacity to generate data supersedes their capacity to use it effectively for pedagogical reasons.
- The modern teacher's access to professional learning is in part influenced by the obligations to the partnerships and networks that they participate in.
- The modern teacher's access and use of professional learning is in part influenced by the learning standards within curriculum that they require.

(Leadbetter, 1999; Furlong, 2005; Bradbury et al.; 2010; Deluca, Bolden, & Chan, 2017).

There is consensus within the professional learning literature as to what constitutes effective professional learning. Effective professional learning is:

- sustained and cumulative over time, and offers a progression of skills and knowledge, and opportunity for practice of these skills.
- able to provide opportunities for collaborative and meaningful discourse and activities.
- embedded in schools.
  (Penuel, Fishman, Yamaguchi & Gallagher, 2007; Darling-Hammond et al., 2009; DeLuca, Shulha, J., Luhanga, Shulha, L.M, Klinger, & Christou, 2015; Opfer, 2016; Campbell et al., 2017).

Professional learning platforms that stem from such attributes include professional learning communities, collaborative and transformative learning amongst colleagues, and dyadic structures like coaching and mentoring. However, other professional learning platforms such as workshops and seminars, courses with little recourse for feedback and those that are self-directed without parameters, drop significantly in effectiveness (Cole, 2012; Jensen et al., 2016).

With little investigation and evidence of Australian teachers' participatory record in the spectrum of professional learning, there was a need to look at what other education systems are doing overseas. Results from a recent American survey indicated that over 80 per cent of professional learning available to American teachers occurs in a workshop format (Campbell et al., 2017).

Cole (2004) along with Richards and Farrell (2005), believe that stand-alone workshops can be fragmented, have low intensity, and offer little recourse for follow up, making them weak options for professional learning. Bodkin (2013) noted that, "workshop series raised awareness, but transfer is not guaranteed without time, follow-up and coaching support" (p. 25).

When some of the important principles of effectiveness like duration and continued support are applied to one-to-one structures like co-teaching, mentoring and coaching they are among the most sought-after professional learning platforms by teachers (Wilson, 2013; Kemmis, Heikkenen, Frannson, Aspfors, & Edward Groves, 2014; Adams, 2017). By introducing a more intensive arrangement like a one-to-one relationship with the specialist, the teacher has greater input and can guide the professional development to suit their needs. Simmel's 1950 model of dyadic relationships was used in this study to investigate the one-to-one relationship between specialist and teacher. Simmel's model between a practitioner and a respected other,

laid the foundations of the modern interpretations of coaching and mentoring (Garvey, Stokes & Megginson, 2009). The core philosophy behind Simmel's model was the idea that two people was ideal in fostering a mutually productive and private relationship (Simmel, 1950). These are attributes which are seen in regarded dyadic professional learning models like mentoring, tutoring, coaching, and co-teaching (Garvey, 1994; Willis, 2005; Aspfors & Fransson, 2015).

This study focused on building an extended non-lineal model for teachers that can be tailored for specific teacher needs like pedagogy, location, and student cohort (Clarke & Hollingsworth, 2002; Desimone, 2009; Adams, 2017). Consequently, there was significant inquiry regarding the professional dyadic structure between teacher and specialist as an effective platform for professional learning. This study focused on supporting professionals' agency to participate in authentic learning (Webster-Wright, 2009; Oweis, 2014) into a current area of concern for teachers.

The area of concern, Mathematics Anxiety, is a condition with prevalence levels on the rise (Ashcraft & Moore, 2009; Beilock & Willingham, 2014; Dowker, Sarkar & Looi, 2017). Ashcroft (2002) describes it as a learning condition that can be encapsulated as "a feeling of tension, an apprehension or fear that interferes with math performance…" (p.1). The increase of Mathematics Anxiety in 21st century classrooms heralds two possible underlying factors. The first is effective dissemination of knowledge from some of the learning sciences like educational neuroscience, interpersonal neuro-biology and developmental psychology is poorly guided and constructed, and the second, the existence of Mathematics Anxiety in 21st century classrooms questions pedagogical practice used currently in mathematics classrooms.

Inadequate dissemination and insufficient understanding of the issues surrounding and addressing Mathematics Anxiety (Ansari & Coch, 2006; Goswami, 2006; Varma, McCandliss, & Schwartz, 2008; Macdonald, Germine, Anderson, Christodoulou & McGrath, 2017) makes this a sound area for investigation and a testing ground in how teachers and specialists can effectively collaborate with each other to improve practice in a classroom setting. This work may impact how issues like Mathematics Anxiety can be realistically addressed at the interface between educational theory and practice. A key feature of 21st schooling is the ever-concerning rise of mental illnesses like anxiety, depression, and trauma-related disorders (Australian Bureau of Statistics, 2008; Douglas & Wodak, 2016). The outcomes from this investigation have enabled the development of recommendations to assist

classroom teachers to effectively translate information and strategies regarding Mathematics Anxiety.

IV. Approach and Structure of Dissertation

This inquiry was based on ethnographic case study attributes along with participatory developmental research and therefore used a multi- methods approach. Four teachers were part of a purposive sample to investigate the structure and effectiveness of a dyadic professional learning structure around Mathematics Anxiety.

The area of Mathematics Anxiety was chosen for professional learning between researcher and teacher, due to the current inconsistent capacity and knowledge of teachers to support students with this condition (Brian, 2012; Beilock & Willingham, 2015; Dowker, Sarkar & Looi, 2016; Mammarella, Caviola, & Dowker, 2019). The literature review outlines the gap between teachers' knowledge and capacities, and what has been accomplished in the learning sciences over the last few decades. The review also describes the background of three evidence-based strategies chosen for the intervention: positive priming and mindsets; affective vocabulary and biblio-therapy; and working memory. Also discussed in the literature review is the construction and duration of the dyadic professional learning platform in line with current research and findings from the literature on professional learning.

The researcher as part of this investigation, was introduced into four classes as the specialist to disseminate knowledge about Mathematics Anxiety and share three key evidence-based strategies (positive priming/mindsets, affective vocabulary/biblio-therapy, and working memory) within the classroom. Although the specialist and teacher were the primary agents of the study, the student cohort played the third agent and an important supporting role in the direction and success of the activities performed throughout. Actor Network Theory (ANT) was chosen as the theoretical framework to describe how information and learning is translated and understood between the three agents and on a variety of levels (specialist and teacher, teacher and students, specialist, and students).

Chapter III explains the initial theoretical framework, and the use of ANT. Addressed in this chapter is the author's interpretation of the framework, and how it was used to explain the data gathered during the investigation.

Chapter IV outlines the methodologies used for the investigation, a mixed methods approach. An initial survey identified initial knowledge and attitude levels of teachers. From this information, working relationships between the teachers and researcher (specialist) were formed. Teachers were informed that the collection of data served two key complementary purposes. One is at a static level, where teacher and specialist have a reasonable amount of time to observe, analyse, and learn from the work of students within the classroom. The other level is developmental, encompassing the professional learning journeys of teachers. Teachers were given the capacity to reflect and develop their learning and practice through meetings, collaboration and dialogue with the researcher.

Chapter V describes the contexts of the four schools involved in the shape of initial Actor Network Theory maps, along with a more detailed description of the differing student cohorts and teacher participants. This assists the presentation of findings in Chapter VI, where the learning and development of the four participant teachers is explained and the corresponding results evidenced in the student cohorts. Recommendations are made for future research, along with some final comments in relation to professional learning and Mathematics Anxiety.

V. Summary

This chapter outlines to the reader the study and scope of this dissertation. It explains the rationale of the research questions and significance of the study to the education community. The approach of research and organisation of this inquiry has been outlined to provide the reader with the understanding and direction of this thesis.

Chapter II: Literature Review

I. Overview

The literature review is divided into four sections. The first outlines current global research depicting the general perception of what is known about Mathematics Anxiety, in comparison to what is known from the learning science community. Section Two discusses how new findings from scientific fields which may be important to the discipline of education are not normally being effectively transferred and translated into understandable and workable knowledge for teachers. The third section of the literature review targets recent research literature in relation to Mathematics Anxiety and the impact of positive affect and mindsets, affective vocabulary, and expression, and improving working memory. The final section will address the implementation of these strategies and an examination of the current state of professional learning in Australia in terms of dyadic frameworks such as, mentoring, tutoring, and coaching.

II. The Complex Guises of Mathematics Anxiety

In its first formal definition, Mathematics Anxiety was described as involving feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Richardson & Suinn, 1972, p.551). Advances and new interpretations in neuroscience and psychology over the last thirty years have not changed the general interpretation and definitions of Mathematics Anxiety.

Definitions may influence many to see Mathematics Anxiety simply as a learning difficulty due to its 'seen' behavioural markers (Shalev, 2009; Mazzocco, 2009). A learning difficulty is one where environmental and non-biological factors influence the state of learning (Shalev, 2009; Mazzocco, 2009). Defining Mathematics Anxiety as a learning difficulty does not effectively incorporate the unseen developmental attributes that can arise from changing socio-biological conditions from within a sufferer. Ashcraft (2009), frequently questions whether Mathematics Anxiety is a learning disability or not and concluded that it does not fit the classic indicators of a learning disability and that the characteristics of Mathematics Anxiety need to be taken quite seriously. Nearly 20 percent of the population can suffer anything from a mild to severe form of the anxiety disorder indicating a spectrum of

causalities as well as symptoms (Ashcraft & Moore, 2009; Johnston-Wilder, Brindley, & Dent, 2014).

In its severest form, Mathematics Anxiety functions as a mathematical learning disability and as an anxiety disorder (Ashcraft, 2009; Carey, 2014). It is a condition that can produce panic attacks that affect both body and mind physically and mentally (Jensen & Nutt, 2015; Shackman, Salomons, Slagter, Fox, Winter, Davidson, 2011; Eisenberger, 2012).

There is a range of causalities that can be predisposed: neuro-cognitive, socio-cultural, and educational (Ashcraft, 2009; Rattan, 2012; Scrimin 2014; Yanuarto, 2016). From the cognitive neuroscience perspective, Mathematics Anxiety may come from cognitively innate (working memory deficit) or 'learnt' developmental experiences (Ashcraft & Kirk, 2001; Ashcraft & Moore, 2009; Ma & Xu, 2004).

Rubensten and Tannock's (2010) landmark study positively correlated Mathematics Anxiety as being a co-occurring condition with the most prevalent of mathematical learning disabilities, developmental dyscalculia. By using numerical and negative affective priming, Rubensten & Tannock were able to provide affective evidence that children with Developmental Dyscalculia view mathematics with fear because of their learning disability. Further work investigating the possibility of a negative attentional bias among children with Mathematics Anxiety confirms this and has set the groundwork for the research into future affective modification programs (Rubinsten, Eidlin, Wohl, & Akibli, 2015; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2016).

The relationship between Mathematics Anxiety and Developmental Dyscalculia, therefore, may be a significant indicator that Mathematics Anxiety could mask other related co-occurring conditions like Attention Deficit Hyperactivity Disorder (ADHD) and other significant learning disabilities (Bevan & Butterworth, 2007). Apart from working memory, Mathematics Anxiety may signal other neuro-cognitive deficits in mathematics like attention (Askenazi, 2010) or difficulty in counting (Maloney, Risko, Ansari & Fugelsang, 2010).

School stressors including such tasks as being asked to answer in front of the class and working within a time frame have been shown to reduce performance (Scrimin, Mason & Moscardino, 2014) along with stereotype threat based on gender or cultural background (Beilock, Gunderson, Ramirez & Levine 2010). Learned helplessness (Parmar & Cawley, 1991) and teacher and parent perceptions about mathematics are socio-cultural factors that can seed Mathematics Anxiety (Mercer & Pullen, 2009).

The literature indicates a depth and array of complexity around the condition of Mathematics Anxiety that teachers may not be aware of. There has been a significant lack of exploration into teachers' understanding of the prevalence or parameters of the condition and how teachers deal with Mathematics Anxiety in the classroom.

In Headley and Campbell's Australian study conducted in 2013, 358 primary school teachers were surveyed about their general concept of anxiety. The study found that the teachers presented a basic understanding of anxiety and could identify a reasonable spread of symptoms (cognitive, physiological, emotional, and relational) which had not been acknowledged before. However, most teachers found the experience of anxiety among their students to be un-natural and that it was simply a response that the students were not coping (Headley & Campbell, 2013). The authors agree that this response reflects a lack of awareness that anxiety is a natural experience to certain stimuli and found that the teachers did not see anxiety as a concept with a spectrum of severity from mild to severe forms as illustrated in Eysenck's model (1997). Many of the teacher participants agreed that although they were expected to identify anxiety markers, they had a low understanding of the area and may not be able to successfully provide adequate support for the affected students (Headley & Campbell, 2013).

Unlike scientific research conducted over twenty years ago which demonstrated a significant correlation between Mathematics Anxiety and low mathematics ability (Hembree, 1990; Gordon, 1992; Ma X, 1999) more recent research claims that Mathematics Anxiety can be described as a 'reciprocal' phenomenon (Carey et al., 2016) and can also be indiscriminate on a variety of levels (Lau, Hawes, Tremblay & Ansari, 2022). This means that either anxiety or low mathematical ability can potentially trigger the condition, and that those students with high mathematics ability are just as susceptible as students with low mathematics ability (Wang, Hart, Kovas, Lukowski, Soden, Thompson, Plomin, McLoughlin, Bartlett, Lyons & Petrill, 2014; Carey et al., 2016).

A recent scientific study (Devine, Hill, Carey & Szucs, 2018) made a significant education call that interventions needed to be far-reaching to include students with average and above-average mathematical aptitude:

> ...the majority of children with high mathematics anxiety have adequate or even high mathematics performance. These findings suggest that for the most part, each of these math learning problems needs to be treated separately; interventions targeted toward reducing or offloading worrying thoughts may be beneficial to children with math anxiety, whereas interventions focusing on improvement of numerical

> skills and working memory are more likely to be successful in the treatment of developmental dyscalculia (p.431, Devine, Hill, Carey, & Szucs, 2018)

This statement demonstrates that the broad cognitive and affective causality of Mathematics Anxiety can influence a large proportion of children within a classroom. Although students with limited or deficient mathematical capacity can be affected by Mathematics Anxiety, students with strong cognitive and emotional capacity can also fall victim to the affective aspect of Mathematics Anxiety (West, Kraft, Finn, Martin, Duckworth, Gabrieli & Gabrieli, 2016; Lau et al, 2022).

The above research demonstrates that Mathematics Anxiety can take on the guise of a learning disability, an anxiety disorder, and socio-cultural dimensions that teachers need to be aware of (Pellizzoni, Cargnelutti, Cuder & Passolunghi, 2021; Lau et al, 2022) to provide a sufficient range of interventions and assistance to students. If both culture and genetics play a role in the manifestation of Mathematics Anxiety then "anything less than an interdisciplinary approach spanning multiple levels of analysis leaves something missing" (p.407, Stein, Connell & Gardner, 2008).

For Mathematics Anxiety to be addressed in the classroom, interventions need to encompass the social, neuro-cognitive, personal, and biological levels of the condition. This may seem daunting, but interpersonal neurobiology (Siegel, 2012; Chopra & Tanzi, 2017; Siegel, 2018) along with input from neuropsychology and social/affective neuroscience allows for recognition of the full mind-body experience (Cozolino, 2014; Siegel, 2014) of a student with Mathematics Anxiety within a network of significant others that include parents and teachers.

III. The Learning Sciences Gap: Paving the way for a Specialist Intermediary

Neuroscience, along with other learning sciences, can pose a significant enticement to the teaching profession. In a 2007 survey nearly 90 percent of respondents from a teaching background believed that a knowledge of the brain was important (Pickering & Howard-Jones, 2007), believing that 'scientific evidence' provides teaching interventions with an evidence-based foundation. A more recent survey in the United Kingdom supports this view (Simmonds, 2014) with a cohort of over 1000 teachers responding to a wide range of questionnaires about the use of neuroscience in the classroom with many showing significant

interest in the areas of dyslexia and dyscalculia. However, an unsettling finding was that over 60 percent of teachers accepted that their knowledge of neuroscience was insufficiently small (Simmonds, 2014).

Studies by Weisburg, Keil, Goodstein, Rawson and Gray (2008), and Zambo and Zambo (2011) highlight that the mere mention of neuroscience as a field swayed the judgement of teachers in their beliefs and teaching practices. McCabe and Castel (2008) along with Weisburg et al, (2008) deliberately fabricated scientific information in their surveys to test the resolve of teachers. Over 75 percent of both teacher cohorts believed that the presented 'scientific facts' were true even though they were not. Although this could be seen reflective of the general community, these findings demonstrate that educators may not have a solid foundational understanding of the learning sciences.

This demonstrates that the teaching profession may not be sufficiently trained or equipped to protect themselves from the fabrication of science. It also demonstrates that there may be significant cognitive biases at work. Teachers may be reacting to constructed assumptions about the learning sciences. Whether this can be attributed to some type of cognitive bias educators may not have a sufficient scientific literacy to sift through a quagmire of information that may come from a range of pseudo-science, scientific opinion, or peer-reviewed science literature. The challenge for teachers with limited scientific knowledge is to know where they can put their trust and what they can trust on the internet, and in the literature. A culture and market are emerging that could potentially harm the relationship between education and the learning sciences. Since the 1990s, pseudo-scientific information in the form of brain-based learning and self-help products making promises to improve learning, teaching, and behaviour are being sold to parents and teachers everyday (Willis & Willis, 2006; Dekker, Lee, Howard-Jones & Jolles, 2012; Howard-Jones, 2014; Canosa & Collado Ruano, 2019).

A key example of this potentially harmful culture is demonstrated by the emergence of 'neuromyths'. Neuro-myths can be described as popular but false beliefs about the brain (Dekker, Lee, Howard-Jones & Jolles, 2012; Howard-Jones, 2014). One type of neuro-myth can be the commercial construction of a methodology based on misconstrued information about the brain, better known as brain-based learning. Key examples include Brain Gym and the Dore Program that have been highlighted by organisations like Specific Learning Difficulties Association of South Australia (SPELD, S.A.) and Macquarie University Special

Education Centre (MUSEC) to be based on poor or questionable research (https://speld-sa.org.au/faq/helpful-educational-practices-program-for-your-child.html). Howard-Jones (as cited in Sparks, 2012) suggests that "we don't have much neuroscience in our teacher training; most of the books available are from the brain-based-learning industry, not scientists…In the absence of legitimate neuroscience in education a neuro-mythology has arisen in schools" (p.16).

The other type of neuro-myth is based on antiquated or simply incorrect information about the brain. For example, left and right brain learners is an over-simplification of how localisation works within the brain, along with the perception that the brain must go through 'critical periods' of development to fully mature (Christodoulou & Gaab, 2009; Dekker, Lee, Howard-Jones, & Jolles, 2012; Betts, Miller, Tokuhama-Espinosa, Shewokis, Anderson, Borja, Galovan, Delaney, Eigenauer & Dekker, 2019).

To correct some of these assumptions, the human brain is highly malleable. The process of neuroplasticity has shown to be an important tool for those undergoing physical rehabilitation, compensating sensory impairment, or overcoming a learning disability (Christodoulou & Gaab, 2009; Dekker, Lee, Howard-Jones & Jolles, 2012; Carey, 2014; Pittman & Karle, 2015).

Neuro-myths and the expanse and effect of the brain-based industry demonstrates the difficulty teachers are currently facing in knowing who to turn to, to provide accurate information about the learning sciences. Nouri and Mehrmohammadi (2012) describe the need to tame the "eager educators who are desperate to translate brain research into classroom practices. That unbridled exuberance is why the educational field is wrought with overgeneralizations, misconnections and lingering myths about the brain and learning" (p. 15).

This situation highlights a significant professional learning issue in how teachers can freely access raw unsolicited information about the learning sciences. Cyber-space has allowed non-trained as well as trained observers to consume the information of neuroscience freely and easily. The science community requires a conduit and mechanisms by which scientific information is appropriately harnessed and filtered for teachers to use.

The deployment of specialist teachers with a solid understanding of sciences in professional learning settings is one possible solution. The use of specialist intermediaries is an ideal way for teachers to be exposed and learn how to critique the 'neuro-myth' culture while being

educated in a topic area like Mathematics Anxiety (Gardner, 2008; Fischer, 2009). This idea, however, is not new.

The idea of an intermediary or 'neuro-educator' was first conceptualised by Fuller and Glendining (1985) and then popularised by Gardner (2008) and Fischer (2009) over a decade later, to bring in an agent (trained in educational practice) to communicate and use neuro-scientific knowledge in a discourse that teachers could comprehend and utilise. Only recently, commentators in the field of educational neuroscience have started raising this matter again (Sylvan & Christodoulou, 2010; Summak, Summak, & Summak, 2010; Zadina, 2015). A void is further emerging today that teachers do not necessarily have regular access and contact to outside experts for not only their own learning and development, but to directly address current student issues like Mathematics Anxiety.

IV. The Intervention (Three Strategies)

i. From Negative Affect to Positive Affect and Disposition

Recent literature from social psychology and affective neuroscience have been calling for the need for positive affective interventions to be introduced into the mathematics classroom (Maloney & Beilock, 2012; Wang et al., 2015; Carey et al., 2016). Research by Beilock and colleagues (2010) has demonstrated that the opposite behaviour (negative affect and outlook) has proven damaging for girls in mathematics. This is better known as stereotype threat which can act like a self-fulfilling prophecy where a girl believes that she will not do well at mathematics because she has been taught that girls are not as good at mathematics as boys. Where negative stereotype threat is different from a self-fulfilling prophecy is that stereotype threat is a self-confirming belief that may be evaluated based on a negative stereotype through the socially and culturally primed language and actions of others, as well as by themselves (Gunderson, 2012; Maloney, Ramirez, Gunderson, Levine & Beilock, 2015). Research in the United States has demonstrated that minority groups such as African Americans can be marginalised and subjected to this behaviour. Simply by writing down personal information like race and ethnicity on a test can negatively prime popular stereotypical views that people may believe about themselves (Steele, Spencer, Aronson, 2002; Gladwell, 2005).

Worry can be viewed as self-induced anxiety (Chopra & Tanzi, 2017). Adolescents and teenagers need to be taught strategies to confront and break these emotional habits (Jensen & Nutt, 2015). According to LeDoux (1998) at a closing conference session describing the interplay between both nature and nurture, "we come into the world capable of being afraid and capable of being happy, but we must learn which things makes us afraid and which make us happy". This general capacity, in the past, has been known as emotional intelligence – the capacity to effectively perceive, express, and understand and manage emotions (Geake, 2009). However, for those students with reasonably strong and profound mental illness, there is a need for direct guidance to take them through key neuro-psychological developmental steps to accomplish this. A general accepted starting point is setting up an emotional filter or what some call states of mind, mindsets or cognitive biases (Ashcraft & Moore, 2009; Fox, 2013: Greenfield, 2014).

As we start to internalise a positive self-talk about ourselves, we start to affect our actions and language not only to ourselves but also to others. (Fox, 2013; Chopra & Tanzi, 2017). This emotional affect regulation needs to be maintained over a period of time for the cementing of positive memories and changing of habitual behaviours. This can be achieved by a variety of processes; Fredrickson's and Losada's broaden and build theory (Fredrickson & Losada, 2005); Seligman's model of authentic happiness using positive emotions (Seligman, 2012); and Siegel's continual process of being aware (Siegel, 2018) of your mindsight, reflection and attunement strategies (Siegel, 2007; Siegel 2012; Siegel, 2020).

Commonly, these metacognitive processes are dependent on a key neurological function called neuroplasticity in order to work (Merzenich, 2013; Cozolino, 2013; Birbaumer, Zittlau, & Shaw, 2017). In support of this neural capacity is your own neuro-psychological ability to imitate and eventually anticipate the behaviours of others (Hass-Cohen & Findlay, 2015), known as the mirroring system in the frontal cortex of an individual (Klemm, 2014).

Effective positive affect and positive priming on the other hand, come from external agents. Positive affect can be defined as "patterns of affect (attitudes, beliefs, values, and feelings) and behaviour that helps foster children's intimate engagement, interest, concentration, and persistence" (Alston, Goldin, Jones, McCulloch, Rossman & Schmeelk, 2007, p. 327) whereas priming demonstrates the brain as a subconscious anticipation machine (Siegel, 2007) readying itself for affective, cognitive, and environmental influences.

As an external affecting influence, the cognitive psychological process of priming from others (Siegel, 2007) helps you anticipate upcoming actions and associated emotions. The capacity for affect regulation, however, is greatly enhanced in the presence and support of trusted others (Siegel & Hartzell, 2003) like teachers and parents. In many ways, the external agents are an important dynamism to the individual. This infers a greater reliance on the individual student or key actors within the student's personal relationships network to be positively receptive and engaging with each other. In affective neuroscience/interpersonal neurobiology this is known as a person's social engagement system (Cozolino, 2014). A key tenet of interpersonal neurobiology (Siegel, 2007; 2012; 2018) states that through interactions with others an individual's mind tunes in better with its own intrapersonal self, and therefore requires fewer individual resources for emotional and social well-being and functioning (Beckes & Coan, 2011).

This type of behaviour has been demonstrated in the work of Beilock et al., (2010) and Maloney et al., (2015), leading authorities in the stereotype threat of girls in mathematics classrooms. Their work in using positive affective language using mindsets for girls, greatly influenced the girls' attitudes about their capacity to be successful at mathematics.

The potential stereotype threat of girls' mathematical abilities, along with others who perceive their own mathematical abilities negatively, demonstrate some probable outlier groups within a mathematics classroom. Both outlier groups can be viewed under the umbrella category in having Mathematics Anxiety.

There has been some recent inquiry into the effectiveness of positive mindset interventions as a global strategy within the classroom. These studies have demonstrated that the introduction of positive mindset interventions into classrooms may have a relatively low impact on the overall improved performance of a student cohort, but can benefit targeted outlier groups like the academically at risk and those with low socio-economic status. In these studies, outlier groups demonstrated greater resilience, positive assertiveness and self-determination even though mathematical performance was at times intermittent (Burgoyne, Hambrick, Moser & Burt, 2018; Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). It is developing positive emotional attributes like these into learned habits that may help turn mathematical performance around for students with mathematics anxiety.

a) Strategy One (Positive Priming & Mindsets)

Strategy One has little input from the student cohort. It is mainly an initial external intervention from the teacher and researcher in positively preparing the classroom environment with language and behavioural cues which may be explicit (signposting) or may be implicit (priming) (Oakley, 2014).

The input from students is based on reinforcing the work of teacher and researcher, by motivating themselves with a positive mindset. This refocusing helps to filter out negative feelings while attending to the positive. In short, attention and emotion are intimate partners (Davidson & Begley, 2012). This can be done with emotional find-a-words and personal vocabulary list development, invoking the spontaneous valence responses that have been used in a variety of psychological priming situations (Bargh, Chen & Burrows, 1996; Bargh, Gollwitzer, Lee-Chai, Barndollar & Trotschel, 2001; Gladwell, 2005). This type of priming is associative, and it works best when both the stimuli and response are in the same modality – reading a passage invokes a language association (Stanovich & West, 1983; Bargh et al, 1996).

The development of interpersonal neurobiology over the last twenty years (Cozolino, 2013; Schore, 2003, 2016; Siegel, 2014, 2018, 2020; Siegel, Schore & Cozolino, 2021) has shown how verbal and nonverbal positive stimuli has helped develop interpersonal relationships. As stated by Siegel, "Intentions create an integrated state of priming, a gearing up of our neural system to be in the mode of that specific intention: we can be ready to receive, to sense, to focus, to behave in a certain manner." (p.177, Siegel; 2018)

From this work, psychologists like Frederickson (1998; 2004; Tugade & Frederickson, 2004; Frederickson & Branigan, 2005) have created useful practical theories like the Broaden and Build Theory to help practitioners put this work into action.

The use of personal vocabulary lists is to help reduce the criticism of IATs (Implicit Association Tests) in terms of the lack of language familiarity amongst outlier groups like ethnic communities in terms of their understanding of English (Ottoway, Hayden & Oakes, 2001). Students can make their own lists according to their knowledge levels. The vocabulary lists become explicit measures downplaying the criticism that IATs sometimes do not have any greater predictive validity than implicit measures (Oswald, Mitchell, Blanton, Jaccard & Tetlock, 2013). Importantly, the IAT has demonstrated successfully that implicit associations can be a significant marker recognising potential patients of anxiety disorders

(Teachman & Woody, 2004). Therefore, positive priming is working alongside mindsets in this strategy. For the individual child, the affective response may be gained either implicitly or explicitly.

Strategy One is used to help embed new habits amongst the students during mathematics lessons. The use of positive affect and setting up students' positive mindsets for the day are used to turn self-discipline and regulation into an organisational habit (Duhigg, 2012; Sisk, Burgoyne, Sun, Butler & Macnamara, 2018) over a period. Rumination (worry and anxiety learnt behaviour) saps our intellectual resources thus affecting attention and concentration (Winch, 2013), but the anticipation from positive priming and other external cues will help rewire the brain with new habits (Pittman & Karle, 2015; Siegal, 2020). The development of affect-based habits allows minds to ease down to regular default conditions more often and allow more mind workspace for the anticipated mathematical activities.

ii. Affective Vocabulary and Expression

Affective neuroscience experts like Barrett (2017), believe that emotional intelligence is demonstrated by the degree of granularity expressed – constructing finer-grained emotional experiences with constructed associated words. Barrett (2017) explains that "emotional intelligence is better characterised in terms of concepts…fifty shades of crappy (angry, aggravated, alarmed, spiteful, grump … your brain would have more options for predicting, categorizing and perceiving emotion" (p. 180). Therefore, emotions are psychological constructions (LeDoux, 2015) that are very personal to the individual. So personal, that expressions of emotions once thought to be universal (like anger and happiness) can have highly idiosyncratic features for the individual (Barrett, 2017), even though there are some common general markers.

We remember experiences and things from the internal narrative or inner voices we provide for them from our logical left hemisphere (Kellogg, 2013). Once we have written these experiences down on paper, we then start to think about further description and analysis, and possible editing. This is our right creative hemisphere kicking into gear. Writing about something leads to discovering what and why you think about it (Carey, 2014). Unless we actively try and edit and elaborate in our minds first, we are rarely satisfied with what we have written. When we read and start rethinking - we are now critiquing our inner narrative – with both hemispheres working together.

This process is so important for those of us who can be confused with reality at times, and in states of stress and mental illness (Pittman & Karle, 2015) when our logical left hemisphere is being over-run by our emotional (limbic brain) centre dictating an emotional narrative. Consequently, writing these emotional states down can help us to review in a different mental capacity. As stated by the psychologist Cousineau (2018), "reflective writing helps the soul" (p.171).

The emotional and physical benefits of expressive writing for someone with mathematics anxiety can decrease stress, heal emotional wounds, improve perspectives about topics and working relationships (Ramirez & Beilock, 2011; Pennebaker & Smyth, 2016). Through writing and speaking, students can communicate and co-regulate their emotions with a significant other, and with self-critical skills (Greenberg, 2011). Ferre and Sanchez-Cassas (2014) also view the use of writing as part of an important positive feedback process between teacher and student, particularly for those students who are less likely to assert themselves and share orally.

In recent years, biblio-therapy has developed from solely being a therapeutic way for clients to read and respond to literature and extracts that correspond with their mental state. It is now being used as an educational strategy to help pre-service and practicing teachers, who themselves have Mathematics Anxiety, be aware of and respond to their emotional state and well-being (Wilson, 2009a, 2009b; Wilson & Raven, 2014; Wilson, 2019).Some key studies in biblio-therapy over the last ten years (Schechtman & Nir-Shfrir, 2008; Detrixhe, 2010; Cannon; 2018; Gumber; 2021) have demonstrated promising results with a variety of social groups over a wide range of psychological ailments. Therapists have successfully guided groups of between 20-30 clients into a reflective component which required questioning and writing. This has led to a significant rate of successful transfer at the school level with at-risk students (Prater, Johnstun, Dyches & Johnstun,2006) and with pre-service teachers experiencing Mathematics Anxiety (Wilson & Thornton, 2006 & 2008). These findings concur with the work into reflective writing as an influential strategy in minimising stress and anxiety for students prior to mathematics tests and examinations (Foley, Herts, Borgonovi, Guerriero, Levine, Beilock, 2017; Ramirez, Shaw, & Maloney, 2018).

b) Strategy Two: (Affective Vocabulary & Biblio-therapy)

To help initially guide students into the sphere of affective reflective writing, students will develop an affective emotional vocabulary that is their own. This branches from the work of world-leading experts like Davidson and Begley (2012) Barrett (2017) and LeDoux (2000, 2009) who state that affective/emotional states are highly personal. Although students initially start with a generic emotional vocabulary to describe their feelings and affective states, these lists grow as students find words that fit the meaning of their own personal affective/emotional states – thus gaining ownership over their emotional expression.

Biblio-therapy is being used to help skill students into developing emotional intelligence abilities like reading and developing an empathetic response from personal written expression. This is accomplished by dissociating from potential personal stress and anxiety states and providing reflection and critique; and to develop a finer granularity in emotional vocabulary and expression – like with metaphors (Brady & Winn, 2014). This finer expression may not only enable students to better reappraise their attitudes to mathematics, but to reduce ruminating behaviour, and subsequently improve working memory load (Dowker, Sarkar, Looi, 2016). There are many biblio-therapy studies that have positively impacted teachers, but only in in part students with Mathematics Anxiety (Iaquinta & Hipsky, 2006; Wilson, 2009a; Wilson 2009b). This is a strategy that still requires further investigation but one that has already been earmarked by the Victorian Education Department as an important tool in helping students with Mathematics Anxiety (Department of Education & Training, Victoria, 2022).

iii. Working Memory

Mathematics Anxiety has a significant cognitive deficit that needs to be addressed – working memory. Studies in recent years have demonstrated a direct relationship between working memory and anxiety (Hadwin & Richards, 2016; Suarez-Pellicioni et al., 2016; Ward, Lotfi, Sallman, Lee, & Larson; 2020). There have been a variety of studies that have demonstrated that greater working memory reduces anxiety load by seeing reduced activation in the amygdala (Ashcraft & Kirk, 2001; Shackman et al., 2006; Ramirez, Gunderson, Levine & Beilock, 2013; Qi, Zeng, Luo, Duan, Ding, Hu, Hong , 2014) demonstrating the intricate link between working memory, performance and anxiety. As demonstrated in the infographic

(Figure 2.1), the greater load of anxiety within an individual, the lesser the effective amount of working memory and performance.

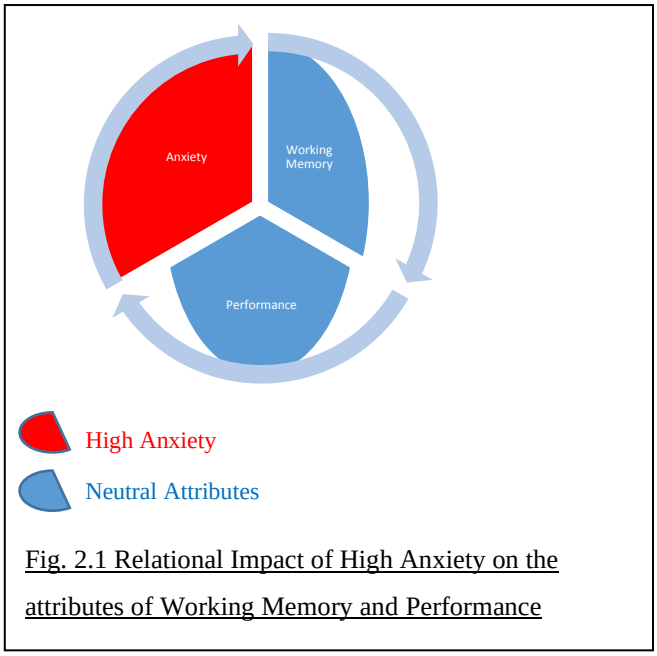
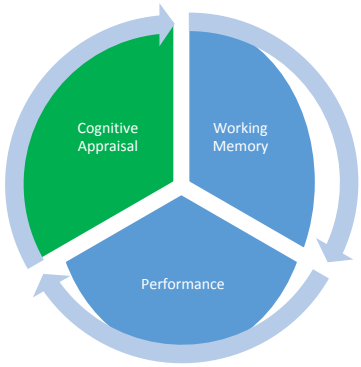


Fig. 2.1 Relational Impact of High Anxiety on the attributes of Working Memory and Performance

Literature in the similar areas of positive re-framing and cognitive reappraisal report findings from clinical trials with children that demonstrate that these approaches positively affects working memory load and thus improves other aspects of executive functioning, like attention and inhibitory control (reducing the amount of negative input attributes like anxiety). The literature concurs that effective cognitive strategies lessening the effect of anxiety will in turn improve a child's working memory, thus bettering their performance in mathematics (Cowart & Ollendark; 2010; Hadwin & Richards; 2016; Pizzie, McDermott, Salem & Kraemer; 2020), as demonstrated in Figure 2.2.



Cognitive Appraisal

Neutral Attributes

Fig. 2.2 Relational Impact of Cognitive Appraisal on the attributes of Working Memory and Performance

A child's anxious mind-set can become overly fixated on negative thoughts and feelings, which in turn reduces their ability to retrieve basic facts and perform a sequence of mathematical tasks and calculations. During mathematics lessons, it is the role and capacity of a child's working memory to attain these objectives. One of the key markers to demonstrate that the intervention strategies are working, is to not only assess performance outcomes but to assess a student's working memory. Even though we would like to think that our logical left hemisphere keeps us in check, it is where our linguistic inner voice comes from. If our inner voice is largely negative, it will take up a large chunk of our verbal working memory (Kellogg, 2013). Writing our thoughts out on paper as demonstrated in **Affective Vocabulary & Expression** (page 19), helps our mind go from verbal working memory to visual working memory freeing up cognitive resources (Beilock as cited in Oakley, 2014; Giofre, Donolato & Mammarella, 2018). Worry is known to be highly verbal and this is demonstrated by individuals who worry excessively and report an abundance of negative self-talk rather than unpleasant visual images (Kellogg, 2013). As future worries take hold in the mind of an anxious student, they take hold and are continually recycled through the verbal store of working memory negative self- talk.

Research findings from positive psychology and affective neuroscience (Ashcraft et al., 2009; Fox, 2013; Ramirez, Gunderson, Levine & Beilock, 2013; Beilock & Willingham, 2014)

indicate that there is a strong cyclic relationship between anxiety, working memory, and performance. High anxiety will reduce working memory capacity which will in turn affect performance outcomes negatively. On the other hand, a highly positive affective state reduces the social load within a child's working memory, thus allowing more space for cognitive work. Consequently for positive priming and mindsets to effectively work within the intervention , a continual connection needs to be established between child's affective state and cognitive state.

This is where the division of working memory into social and cognitive working memory (Meyer, Taylor & Lieberman; 2015; Meyer & Lieberman, 2016; Giofre et al, 2018) becomes a useful tool within this study. It is far easier to hold positive social load in one's working memory, due to the quickly accessed associations that can be made readily by positive relationships and experiences from one's episodic memory (Fox, 2013; Meyer & Lieberman, 2016). Cognitive load, on the other hand, requires more work by retrieving facts from the other form of declarative memory - one's semantic memory.

Studies have demonstrated that those with high social working memory, have less anxiety and cognitive load, and are more likely to seek help and assurance from others (Meyer & Lieberman, 2016; Krol, Meyer, Lieberman & Bartz, 2018), making students more socially assertive in their learning. In contrast, there have been some criticisms of computer-based and general classroom programs designed to teach working memory for students. Students cannot necessarily demonstrate generalizability of skills learnt; cannot retain information learnt due to increased cognitive load; and can become context or tool dependent on the program itself (van der Donk, M., Hiemstra-Beernink, Tjeenk-Kalff, Van Der Leij, & Lindauer,2015; Melby-Lervåg, Redick, Hulme, 2016).

c) Strategy Three: Working Memory Checks

Nevertheless, when working memory aids are brought to the attention for students as a signpost or review point in a lesson, they have been measured as being far more successful (Alloway, 2011; Alloway 2012). The idea of working memory checks is one element borrowed from the successful Mind-Mates program (Colmar, Davis, & Sheldon, 2016; Colmar, Double, Davis, Sheldon, Phillips, Cheng & Briddon, 2020).

Working memory checks should occur at three points throughout a lesson. The purpose of the working memory check is for students to evaluate their performance alongside their own affective well-being. Consequently, to help instil confidence an initial part of the working memory drill is to remember up to seven positive affective words from the work that they did from Strategy One and Two activities. This drill not only reflects their own social working memory but helps prime students to improving the social-emotional perspectives that they make during lessons (Meyer, Spunt, Berkman, Taylor & Lieberman, 2012; Meyer & Lieberman, 2016). Interestingly, according to recent research, social working memory (SWM) does not only share neural networks with typical cognitive working memory but shows signs that they have their own specific neural networks (Meyer, Taylor, & Lieberman, 2015) which, therefore, helps reduce overall cognitive load. Two further quick drills should be based on cognitive working memory, specifically related to mathematics recall. Each drill is out of seven words or numeric facts, which the students record into their folders. An arithmetical mean average is recorded over each set of three drills by the researcher or teacher-participant after each lesson.

Students should be shown that although working memory checks may be irregular in terms of content and style, that the timing of the checks will be constant throughout the lesson. This is to ensure that affective and cognitive performance are habitually measured. In the literature, there has been some criticism against working memory (brain-training) games in classroom lessons. There is the fact that after an excessive amount of practice in learning a particular game, that new skills are achieved in performing that game rather than improving cognitive working memory (Greenfield, 2014).

This dilemma is catered for by the uncertainty and frivolity of the working memory game used. Students will be primed to know that they will be doing a working memory game/test at a point without knowing its content or structure.

iv. Bringing all Strategies Together

The strategies to improve mathematic performance and lessen mathematics anxiety demonstrates that concepts and recommendations from the learnings sciences could translate (Immordino-Yang & Damasio, 2007; Immordino-Yang, 2011; Stafford-Brizard, Cantor & Rose, 2017) into potential practices that will not only improve student learning but lay the basis for ‘authentic’ professional learning for a classroom teacher (Webster-Wright, 2010).

The ‘authentic’ setting in which these three strategies will happen is context sensitive as Mathematics Anxiety is primarily seen and experienced within the mathematics classroom. The connection between the individual mathematics teacher and the researcher, as well as the context in which they develop must be reflected in features that promote strong working relationships among the professionals within the classroom (Reeves, Macmillan & van Soeren, 2010; Webster-Wright, 2010). The findings and ideas used from the learning sciences, are based on this relational importance. Affective and relational neuroscience (Fredrickson & Losada, 2005; Beilock, 2015; Hass-Cohen & Findlay, 2015) along with interpersonal neurobiology (Siegel, 2007; 2012; 2020) demonstrate what affective and socio-emotional strategies may lessen Mathematics Anxiety and how it may be done, and yet are dependent on assumed strong relationship structures within the classroom.

Although there has been scarce practical inquiry at this translational interface between education and neuroscience in the classroom, there has been ongoing calls and ways how to go about it from a variety of experts and commentators (Howard-Jones, 2008; Nouri & Mehrmohammadi, 2012; Immordino-Yang, 2015, 2016; Jamaludin, Henik & Hale, 2019; Coch & Daniel, 2020).

The similar theme among these commentators is that issues like Mathematics Anxiety become increasingly do-able if ‘boundary objects’ (whether interventions or people) allow for cooperative intersections of those working in a particular situation.

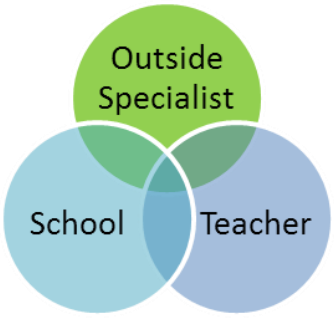


Fig.2.3 Relational System – A Potential Nexus of Professional Learning

This perspective has seen a flurry of theoretical work looking at what is being sometimes called ‘boundary work’ between education and the learning sciences (Devonshire & Dommett, 2010; Nouri & Mehrmohammadi, 2012; Beauchamp & Beauchamp, 2013; Edelenbosch, Kupper, Krabbendam, & Broerse, 2015). By taking on a systems or network

approach (see Fig. 2.3) with the major agents of this investigation, Actor Network Theory (ANT) becomes an ideal way of observing and interpreting the growing mechanics between each agent. ANT provides an avenue as to how human actors (teacher, specialist, and students) relate to non-human actors, like the intervention (the three strategies). This network structure, however, relies on driving elements of self-organisation. Brandt's triangle of self-organisation (2016) provides the motivation, the rules of implementation, and goal for the teacher and specialist to accomplish.

V. Current State of Professional Learning

Current literature indicates that an outcomes-based, linear approach to professional learning is not enough in meeting the diverse needs of teachers at varying stages of their careers. Nor does it address the complexities of learning that occur in education (Clarke & Hollingsworth, 2002; Desimone, 2009; Opfer & Pedder, 2011). Clarke and Hollingsworth's (2002) interconnected model of professional growth acknowledges that teacher learning occurs in a variety of ways. Their approach has encouraged researchers to explore a variety of complementary learning pathways including mentoring (Aspfors & Frannson, 2015), co-teaching (Gallo-Fox & Scantlebury, 2016) and collaborative inquiry (DeLuca, Bolden & Chan, 2017). Education researchers even warn against simply using professional learning communities, as this type of professional learning may be insufficient for teachers searching for guaranteed support in their collaborative work (Nelson & Slavit, 2008; DeLuca, Shulha, Luhanga, Shulha, Christou & Klinger, 2015; DeLuca et al., 2017).

In Australia, this work has been reflected in some large-scale projects demonstrating that teacher professional learning needs to be diverse and appropriate to teacher needs (Doecke, Parr & North, 2008; Mayer & Lloyd, 2011).

Current literature highlights the following practices required to ensure high-quality professional learning:

- sustained and cumulative over time and offers a progression of skills and knowledge, and opportunity for practice of these skills.
- able to provide opportunities for collaborative and meaningful activities.
- embedded in schools.

(Opfer, 2016; Campbell et al., 2017).

Consequently, there is consensus in the professional learning literature (Penuel, Fishman, Yamaguchi & Gallagher, 2007; Darling-Hammond et al., 2009; DeLuca et al., 2015; Opfer, 2016; Campbell et al., 2017) as to what the core attributes for effective professional learning look like. When some of these principles like duration and continued support are applied to one-to-one dyadic structures like co-teaching, mentoring, and coaching they are among the most sought-after professional learning platforms by teachers (Kemmis, Heikkenen, Frannson, Aspfors, & Edward Groves, 2014; Adams, 2017). In contrast to the above indicators of what successful professional learning looks like, there are professional learning practices and behaviours that do not allow for enough comprehension of relevant information, retention of concepts learnt, or translation into the classroom.

i. Current Divide in Professional Learning

For many years, Professional Learning in Education has developed into an ever-growing and self-sustaining industry with a managerialist approach where so much information is generated that it becomes increasingly compartmentalised and sterile (Furlong, 2005; DeLuca, Bolden & Chan, 2017). As stated by, Bradbury et al., (2010) "it becomes very difficult to feel comfortable with one's own sense of expertise, as there is always a new book we have not read." (Bradbury, Frost, Kilminster, Zukas, 2010, p. 17).

Workshops tend to become the likely pathway infilling in this information or curriculum gap among teachers, as schooling systems try to keep up with a rapidly changing world. The ironic aspect about this is that the literature states that teachers are less likely to change practice via presentation and the memorising of new knowledge normally seen in workshops (Wayne, Yoon, Zhu, Cronen, Garet, 2008; Cole, 2004; Cole, 2012).

This growing managerial culture can make teachers feel isolated and feel obligated to 'buy in' (DeLuca et al, 2015) to the needs of learning area or school communities rather than themselves. The growing managerial culture of professional learning can lend itself to simply being curriculum or assessment updates delivered to teachers lacking or 'deficient' within an area making them feel more like technicians delivering a prescribed curriculum and feeling detached from the work they provide to students (Ball, 2003; Fernet, Lavigne, Vallerand & Austin, 2014; Skinner, Leavey & Rothi, 2019). Cole (2012) states, that "professional learning is not supposed to be an innocuous activity, it is supposed to make a difference" (p.6).

Teachers who feel that they are stuck on this professional treadmill as a failure to attend and absorb this professional knowledge, in turn would affect their expertise knowing it would soon be out of date (Bradbury, Frost, Kilminster & Zukas, 2010). Workshops subsequently become a necessary panacea to this professional knowledge process, despite the never-ending call from critics that workshops are an ineffective model of professional learning (Lumpe, 2007; Wayne et al., 2008; Cole, 2012; DeLuca et al., 2015).

Consequently, there is a professional learning and development dilemma that teachers, principals, academics, and trainers need to appreciate. Due to the greater professionalisation of the teaching community around the world, teachers need to recognise that there will always be workshops and short on-line courses that they must complete, to maintain their professional status and development levels, despite how ineffective they may be. On the flip side to this however, teachers need to realise that there are highly effective professional learning pathways available to improve their own pedagogical proficiency and capacity to improve student outcomes. This professional pathway should be called professional learning, rather than professional development

This goes against a growing managerial culture view of education from teachers around the world that perceive professional learning simply as a cause-and-effect approach of professional outcome standards that they need to achieve, making them feel disconnected to their work (OECD, 2013; Opfer, 2016; Calvert, 2016; Scherff, 2018). Researchers within the field advocate a more complex approach which acknowledges that all professional learning is contextually situated and determined by the value from teachers according to their current experience and skills (Dana & Yendol-Hoppey, 2009; Grossman, Hammerness & McDonald, 2009; Coldwell, 2017).

The importance in illustrating this divide in professional learning, is that it will not go away in our current climate. Instead, it may further strengthen as two separate paths that teachers need to appreciate and fulfil.

ii. Developing a Relational Dyadic Professional Learning Platform

Literature suggests a range of difficulties that current professional learning faces, including adapting theory to specific classroom settings, varying degrees of teacher knowledge and experience, unexpected emergent difficulties, generalisability, and sustaining practices over a

length of time (Desimone, 2009; Jackson & Bruegmann, 2009; Cordingly, Higgins, Greany, Buckler, Coles-Jordan, Crisp, Saunders, & Coe, 2015). This highlights that there should not be a one-size fits all approach for professional learning. Outside specialists cannot simply come from any domain or profession. The outside specialists need to be established education practitioners (Reeves, Macmillan & van Soeren, 2010) who can provide essential stability and guidance to the professional learning relationship. This demonstrates a relational focus to the investigation, as both agents have something that they can relate to – education. Education becomes the practice by which specialist and teacher can relate to each other.

Current trends in professional learning tend to centre around the hugely popular and widely practiced professional learning communities (Vangrieken, Meredith, Packer, & Kyndt, 2017) and collaborative inquiry (Donohoo, 2013; DeLuca et al, 2015; DeLuca, Bolden, & Chan, 2017) initiatives within schools. In contrast to this, there are a group of dyadic structures that are on the rise in professional learning. Co-teaching (Gallo-Fox & Scantlebury, 2016), mentoring (Sundli, 2007; Aspfors & Frannson, 2015; Banerjee-Batist, Reio & Rocco, 2019), dyadic coaching (Whitmore, 2009; Egan & Hamlin, 2014; Muhlberger & Traut-Mattausch, 2015) are commonly viewed as the most popular dyadic structures.

However, the lack of work around these more complementary dyadic approaches reveals the lack of current theory and conceptualisation for a relational dyadic professional learning model involving a teacher and a specialist. The alignment of mentoring, supervision, and coaching lacks corroboration within the literature (Aspfors & Frannson, 2015). A recently published meta-review of over sixty diverse coaching programs in the United States demonstrated the relatively strong efficacy of this type of professional learning. However, the meta-review highlighted the lack of identified effective features in coaching models studied, and the key characteristics required of the coach/specialist (Kraft, Blazar & Hogan, 2018). Consequently, because of the continual evolution and cross-over of professional learning structures like coaching, mentoring, and supervising it is probably more prudent to place these similar structures under the spectrum of dyadic professional learning as suggested by Simmel way back in 1950 (Wolff, 2015) and refer to individual terms when their features are clear.

Two potentially debilitating aspects of a dyadic structure, however, are time and the costs involved. If an instructional specialist working one-on-one with teachers in person over a

sustained amount of time remains at the core of effective coaching models, then this approach will always require sizable financial and human capital investments (Kraft et al, 2018) and must be weighed up against school needs and the effectiveness of delivery.

Time is one of the essential aspects of successful professional learning (Darling-Hammond, Wei, Andree, Richardson & Orphanos, 2009; Jensen, Sonnemann, Roberts-Hull & Hunter, 2016) in terms of quantity and where and how it is used. Darling-Hammond et al., (2009) argue that sustained professional learning needs should be contextualised and cumulative in offering a progression of knowledge, skills, and practice development over time. However, time can also be a significant cost when it comes to the professional learning of one teacher over a group of teachers. This will be the case if education authorities need to single-handedly take on the responsibility of organising and selecting those who may go into schools.

Schools, however, already have strict protocols as to the type of visitors and volunteers who enter schools. Those entering schools must have a police clearance and a mandatory notification certificate. A pool of potential people that schools may draw upon are those experienced teachers who go back to university to complete post-graduate studies, or new out-of-field teachers who have come from related or potentially useful disciplines like social work, psychology, and the learning sciences. This pool of people may ask for recompense, but many may also require the opportunity and time to visit a variety of sites to complete or fulfil post-graduate or professional requirements.

Teachers need to feel that they have control over their own professional learning narrative (Adams, 2017). Teachers want to be able to recognise their strengths and needs and draw upon a select group of professional specialists who can provide them with the amount of time and level and depth of understanding of a topic area, that normal avenues of professional learning cannot provide. It is from the development of professional relationships like these, that we will broaden and deepen the expertise of our teachers.

iii. Summary

This chapter demonstrates that current teachers are experiencing a greater delineation of what their professional learning journey may look like throughout their career. As teaching becomes more professional in terms of work and outcome requirements with their students,

there is a continual need for teachers to understand these developing standards. This should be aptly described as professional development. However, teachers also require a pathway of professional learning that reflects their strengths and motivations. A balance needs to be maintained between these two pathways to help ensure teacher participation and motivation.

This chapter has described some significant gaps currently affecting professional learning practices in the field of Education. The lack of intensive one to one professional learning platforms for teachers, not only reduces teachers' capacity to contact and use expert help to greatly develop their own learning but retards their access to expert help to address complex issues like Mathematics Anxiety. Instead, this reinforces a division of knowledge between those who have expertise in the educational matter and those who teach.

This study proposes building a dyadic structure, where an intermediary with expertise in the educational matter, comes to the teacher. The following chapter will not only outline the structure itself however, but demonstrate the responsibilities and duties of those involved, and how the professional learning will unfold over time.

Chapter III: Developing a Relational Dyadic Professional Learning Network

Actor Network Theory (ANT) has been chosen as the initial framework because it can serve two important functions. It can be initially used as a functional analytical tool in describing a relational system. Secondly, in its later form (After-ANT), actor network theory allows for greater flexibility and mobility. The first section of this chapter envisages professional learning for teachers as a social relational system that can be embedded or situated in school classrooms. The second section looks at how we can build links and bridges between the learning sciences and education, and how translation can be an important productive attribute in professional learning. Once this has been established, section three will outline and define the concepts and attributes of Actor Network Theory (ANT) and apply them to the proposed professional learning framework.

I. Viewing the Classroom as a Social Relational System

Based on the literature previously outlined, this study will necessitate a professional learning approach situated contextually within the classroom to answer the research question. The classroom environment would allow the teachers to not only learn from the results of students, but also from observations and interactions with the researcher and students.

The need for 'authentic learning' in professional learning (Webster-Wright, 2009; 2010) for teachers indicates the elements required for a professional learning system: "Professionals learn in a way that shapes their practice, from a wide range of activities from formal PD programs, through interaction with work colleagues, to experiences outside work, in differing combinations, and permutations of experiences" (Webster-Wright, 2009, p.705).

Webster-Wright's work in 'authentic professional learning' (2009; 2010) has paved the way for other researchers to investigate how teachers learn during authentic professional practice (Brennan, 2016; Cervero & Daley, 2016; Clarke & O'Donoghue, 2017; Wareing, 2017). Although not necessarily a primary site for professional learning, the classroom is the main site of professional practice for most teachers, making it an ideal stage to investigate. The social, situated nature of professional learning is widely referred to within the literature (Borko, 2009; Burbank & Kauchak, 2003; Garet, Porter, Desimone, Birman, & Yoon, 2001; Stoll, Bolam, McMahon, Wallace & Thomas, 2006). However, within the classroom key

relational actions take place which can be different to other social, situated settings in professional learning like workshops and professional learning communities.

There are, for example, already significant relationships between the teacher and classroom students, as well as the new relationship with a significant other (educational expert) when they are present. It is true that the teacher receives responses and feedback from the students, but the presence of another significant other can transform this social learning into professional learning, denoting the basis of a simple robust working system. Brandt's triangle of self-organisation (Fig. 3.1 Brandt, 2016) provides the motivational structure to this complementary system within the classroom, as demonstrated in some recent education investigations using ANT (Royle & Nikolic, 2016; Rolye, 2020).

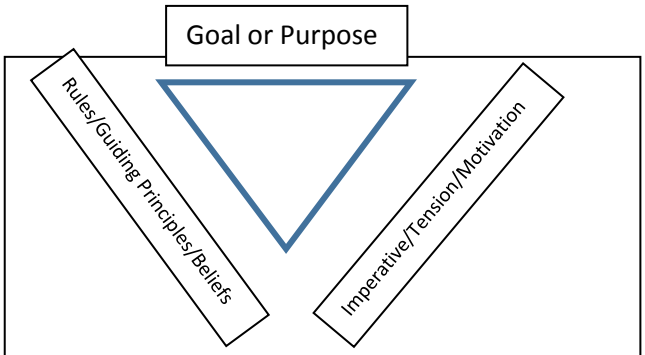


Figure 3.1 Triangle of Self-Organisation (Brandt, 2016)

It would be difficult to measure some of these processes alone, but when they are all attributes of a holistic systems framework they can be better measured by their relationship to each other. For example, there are actors and artefacts within this systems framework like the teacher, the researcher, the introduced intervention, and the school curriculum that all play and *relate* to each other in specific ways. Professional learning, if it occurs, necessarily modifies contexts for practice just as contexts of practice continually modify professional learning and it is their mutual adaptation that is required to secure sustainable change (Reeves & Drew, 2013).

The framework proposed is both developmental and dynamic as the relationships between the actors and artefacts can be fluid with processes like adaptation and growth. With these dynamic attributes of professional learning, the system is never static. Consequently, there

needs to be a starting point. An initial system/network foundation will be recognised by the key actors of researcher and participating teacher. ANT through its philosophical underpinnings expects the key actors to acknowledge this as one of its key initial stages. Research is then viewed through the eyes of the key actors as work and data are collected, attributed, and analysed.

ANT, as a systems approach, can define this work and data at a relational and developmental level between actors and artefacts. Artefacts like curriculum, strategies and resources can have a profound impact on the receptive learner (actor), depending in how they are used by the teacher (actor). Consequently, from this point on, the word network will be used rather than that of system.

The introduction of the intervention package by the researcher into the classroom, will help stimulate what changes are being made to influence teachers' knowledge and pedagogy. This deployment demonstrates the need for a qualitative in-depth case study approach, outlining a need to develop a network for each classroom. ANT provides not only a way to perceive the parts and overall view of the network but provides theoretical concepts and constructs as to how the network operates.

Consequently, the framework of the study is developmentally three-fold. An acknowledged network by participating actors (teacher and researcher) is set-up using theoretical constructs from ANT. Secondly, each acknowledged network goes on a developmental path adapting or refining attributes that fit their own pathway. Finally, features will be described showing discerning attributes of each network.

Figure 3.2, on the following page, illustrates the three stages of the developmental framework sequentially. One important omission from the figure is that during Stage 2, this is the likely time that individual networks may gain features that ear-mark their distinctiveness. However, it cannot be assumed that all networks will undergo the same transformation. Therefore, in Stage Three the researcher and teacher could discover and use specific features that enhance a professional learning network.

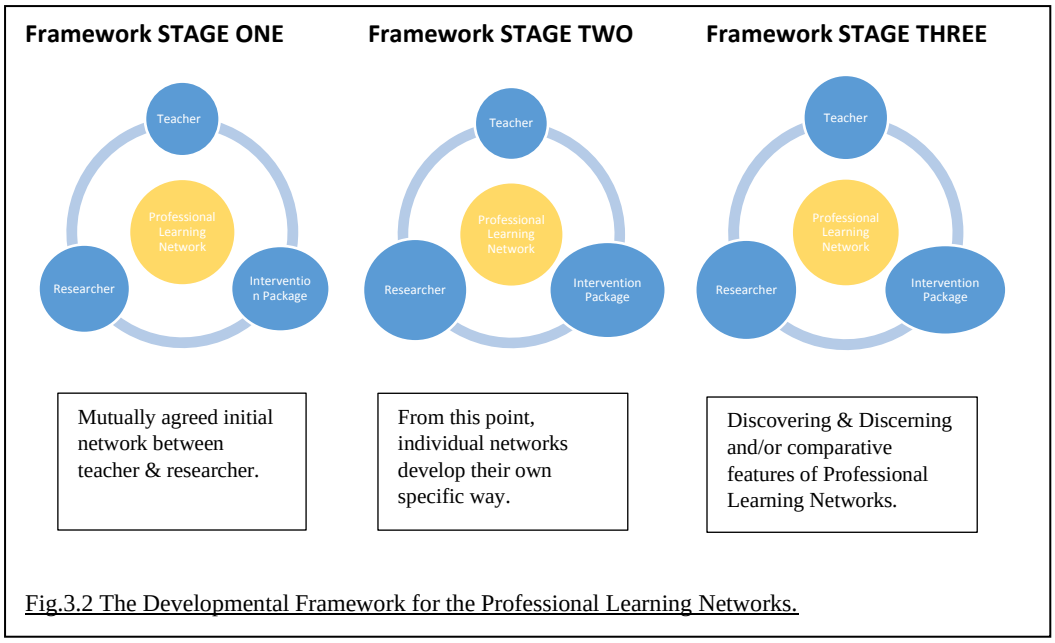


Fig.3.2 The Developmental Framework for the Professional Learning Networks.

II. Applying the Key Components of Actor Network Theory to a Dyadic Professional Learning Framework

ANT is both a 'systems' framework and perspective in analysing its components. Latour (1987), Callon (1991) and Law (1999) are the main exponents of this theory in both its original form from 1987 to 1998, and its revised form after 1999. In its original form, it was a highly structuralist framework assigning agency equally to actors (human participants) and artefacts (objects) calling them all actants. This naturalising aspect kept away any prior ontological baggage of these actants, allowing the researcher to focus primarily on how actants related and worked with each other within a network (Fenwick & Edwards, 2010).

ANT is clearly a representational philosophy. It is a way of describing and naturalising objects and people in a variety of situations, through associations and relationships. It is a good template to initially investigate the elements of emerging or intricate systems. However, if the researcher seeks to understand why certain actors/artefacts have been enrolled into a system, or explain unusual behaviour like the high prevalance of translational processes, greater qualitative insight is required. This is where the new incarnation, known as After-ANT (Law, 1999) becomes a useful perspective. After-ANT philosophy is based on the premise that it is the contexts, ambivalences, and backgrounds of the actors/artefacts that delineate networks from each other and provides greater understanding (Fountain, 1999; Callon, 1999; Law 1999; Nespor, 2006).

In terms of the research investigation, ANT in both of its forms has a significant purpose. In its original form, ANT allows the researcher to initially outline and describe the key elements of the framework. In its latter form, the researcher can then unravel some of the highly descriptive complexities when actants behave differently with the emergence of new actants or processes. This is especially important for the research investigation, as the teacher develops from the professional learning, changes will occur.

There was relatively little uptake of ANT in education research since the turn of the 21st century, (Roth & McGinn, 1997, 1998; Fountain 1999), but in the last decade ANT has demonstrated itself in being a useful tool with the greater commercial, leadership and technological analysis of education. ANT can provide a framework in evaluating the human agents (school staff and students) on a comparative level to artefacts like curriculum and technologies, with cultural and professional expectations enveloping this educational system (Alcadipani & Hassard, 2010; Horn & Little, 2010; Mulcahy, 2013; Koyama, 2015a; 2015b; Royle & Nikolic, 2016; Wiesemann & Lange, 2019; Royle, 2021). With this systems approach, the researcher can skew the focus to the educational intervention, program or actor, depending on the educational need.

The Professional Learning Network proposed develops out of the synthesis of two networks (see Figure 3.3). Much of the professional learning experienced by teacher-participant and researcher occurs during lesson time within a classroom setting. Consequently, the incorporation of a professional learning network is reliant on the stability of a steadfast classroom network.

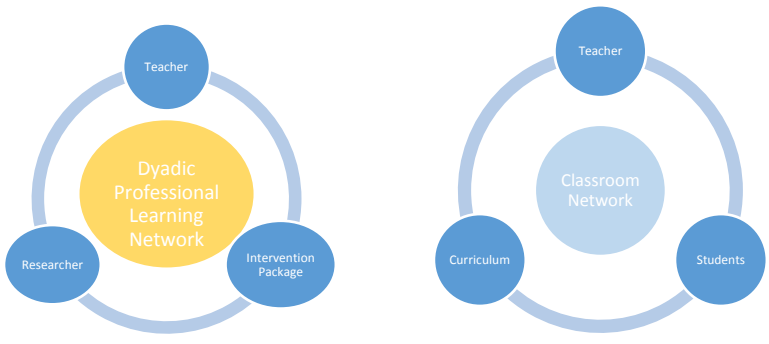


Figure 3.3 Synthesis of Two Key Networks: Professional Learning Network & The Classroom Network

Actors and actants from both networks combine to make a professional learning network that can occur during classroom lessons, as well as outside the classroom. Figure 3.3 outlines the

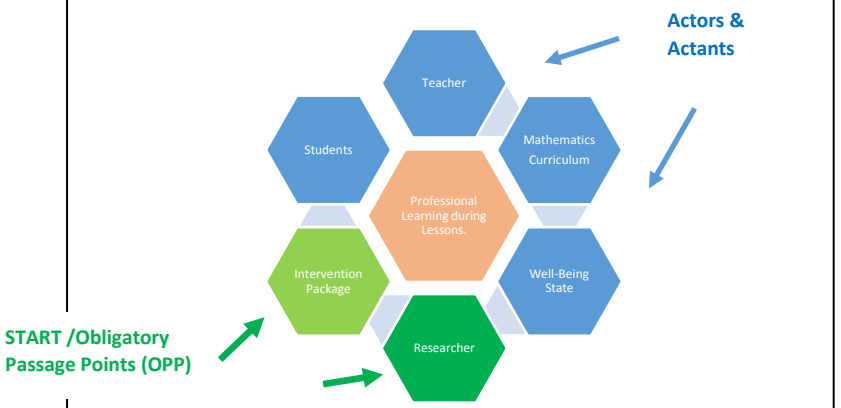


Figure 3.4 The Professional Learning Network (during classroom lessons).

key elements (actors and actants) of the professional learning network. However, it must be acknowledged that there may be unidentified actants and actors that, later, may enhance and solidify the network during its development. Although Figure 3.3 outlines the key elements of the professional learning network it does not illustrate possible processes that support these elements or are apparent of ANT. A significant amount of time is spent within a fluid dynamic environment (classroom lessons), so how lessons start, function and end are useful practices to outline. Initial key processes include the obligatory passage point (OPP) in which the researcher and intervention package are introduced to the class (see Figure 3.4). A state of well-being is a practice that is established and maintained throughout the intervention period, along with mathematics curriculum which further delineates this network. Feedback from the students, and the farewell of the researcher at the end of the lesson, defines the halting of the professional learning network.

The merging of the two networks from Figure 3.3 allows new actors (students) to be influenced not only by the researcher but by the main artefact actant (the intervention package). The intervention package actant in this investigation takes on a variety of roles in ANT. Initially it is a latent artefact that is discussed between teacher and researcher, and then introduced to the students within the classroom. The intervention package is what brings the above two networks together and initiates change. Consequently, in ANT language the intervention package becomes a obligatory passage point (OPP), as illustrated in Figure 3.4

All significant action and discussion stems initially from and through the OPP targetting key actors and actants within the network.

The OPP for this study's professional learning network however, can be seen at two points in Figure 3.4 . Apart from the intevention package, the researcher has a variety of important roles within the network. The researcher has the role of critical channel by which communication and actions must pass through at some point, making him an important OPP as well (Callon, 1986a; Fenwick & Edwards, 2010). In this network, it is vital for the stability and dynamism of the network to have two OPPs. The researcher OPP has a primary role in setting up the configuration of the network, and how initial actions will be performed. However, as things progress it is hoped that the intervention package OPP succeeds as primary OPP, as the network strengthens with its nodes and actions.

As the researcher is representative of the knowledge and ideas being brought into the network, he is also a delegate (key actor) and mediator. The role of delegate enables the researcher to set up the network and be the main point of transmission and translation of ideas. Within the neuroscience literature, the idea of delegate and intermediary has been well pronounced by the idea of the neuro-educator (Fuller & Glendining, 1985; Gardner, 2008; Fischer, 2009; Sylvan & Christodoulou, 2010; Summak, Summak, & Summak, 2010; Zadina, 2015). However, in ANT terminology an intermediary is an entity that makes no difference – it is just an avenue of transmission. For clarity, the term mediator is a more appropriate term for the researcher and teacher actors, as they both generate differences and connections from their work and collaboration (Latour, 2005).

There will be times, for example, when the researcher becomes a detached observer, and allows the intervention package to be used mainly by the teacher and students. By this time, the intervention package is no longer an artefact (object or reference of discussion) but a token (object of exchange and use). In Fig 3.5, on the following page, all three main actors can use the intervention package as a token. As the token is exchanged amongst the actors it becomes a tool of responsibility and action for that actor-recipient.

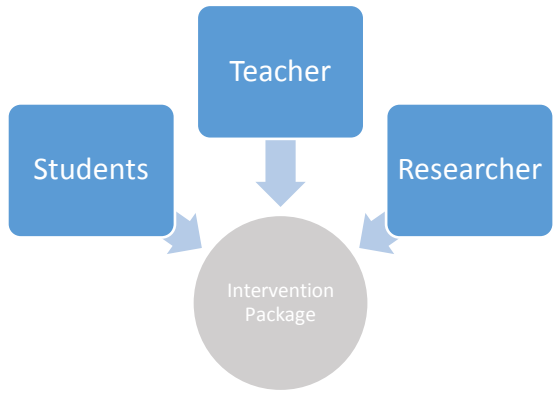


Fig 3.5 The Intervention Package as a Token.

The success of the intervention package as a token can be portrayed through the black box

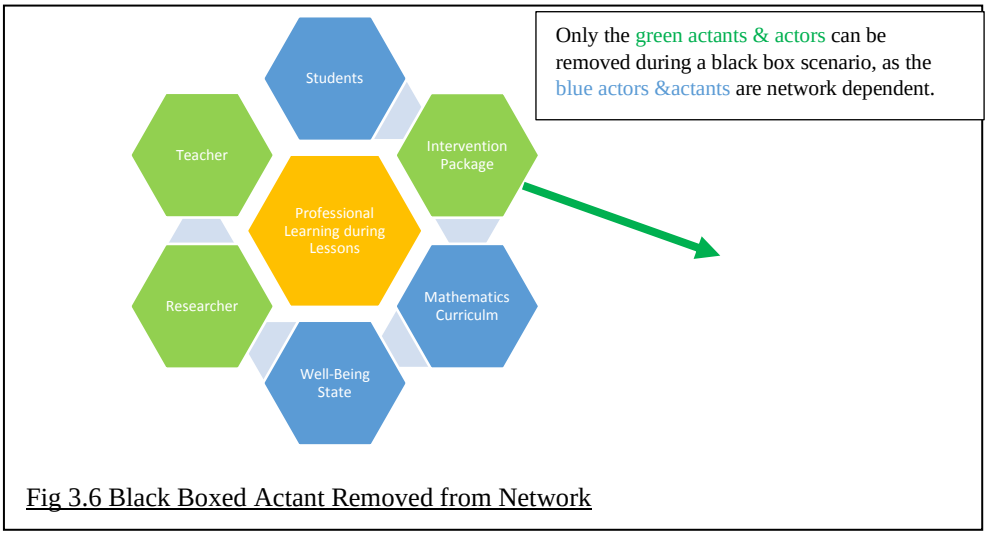


Fig 3.6 Black Boxed Actant Removed from Network

concept of ANT. In the description of ANT, a black box actant can be an object like a car, a television that operates exactly as it should (Callon, 1991) within a given environment or network. When the network is under strain or showing deterioration then the black box is temporarily removed (as shown in Figure 3.6), fixed, and then returned. If it functions as it should, then the black box actant is fulfilling its role within the network.

The black box scenario is ideal for both researcher and teacher participant under professional learning circumstances, as one of them can be also removed to repair or modify the black box actant. This fluid environment also allows both actors to observe the effectiveness of the intervention package while learning from any modifications or additions that are made to the package in its removal and return to the network.

III. Applying the Key Stages of Actor Network Theory to the Dyadic Professional Learning Network format

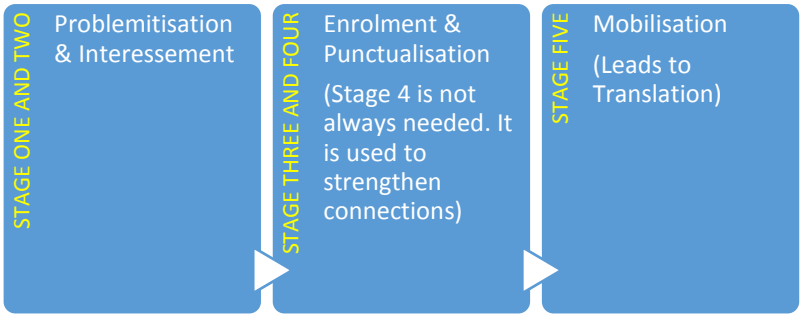


Figure 3.7 The Key Stages of Actor Network Theory

Fig 3.7 outlines the key stages of ANT and the progression that these stages normally take. For example, the coming together of actors, actants and components of the network, are part of problematisation an introductory but not exclusively initial stage of ANT (Callon, 1986a; 1986b).

In this study, an actor (researcher) highlights the issue of teachers not having sufficient knowledge and practices to appropriately address Mathematics Anxiety within their classroom, and frames the classroom as the site of the network where transmission and translation of ideas take place, with the expectation of reducing the incidence of Mathematics Anxiety.

The initial shared collaboration between the researcher and teacher actors demonstrates that there are already solid foundations through the initial stages of ANT. Problematisation is accepted and appreciated by the main actors, from the researcher being invited into a teacher's school. Interessement starts prior to the researcher being introduced to the student cohort and is the process by which researcher and teacher go through the practices of negotiation of roles and engineering as how to set up the class for the implementation of the intervention package.

Interessement is a continual and significant stage in this particular network. For example, there is always the process of where the two main actors are observing and actively questioning their environment on their own terms. However, there is also a shared

arrangement in which the main actors are also partaking in social engineering. We follow the two main actors building up and rebuilding the actants and elements of the network (Cressman, 2009).

The importance of interessement and the sub-process of punctualisation (see Figure 3.7) within the study's network, allows the main actors of researcher and teacher to be involved intently on a certain aspect of the curriculum, strategies, and/or how it is presented. Enrolment, although an important stage in any ANT network, is less pronounced than other stages in this network. Both researcher and teacher are 'enrolled' actors right from the beginning due to their vested interests in the completion of the study. The students have enrolled through the consent of their parents and school.

Mobilization, the final stage for this network, is restricted by design. The main three actor groups are the researcher, teacher, and students. The researcher may mobilise constructive functional aspects of one network to another case study network, but they are all bound not only by confidentiality but by possible contamination if something does go wrong from bringing practices 'developed' from other sites. All case study networks share the same artefacts and actants brought in by the researcher. This allows influence to come through via only two channels - the OPP by the researcher and the artefact (the intervention package). This allows any variation to stem from the actors and actants specific to the case study locality. In many ways the designed networks are closed systems, as the boundaries are defined and outside actors and actants do not have access.

The greatest area for mobilisation is within the network itself, with the students mobilising a variety of processes-sharing, responding, reflecting, and transforming with/to the artefacts and tokens within the network. This inner dynamism within the network is important for the two main actors to observe, learn and reflect on, leading to translation. All elements (whether actor, actant or artefact) of the networks need to play their part at the appropriate time for the networks to remain stable, they need to cooperate (Law, 2007), since they all depend on each other. If the translation works, the network is viewed as successful and the knowledge accepted as fact (Latour, 1987). Translation can either lead a pinnacle state of the network, and/or transformation to a new network. In the case of the professional learning network, translation leads to a pinnacle state. However, this does not prevent the teacher participant nor researcher from applying the basis of this network to a similar situation elsewhere – thus demonstrating some form of generalisability.

While the external validity of this approach can be questioned with respect to other related networks, at the individual level, the network is robust. "The longer these networks are, the more entities that are enrolled in them, the stronger and more durable they become" (Spinuzzi, 2008, p.49). Consequently, from the description of the ANT stages above, each network in this study, has its own developmental signature.

As demonstrated by its representational nature, ANT is not really a philosophical theory, but more of a theoretical framework that provides a perspective or sensibility (Fenwick & Edwards; 2010; 2011) in how to view a network like a classroom. Therefore, human intent and action are decentred, and we focus on how the elements within the network (and related networks) function and sustain themselves. The network is treated like an organism, where ANT focuses on the highly specific negotiations and relations at the points of connection.

In ANT, truth and other essences change over time within a network. It is the role of the researcher to recognise the forces that influences these essences. Many times, it is how the relationships between actors/actants grow and interact with each other that influences how these processes in turn affect actors/actants (Callon, 1986a). Consequently, ANT-driven research attempts to present the dynamics in the making and re-making of groups/networks. However, there are important features in basic ANT that do not cater for a 'developmental' professional learning network. A naturalising ontology between all known elements can lead to a non-critical and non-reflective (Whittle & Spicer, 2008) description of the 'hidden' baggage that actors may bring to the network, outlining complex issues that can be potentially sidelined.

IV. From Basic ANT to After-ANT: Catering for Complexity in the Professional Learning Network.

As a result of the problems previously discussed, ANT further evolved in the late 1990s. Despite its naturalising and relational properties, ANT could not fully cater for the complexities of incomplete, broken or emerging systems. In some ways, ANT had become too formulaic. As stated by Law, "order and mess are mutually constitutive ... order obscures mess; mess obscures the practices of ordering" (Law, 2004). Literature started to come out under the umbrella of 'After-ANT' (Law & Hassard, 1999) to broaden the capacities of ANT. 'After-ANT' theory allows someone to explore networks within networks, honour multiple

ontologies and epistemologies to allow greater critical ability (Whittle & Spicer, 2008), and ambivalent fluid spaces between elements (Fenwick, 2012) along with stronger reflexivity (Nespor, 1994; Elder-Vass, 2015). This interpretation allowed After-ANT to fit better with empirical research which requires a participatory, observational, and/or experiential components.

In the case of the study's networks, the primary actors share a common objective – being able to use and transform the 'intervention' actant. Consequently, an ANT network in the area of professional learning has the inherent expectation for transformation/translation. If it does not succeed, this implies that the set-up relations between actors and actants and the processes inherent of the network may prove to be insufficient.

After-ANT allows the researcher to look at all of the actions over time surrounding the OPP or token, and its capacity to identify and track connections across spaces and structures by paying attention to the way in which knowledge is transformed and recontextualised. Therefore, the actors are collaboratively active participants within the network, developing relations and processes that will motivate their shared aims.

The other determining factors include the teacher (actor) believing that they have gained knowledge from the experience and that it can be sustained to a reasonable degree within their own particular classroom. As stated by Latour, "Translation is paradoxical ... To translate is to betray: ambiguity is part of translation" (Latour, 1996, p. 48). For another similar network to gain the same success there may be need for less or more elements or actants. We cannot predict the complexity of an individual network/system. Teachers and researchers may believe that they are in control of their network but the individual ways they may behave towards other actants and actors may affect the timing and outcomes of their particular work. We need to remember that ANT does not explain why or how a network takes the form that it does. Instead it is a method of exploring the relational ties of a specific network rather than taking description further.

ANT is grounded in work like empirical case studies (Law, 2009) and the associations and relations between actors and actants in a particular situation. We can only understand the development of a teacher's professional learning by following his or her own journey. We can have an idea of how the token works in a case study by following and mapping the way it is mobilised and translated by the actors of that particular network (Fenwick & Edwards, 2010).

Consequently, from case study research basic data stories can be put together and analysed (Lather, 1992). In the initial analysis of the essential ANT networks, similarities and patterns will be relatively easy to see. As supported by Suchman (2014), this technique allows for the associations and practices within a network to be pronounced:

> Like all object making, the delineation of a practice is always and irremediably part of a practice that informs what constitute productive and coherent units of analysis. It is that which makes us responsible and accountable for our research and its inclusions. And it is that which calls on us to be attentive to our own practice's systematic and necessary exclusions...(Suchman, 2014, p.29).

It is the contexts, ambivalences, and backgrounds of the actors/actants that delineate networks from each other. This is where After-ANT philosophy and reflexivity (Fountain, 1999; Callon, 1999; Law, 1999; Nespor 2006) comes into play in this investigation.

This highlights how occasional, partial or incomplete translational events can be to the researcher, revealing what other actants or processes may be introduced or withdrawn when the network experiences changes. It is distinct episodic events like this that can be captured in reflective case-study research, and can instigate the main actors to view the network differently with different ontologies/perspectives (Mol, 2002) sometimes resulting in new objectivities (Haraway, 1991).

ANT has not only matured but has been utilized by researchers in a variety of ways. It can be used as a theoretical framework (Latour, 2005), whereas previously is was seen not as a theory but as a "network-tracing activity" (Latour, 1996, p.378) or as a " a very crude method to learn from actors without imposing on them a prior definition of their world-building capacities" (Latour, 1999, p.20).

Therefore, in this study, ANT has been moulded from its variety of incarnations to accomplish two key objectives. Its traditional form is being used as an initial framework to assess the parameters of a possible dyadic professional learning structure within classrooms, but its After-ANT form helps provide a mindset to guide the actors in the usage of traditional methodologies like participative ethnography and case study research to provide depth and clarity to the framework.

Chapter IV: Methodology and Research Design

This chapter will describe the rationale and strategy behind the methodology and methods used within the study. This investigation stems from questions and research aims generated from the intertwined study of Mathematics Anxiety and professional learning which implies that the investigation does not necessarily fit with any one customary methodological approach. Consequently, the first section of this chapter will revisit the construction of the research aims and questions to see how they address the relationships between the two study areas.

The second section will address the methodological concerns of the study where the research approach is specified and deliberated. The third section describes the complexity surrounding the unit of analysis, while the fourth section describes the specific research strategy taken, outlining the types of research methods used to conduct the data collection and analysis.

I. Research Aims & Questions

Research aims of this study can be viewed as twofold, but they have been deliberately intertwined so that rich data can be used to explain two significant features:

- to observe and develop an effective framework of professional learning between a researcher and a teacher.
- to observe the implementation and impact of learning science measures to reduce the prevalence of Mathematics Anxiety.

The research situation has been purposely generated to introduce a researcher into a mathematics classroom.

Introduction of the researcher into the classroom was premeditated by both teacher and researcher, so as not to be too alien for the student cohort. The study catered for this variable by allowing the teacher time to inform the students of the introduction of the researcher, so that he could be viewed like other adults that may come into the classroom (i.e. parent volunteer, school services officer (SSO), and other teachers). A duration period of six to eight weeks allowed the researcher time to develop authentic relationships with the students.

This investigation sought to answer the following key question:

> How can the gradual introduction of an educational specialist, the researcher, into a classroom impact teachers' knowledge and pedagogy?

The above research question then poses a significant secondary question to the method of inquiry:

> How does an object like the intervention package, brought in by the researcher, influence the professional learning of the teacher?

These two questions illustrate the need to analyse not only relational structures between the key agents and important items within the classroom but address their capacities to learn and grow – demonstrating a significant developmental attribute.

II. Methodology

The research methodology undertaken within this study, is both descriptive and ethnographic (Walliman, 2001), highlighting a dual methodological approach.

Ethnographic research aims to represent a view of the participants in their environment, which is the dyadic professional learning network. It ultimately aims to demonstrate the totality of the environment, by what the participants bring to the network (Clarke, 2005). While building the theoretical basis of a dyadic professional learning network, participants can also bring forward and discuss their predispositions and perspectives. This highlights the descriptive case study element of the investigation.

The initial part of the methodological route is highly descriptive relying on Actor Network Theory (ANT) as the theoretical model in describing how human participants and objects are observed and analysed. Descriptive research relies on observation and human responses as a means in collecting data. Observational data and responses are recorded, and subsequently analysed, in order to examine the specific situation (Clarke, 2005) of the dyadic professional learning network.

The similar research and data collection tools of ethnographic and descriptive research allow this dual methodological approach to work, allowing construction of a framework to unfold while outlining the development of participants. This also signals a multi-methods approach to support the dual methodology. Consequently, at a functional level the methodological

approach is that of a mini-ethnographic case study design (Fusch, Fusch & Ness, 2017; Amaechi & Fusch, 2019). It encompasses a dual methodological approach catering for two units of analysis – the teacher participant and the professional learning network.

The multi-methods instruments used are background surveys for the teacher participants; attitudinal and quantitative performance markers for the student participants; observation notes; teacher and researcher discussions; and preparation meetings.

However, the study also has two significant embedded features to highlight the relational construct of the research design. The data from the student cohort and ultimately from the intervention, help influence and direct the path of professional learning for a case study. These embedded features, however, do not imply a typical embedded research design (Creswell & Plano Clark, 2011). Instead, the embedded features provide essential internal and construct validity for the case studies, ensuring that they can be analysed individually as single independent entities. In terms of the professional learning networks, they will be initially analysed as constructs for their own case study. The main purpose of the multi-methods approach therefore, is primarily developmental.

The approach is to chart the individual professional learning development of teacher participants. Intrinsic and emerging elements of the professional learning networks that allow this to happen, also grow and refine over time. These two significant aspects of the study continually inform and influence each other, highlighting its developmental attributes.

The initial descriptive research (the professional learning network), helps to inform the subsequent part, the greater ethnographic research data made and collected by teacher participants and researcher. Ultimately, the ethnographic data from the individual teacher, refines their professional learning network, and what type of connection that they have with their individual network.

III. Two Units of Analysis / Philosophical Underpinnings

Previous chapters have introduced and outlined a key concept in understanding the structure and course of this investigation – the development of a network. Actor Network Theory (ANT) helps provide the theoretical foundation of the study, by conceptualising how the professional learning network will be analysed at an operational level.

The preliminary unit of analysis is the teacher-participant. A survey and questioning from the researcher helps set up the base-point of the teacher-participant's knowledge and ability levels. The depth of professional learning gained from the teachers, indicates the need for case study research to qualitatively track their professional learning journeys and what they do with the learning.

The professional learning network (PLN), as the second unit of analysis, is constructed and developed by both the researcher and the teacher. As the teacher learns or stumbles, the PLN develops or adapts accordingly. Both the researcher and teacher can explicitly monitor the status of the PLN, which along with ANT, provides ideas in how the professional learning can progress. Consequently, the two units of analysis are complementary with each other.

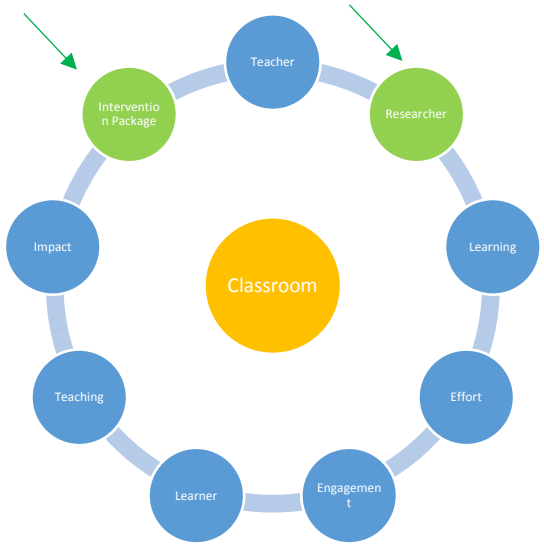
However, both units of analysis takes place within a regular setting (the classroom) with other regular participants (students). Subsequently, there are other important related regular elements that need to be recognised to answer the research question.

The idea of a network/system becomes a key construct in the methodological design of this investigation. Key participants contribute in designing the professional learning framework, as illustrated on the next page (Figure 4.1 A Basic Classroom Network). In systems theory, key participants use conventions of a particular type of system like observing and learning to build on what is known as a nomological network (Alavi, Archibald, McMaster, Lopez & Cleary, 2018).

The idea of a nomological network comes from Cronbach & Meehl (1955) who wanted to test the construct validity of a network/system by the inter-related components, processes and laws that they are based on. A nomological network requires the researcher to visualise and set up abstract constructs from propositions into a logical structure (Bhattacherjee, 2012), and then declare clear correspondence rules to test the network and its inner relations. The following diagram (Fig 4.1), although innovatively used for an education-based network, is

based on key variables described and required within a nomological network (Bhattacherjee, 2012).

Introduced Actor & Actant into Classroom Network



MEDIATING VARIABLE	Academic & Affective Achievement
MODERATING VARIABLE	Effort & Consistency
INDEPENDENT VARIABLE	Intelligence
DEPENDENT VARIABLE	Developing Well-Being & Engagement

(Based on work by Bhattacherjee, 2012)

Figure 4.1 Introduced Actor & Actant to Network

Two new constructs, an invited researcher and intervention package are introduced to this network on the theoretical propositions that the teacher will professionally learn and grow from the package and from the impact that it will have on the students. The initial and continual effort and consistency provided by the teacher & the researcher, will have an impact in moderating the effort made by the students. The effectiveness of the key actors and the intervention package were mediated by the combined academic and affective results students see in their work. It is difficult to ascertain academic results by themselves, as intelligence can be an independent influence. However, all students were seen equally by the co-dependent growth that positive affect and academic prowess can have on each other.

The variables in Fig. 4.1 demonstrate key correspondence rules for the teacher and what is being seen and acted upon within the classroom. The professional learning network is being interpreted as socially constructed (Creswell, 2014) from the social interactions of participants, and their experiences in using an intervention package with their students.

IV. Interpreting the Professional Learning Network

Consequently, the unit analysis of the PLN depends on how teacher-participants and the researcher view and use the correspondence rules constructed for the professional learning network.

This interpretivist perspective has been operationalised by teacher-participants and the researcher using the following questions (among others) to construct their own understandings and experiences.

How are your understandings of Mathematics Anxiety improving from this learning experience?

- Are there some possible instances of Mathematics Anxiety within your classroom? How can you make some alterations to the intervention package? How can the assigned strategies (biblio-therapy, priming and mindsets) be translated into your classroom?
- Are your abilities and confidence in addressing Mathematics Anxiety improving from the opportunities provided by this experience?
- How can you demonstrate experienced improvements in a qualitative and/or qualitative form?
- Is this network, that you are a part of, and the timespan provided making it easier for you to translate key ideas and processes into the classroom?

These operational questions demonstrate the relational basis of a nomological network that can be viewed as a PLN within a classroom. ANT provides an initial theoretical lens to the PLN. A PLN model was ultimately constructed from the above theoretical and operational foundations.

The initial part of the methodology is highly structuralist and functional in nature. Afterwards, the methodology takes an even greater descriptive route as ethnographic contributions from participant teachers and researcher allows them to describe their developing professional learning journey.

Groups of actions will be described and linked so that key relationships, behaviours, actors/actants, and their boundaries are identified and mapped to create the initial professional learning network (PLN). Over time, these PLNs evolved, as student progress and teacher professional learning needs developed.

Although empirical observations played a key part in the research method, the research approach is not grounded theory building. Patterns of events or behaviours are shaped by the rules of ANT and outlining predetermined elements like identifying key actors and actants. This demonstrates a bottom-up conceptual analysis based on inductive reasoning by all participants.

Once the basic structure of individual dyadic professional learning networks is established, the research approach takes a significant turn. As teacher participants and the researcher add their personal experiences to the PLN, the approach becomes more deductive. Observations and personal perspectives provide complexity, confirming attributes like whether the framework is concrete and is flexible to individual teacher needs. This demonstrates a degree of agency theory between researcher and participant teachers, as they not only react to their common interests but to individual predispositions as well (Ross, 1973).

Consequently, the methodology of this investigation is largely interpretivist in nature, relying on some quantitative data from surveys, but more so on qualitative data. The network concept, based on an existing classroom structure, helps with both the construct and internal validity of the approach as both teacher participant and researcher undergo a significant degree of simulation with their teaching and communication to students within the classroom. External validity is affected by the small number of participants in the investigation, and by the varying contexts of the school sites where the intervention takes place. The combination of simulation, case studies, ethnography, with initial and concluding snap-shot surveys, provided a reasonable degree of triangulation. Teacher participants created their professional learning networks from the specific understandings and needs that they bring, not by what other teacher participants were doing. It is true that there may be some structural similarities

laterally between the PLNs. However, the essence of the research question is unilateral and developmental.

The inner elements and workings of the network are significantly more important in answering the research question. The success of professional learning is incumbent on how the internal elements and relationships interact and adapt to the particular needs of the teacher participant.

Therefore, the research methodology of this investigation is dualistic with a multi-methods anthology. The anthology of qualitative methods gathered demonstrate an initial focus on construction followed by enactment, and interpretation.

Therefore, the thinking behind this investigation is greatly allegorical and performative. Although the idea of a network may be limiting of what realistically happens within a classroom, it seeks to demonstrate a utilitarian approach to dyadic professional learning that is understandable to teachers. A dual methodological perspective of this study attempts to bring together the systematic structure of dyadic professional learning to the complexity and multiplicity of what happens in an individual teacher's classroom.

The practical and performative nature of the methods used by the participants, also alludes to a significant reflexive component. If we focus on practice within the classroom, teachers make a variety of choices that influence their development. Their own reality can be simply outcome-specific or multiple, depending on their own individual situation. Reflexivity which is a significant part of the second interpretivist stage, will show how teachers develop and craft their own personal learning journey. The philosophy of After-ANT, which has already been outlined in Chapter 3, helps direct the subsequent stages of this investigation.

V. Research Strategy

A research strategy is required in building and developing the proposed professional learning network. Although the methodology of this study has been defined, in terms of theoretical structure, methods and execution, the research strategy is the specific way in which this is implemented (Saunders, Lewis & Thornhill, 2009; Ciernak, Imhof & Reimann, 2010). The following sub-sections will demonstrate the specificity of the research design of this study.

i. Case Studies: Purpose and Development

Due to the length and developmental aspects of the investigation, the longitudinal element of case-study design (Bryman, 2008) becomes restricted according to the complementary ethnographic element (Amaechi & Fusch, 2019; Fusch, Fusch & Ness, 2017). The case studies look at the professional development of teachers over an eight to ten-week period.

The investigation is seeking the general coherence and variance that may occur with similarly minded teachers of different experiences and skill who teach mathematics. This leads to the concept of naturalistic generalisations (Stake, 1995) where generalised behaviour resides in the minds of the reader or user in how to further comprehend a particular type of habitat, like learning within a classroom. . Naturalistic generalisations are furthered by the concept of phronesis (Thomas, 2007; Thomas, 2010; Spricker, 2011) where the teacher has an inside knowledge and understanding of their educational context and environment from the adaptations, habits, and practices they regularly do. Instead of looking for generalisations based on deductive fact, this investigation looks at inductive observations like patterns and trends that stem from the innate professional learning experiences of teachers within this study's context.

"The case study thus offers an example from which one's experience, one's phronesis, enables one to gather insight or understand a problem" (Thomas, 2011, p. 31). This leads to the idea of 'exemplary knowledge' rather than 'generalised knowledge' which normally leads to generalisations. Exemplary knowledge provides us with a series of specific although limited amount of ways in undergoing and understanding an experience like professional learning for teachers. The phronesis of the case studies in this investigation provides a space where the normative, exemplary or emerging experiences of the participant teachers are all observed. These observed experiences then help form potential guides to action for teachers learning within the highly specific professional learning space presented within this study.

This then leads to the development of theory, of which Actor Network Theory plays a key starting point in this study. Theoretical generalisations begin to form from the populations and settings from which they are based (Tsang, 2014) demonstrating the popular usage of case studies in this type of research (Eisenhardt & Grabner, 2007).

Theoretical generalisations lead to theory building, then allowing empirical generalisations to start identifying empirical regularities (Tsang, 2014). Therefore, developed theory becomes the vehicle by which the case study's validity is tested (Thomas, 2011). Case studies allow

researchers to tease out ever-deepening layers of reality in the search for mechanisms and influential contingencies, and to peer into the box of causality to locate the factors lying between some critical cause and its purported effect (Gerring 2007).

This process creates the depth and detail necessary for capturing the 'hows' and 'whys' rather than only the 'whats' (Harrison and Easton 2004) of how a teacher may learn in a specific situation. A key difference between case studies and quantitative methods is that case studies seek to investigate phenomena in their contexts, rather than be independent of context (Gibbert, Ruigrok, & Wicki, 2008). Although this indicates that this investigation is steering towards a more idiographic approach, it is anticipated that the case studies help cast a heuristic as how to look at a dyadic professional learning network.

Knowledge levels of all teacher participants within the study need to be determined, as their individual experiences and skills may reveal different points of need and reference. A gap of knowledge may not only be the situation amongst teachers, but an understanding of their roles in dealing with the situation of mathematics within a school. Consequently, case studies will become an integral part of the research design to describe the 'totality' of interactions, behaviors and attitudes of each of the teacher-participants.

The classroom becomes an 'ecologically valid' site for the research being conducted. It allows the teachers to immediately accept, adapt, or denounce theoretical concepts into educational practice, as they better understand their environment and student cohort than the researcher does. However, it also highlights the teacher as an essential knowledge generator for data as are the students.

ii. Data Sources

Preliminary surveys will identify teachers' initial knowledge and attitudes which allow for the demonstration of their development. A checklist of clear reflective points between teacher and researcher will also indicate that progress is being made between them at a relational level (See Appendix B). Although the research is based around a defined group of case-studies with co-operative/participant / ethnographic inquiry it is also highly developmental in nature, highlighting that there would be sequential stages of the research process. This signifies a mini-ethnographic case study approach. The stated research goals are viewed to

bring about emergent and changing data in order to develop and define the professional learning framework (Patton, 2011). Consequently, there is a multi-methods approach underlying this investigation bringing qualitative surveys and collaborative ethnographic inquiry together.

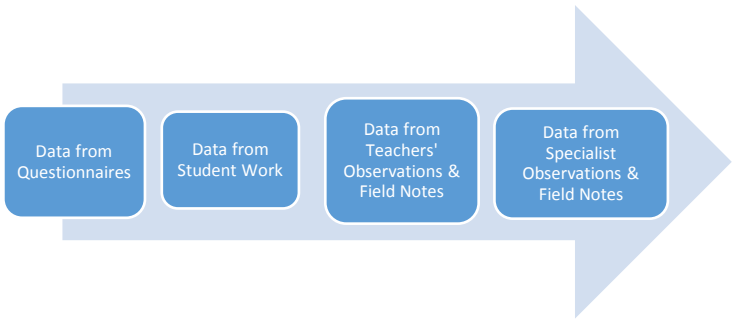


Fig 4.2 Data Sources for Professional Learning Framework

As illustrated above in Fig 4.2, data will come from four specified sources. However, these sources serve two key complementary roles. One is at a static level, where teacher and researcher have an amount of time to observe, analyse, and learn from the work within the classroom. This professional collaborative reflection then transforms the data into indicators of progression and development showing how professional learning has been achieved.

iii. Overview of Professional Learning Network Timeline

On the following page, the timeline (Fig 4.3) for the development of the professional learning network on which the research questions is outlined. The total duration of the data collection spanned eight weeks. The professional learning platform was employed across three sites with no more than two classes at each site.

As shown in Fig 4.3, the development of the relationship between teacher and researcher spans a greater period than just that in the classroom. The pre-intervention stage provides the teacher the opportunity to input their individual learning needs, while the post-intervention stage allows all participants to reflect on and attribute what their professional learning looked like.

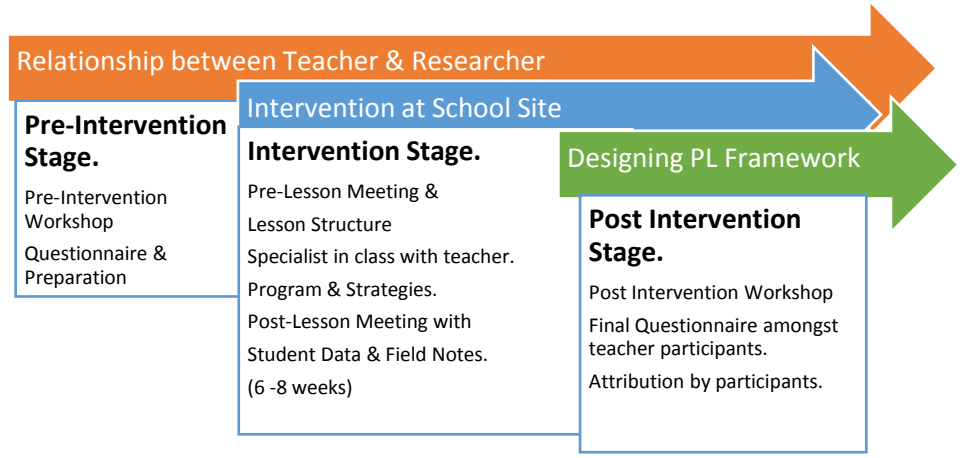


Fig 4.3 Stages of the Professional Learning Framework

iv. Participants

The main participants of the study are the teachers. They are drawn from secondary and primary school sites, with some potential variation (site and socio-economic region, quality of resources).

The teachers were chosen through the process of purposive/purposeful sampling. Patton (2002) provides an outline of 14 reasons as to why a researcher would choose purposeful sampling. In this study, the four significant reasons are to

1. have at least two samples to take advantage of unforeseen circumstances after field-work has begun in a relatively new area of inquiry (known as opportunistic sampling).
2. seek typical cases with some degree of stratification and variation (known as typical sampling).
3. all teacher-participants have pre-determined criteria that they want to learn about Mathematics Anxiety and feel that they may have students with Mathematics Anxiety (known as criterion-based sampling).
4. the teacher-participants must also have an operational / theoretical basis – they seek to be part of and improve their professional learning (known as theoretical sampling).

From an original group of four teachers, three of them completed all three stages of the intervention protocol as illustrated above. One of the four teachers pulled out soon after the start of the intervention protocol for personal reasons.

The students in the teachers' classes are viewed as secondary participants. The role of the students within the classroom lessons are to provide a significant rich stream of data from which the main participants work from.

The classes were chosen from Years 6, 7 and 8 class groups allowing initially four teachers to participate in the study. The initial student cohort was ear-marked to be around 100 students or 4 classes. As one teacher pulled out after 2 weeks of work, the student cohort was reduced to 78 students and the teacher participants to three. The cohort was still significant enough to provide a relatively large base of data through student work to be part of the professional learning for teachers. However, it is the three case studies that completed the eight-week intervention that determined what the professional learning platform would look like.

v. Study Demographics

Teacher participants interested in the area of Mathematics Anxiety, formed the basis of a purposive sample from Department for Education (DfE) sites around metropolitan Adelaide.

The study is determined by the acceptance of teachers and their schools in becoming part of this investigation. Although invitations were distributed to all districts of metropolitan Adelaide, it was not assumed that all metropolitan districts would be represented. The resulting representation became a limitation of the study, highlighting workload concerns of time and availability.

vi. Description of the Intervention.

The scope and scale of the intervention package can be demonstrated in the following intervention summary (Table 4.4):

INTERVENTION STAGE	**EVENTS**	**TIMESCALE**
Pre-Intervention Stage	Introductory Workshop • introduce participant teacher to each other. • Perform Maths Anxiety Awareness Questionnaire (See Appendix C) • Demonstrate research behind the 3 Strategies to be used. • Highlight how Strategies will be delivered. • Set up logistics as to when specialist can come to sites.	**One Week**
Intervention Stage	Classroom Intervention • 2 x 45 min lessons with specialist per week at each site. • Planned post-lesson meetings • Lesson planning & review of lesson and the 3 strategies.	**Six to Eight Weeks** Intervention may conclude after 6 weeks but teacher and specialist may require extra time to consolidate data and findings.
Post-Intervention Stage	Final Workshop • Bring all participant teachers together. • Final Questionnaire (See Appendix D) • Participant teachers to share views of professional learning experience.	**One Week**

Table 4.4 Intervention Summary

As shown in the previous intervention summary (Table. 4.4) a base-line point of all teachers' perceptions and understandings of Mathematics Anxiety was formalised so that the initial

stage of development for professional learning could be set for each case study (teacher participant). An introductory workshop with all participant teachers was conducted to:

1. Determine teachers' knowledge and attitude levels - (Appendix C Questionnaire).
2. Provide teachers with an outline of current research findings and subsequent recommendations regarding Mathematics Anxiety.
3. Link the research to the designed intervention strategies that will be conducted in their classrooms.
4. Familiarise teachers with the processes and procedures regarding the implementation of the intervention.
5. Clarify how data will be gathered and recorded during and after each lesson.
6. Answer any questions pertaining to the research inquiry.

vii. Setting up the Intervention

Class interventions were two to three 45-minute lessons a week. The timespan of each class intervention was four to six weeks depending on school timetabling and the needs of the school.

a) Pre-Lesson Meeting and Lesson Structure.

As part of the intervention structure, there was a pre-lesson meeting between teacher and researcher to confirm roles, data to be collected, and learning outcomes.

At the pre-lesson stage, teachers were tasked the following activities:

- Collecting homework tasks from students as part of the artefacts to be studied.
- Signposting working memory tasks and affective checks to students as part of the lesson routine.
- Recording in real-time students' interaction during a specified classroom task.
- Instructing and modelling biblio-therapy tasks ready for homework activities.

Recording observed working behaviours on lesson checklists, and documenting observations.

The lessons had room for flexibility but will be based on the following protocol:

Introduction	Lesson Part 1	Lesson Part 2	Lesson Part 3	Lesson Part 4	Lesson Part 5	Lesson Part 6	Review
Pick up Homework exercises. **Introduction to lesson format and goals.**	**Lesson Activity**	*Working Memory* *OR* *Affective Feedback* *(2min)*	**Lesson Activity**	*Working Memory* *OR* *Affective Feedback* *(2min)*	*Biblio-therapy Task* *(5min)*	**Lesson Activity**	Working Memory OR Affective Feedback (2min)

Table. 4.5 Lesson Protocol during Intervention Stage

Student information was collected at the end of every lesson from the following:

- Homework artefacts
- Working Memory Results/Personal Affective Checks
- Real-Time Activity Recordings
- Checklist/Observation notes.

The checklist (Appendix A) was used to record positive and negative learning behaviours.

b) Post-Lesson Meeting

The post-lesson meeting becomes one of the main sites for the professional learning to occur. This is an opportunity for the teacher and researcher to share comments and written observations. It is at the post-lesson meeting that student information from a variety of sources can be discussed and interpreted. All teachers had a field-notes journal to record thoughts and views. What was discussed at the post-lesson meeting can be included in future teachers' written reflections.

After the sharing of student data, the specialist collated all work into a portfolio for further investigation. It is at the post-lesson meetings that future lessons were planned according to behaviours or outcomes observed and realised.

The sharing and further interpretation of student data and field notes by teacher and researcher helped direct classroom management and lesson development. This formed the basis of meeting minutes and would also become a key aspect for 'learning' between researcher and teacher. The journal entries by teachers helped to map the professional learning journey with the researcher.

c) Post-Intervention Stage

According to the needs of individual teachers, the post intervention stage occurred two to four weeks after the completion of the intervention, to provide some reflective space for both the specialist and teachers. Teacher participants were asked to join the researcher for a final workshop where a post-intervention questionnaire (Appendix D) was presented. This was not only an important opportunity for teacher participants to demonstrate their confidence and knowledge levels about Mathematics Anxiety, but to assess and signpost what practices embedded from the study could be assigned as beneficial to their own professional learning and reducing the incidence of Mathematics Anxiety. Consequently, during the final workshop teacher participants were able to document or video final testimonies.

viii. Role of Researcher

The researcher performed a variety of roles throughout the study. For example, the researcher would act as facilitator at the initial and final workshops, then work together with the teacher as an active participant in the research during the intervention. However, it must be remembered that the researcher is the specialist within the working relationship. The students were made aware that the researcher would become a regular part of classroom practice on certain days over a length of time.

The researcher mainly took on the role of mentor as suggested by Tomlinson (1995) but as the intervention and professional learning developed so too did the roles of the researcher. Wang and Odell's (2002) three complementary mentoring models (knowledge transmission model, theory and practice connection model, collaborative inquiry model) demonstrate just how vast or specific the functions of a mentor may be. Clarke and Hollingsworth's (2002) and Desimone's (2009) non-linear frameworks assist in describing the attributes of the

teacher and researcher in the binary relationship while accompanying this with the over-arching systemic attributes that you would find in collaborative inquiry (DeLuca et al., 2015).

VI. Data Collection

In order to effectively describe the scope and parameters of the professional learning platform, teacher participants needed to observe and reflect on their professional teaching and learning practice. The way teachers do this, however, needed to be expressed in a regular format in order to maintain a relative level of consistency across the case studies. The summary table (Table 4.4) provided on page 58 outlines what every teacher-participant experienced.

From this, data sources (see Figure 4.6) can subsequently be mapped out from the concepts and theories used throughout the intervention stages. The data sources cover Creswell's (2007) four categories of qualitative data sources: observations, interviews and questionnaires, documents, and audio-visual materials. Apart from Sources 1A and 1B, the other data sources are not being listed nor viewed as data collection stages.

Focus /Question	**Concept / Theoretical Model**	**Data Sources**
How does the introduction of an educational specialist into a classroom over a time period impact teachers' knowledge and classroom practice?	Initial Workshop to provide awareness of Mathematics Anxiety and the 3 Key Intervention Strategies. 'Reflection in action'/ practice-based theory Schon (1983, 1991) and Reflective Practice. Case Study 'Participant Observation' to share meaning and understanding between researcher and teacher of the 3 Key Strategies and capture meaning of professional learning relationship. Reporting observations and sharing with collaborator (Nokes, Bullough, Egan, Birrell, & Hansen, 2008; Aspfors & Frannson, 2015) artefacts of student work. Developing individual professional learning networks using Actor Network Theory. Saturation of data and recorded changes by teacher and researcher is noticed by changes in teaching practice and attitudes. Final Workshop	Questionnaire to map teachers' initial knowledge and abilities (SOURCE 1A) Teachers keeping a regular diary of their practice during intervention period. Teachers are writing journal entries after teaching sessions. (SOURCE 2). Researcher and Teacher record observations of each other. (SOURCE 3) Teachers writing/recording collaboration and meeting notes of their time with researcher (SOURCE 4). Student School work (SOURCE 5) Final Questionnaire to map teachers' resulting attitudes & development. (SOURCE 1B)

Table 4.6 Data Source Validation Table In each case study, the researcher and teacher produced and collected data from each of the defined sources. However, according to personal teacher organisation and expression, output of data may be different among each teacher. As described by Creswell, output can sometimes be restricted by field issues surrounding access, and limitations of the data sources (Creswell, 2013) For example, stakeholders may not agree on the value of materials brought to the meeting, nor speak that much, reducing the quality and output of data. In terms of speech, this happened in Weeks 1 and 2, as the speech between researcher and teacher-participant was quite formal and succinct. As the working relationship developed between researcher and teacher-participant the sharing and verbal output between them also improved. A result of this, was the stringent meeting agenda shown in Table 4.7 below, as in Week 4 and 5, meetings were approaching the hour mark.

Meeting Protocol	
Time of Meeting:	**(average duration of 30-45min)**
Date:	
Place:	
AGENDA	
1.	Minutes from last meeting
2.	Immediate Concerns (At Risk students & behaviours)
3.	Weekly Reflections Discussion
4.	Lesson Tasks & Homework Discussion
5.	Compilation of Results & Annotations
6.	Preparation for Upcoming Lesson
7.	Any other Business

Table 4.7 Example of Meeting Outline Used

A checklist for data collection was brought to each researcher-teacher meetings where date sources were brought to the meeting, and signed that they had been discussed with each person. Being aligned to the data source descriptions outlined in Table 4.6, the checklist on the following page (Table 4.8) demonstrates where the data may have had come from at any given point throughout the intervention period

Data Collection Checklist

Meeting Date	SOURCE 1A Initial Questionnaire	SOURCE 1B Final Questionnaire	SOURCE 2 Teacher Diary Entries	SOURCE 3 Observations by Teacher & Researcher	SOURCE 4 Teacher writing & collaboration at Meetings	SOURCE 5 Student School Work
Week 0	√	X				
Week 1			X	√	√	X
Week 2			√	√	√	√
Week 3			√	√	√	√
Week 4			√	√	√	√
Week 5			√	√	√	√
Week 6			√	√	√	√
Week 7			√	√	√	√
Week 8			√	√	√	X
Week 9	X	√	X	X	X	X
	X – No Data collected		√ - Data source collected			

Table 4.8 Data Collection Checklist

Data collection protocols were developed to help provide a level of consistency in the quality of gathering and production of data. The meeting protocol presented on page 63 (Table 4.7) and observation protocol (Appendix 2) were devised in line with Creswell's (2013) interview and observation protocols. The meeting protocol was revised in Week 6, as the student output discussed in Weeks 4 and 5, was approaching the hour mark. Both teacher-participant and researcher were satisfied with the output, but concurred that they couldn't afford more than 45 minutes for a review meeting.

Teacher reflections, along with observations and dialogue with the researcher are data collecting techniques used successfully with binary professional learning environments like paired student teacher placement (Nokes, Bullough, Egan, Birrell, & Hanson, 2008) mentoring (Aspfors & Frannson, 2015) and co-teaching (Gallo-Fox & Scantlebury, 2016). The teachers were provided with as much time as needed throughout the week to be reflective of their actions and thoughts in their journal entries. They shared their entries with the researcher the following week. The data sources from the students are from classroom

observations, work artefacts, and student journals, and form part of the professional learning observations and conversations that occur between the teacher and researcher.

VII. Strengths & Limitations

A key methodological limitation was the restricted amount of time that the researcher spent within the classroom and with the teacher afterwards. The time within classrooms amounted to approximately 90 minutes a week and a further 45 to 60 minutes alone with the teacher. Over time, the students acclimatised to the new situation in mathematics lessons each week. However, with the process and allocated timing of observations and interacting with key students, the researcher is only aware of students' behaviour and needs when he is present in the classroom. This is succinctly described by Walcott (2001) who states, "I must attend to something, I can't describe everything" (p.36). This is where the mutual activity of teacher and researcher in providing feedback to each other after the lesson, helps to provide a larger window of what is going on within the classroom.

The mini-ethnographic case study methodology is a delimitation. The researcher focuses primarily on the development of a handful of teachers in a restricted environment at regular intervals over a specified timespan. The restricted environment just happens to be the classroom but is the site for where the professional learning takes place.

Coming only into some set mathematics lessons is a delimitation for the area of Mathematics Anxiety. The researcher does not fully appreciate the effect of the intervention on other subjects and activities in the class, except through the regular feedback from the teacher.

A regular limitation of qualitative research is that it is not generally generalisable to the larger population, so has low external validity. However, the significance of the PLN aspect of this study is to develop potentially 'transferable' components to teachers in similar circumstances. For example, there are regular time points throughout the intervention period along with protocols, as to how the teachers should participate and self-reflect. Nevertheless, it is the potential emergence of aberrant behaviours, new learnings and new practices that is important for this investigation.

The results from the case studies do not rely on 'generalised knowledge' but more on 'exemplary or specialised knowledge'. Exemplary knowledge provides teachers with specifically professional and cultural, although limited, ways in undergoing and

understanding professional learning within a specific dyadic educational experience. This utilitarian perspective looks more to the *hows* this can work rather than necessarily to the *whys* it works. This instrumentality provides a scope in investigating teachers' practice and experience within a specific professional learning setting.

Another limitation is the over-arching background presence and behavior of the teacher prior to the researcher entering the classroom. The researcher regularly interacts within the context of the PLN that he is a part of, best determining the 'reality' and workings of the particular situation (Creswell, 2007). The researcher is focusing on the smaller intricacies of the PLN as a functional unit, rather than determining the affect from outside influences.

However, a delimitating aspect of this, is that the teacher-participant is not professional learning in other lesson periods of the day. The behaviour displayed by the teachers during mathematics lessons are possible behaviours the teachers would demonstrate in other professional learning settings, and not necessarily in regular lessons.

VIII. Ethics

The ethics process for this study has occurred jointly through the Research Unit in the Department of Education of South Australia (Reference No: 2018-0038) and through the Human Research Ethics Committee at Flinders University (Project No:7997. Applications were lodged and approved by both providers.

All teacher participants were approached via emails to principals at a range of sites across metropolitan Adelaide. It was a voluntary process for principals and teachers to respond to these emails, so there was a possibility of a second wave of emails to be sent out if the initial response was insufficient.

Once a principal and teacher at a school site agreed to the professional learning, consent forms were sent home to students' families/carers for approval. Students and their families had the opportunity to opt in or out of the assessment part of the intervention but continue to participate in normal lessons. Teachers provided written permission of research practice in their classrooms. All parties were provided with assurance of anonymity with use of avatars and coding in results and findings from the research.

The researcher is a DfE (Department of Education) employee who may be known to some DfE schools.

IX. Data Collection & Preparation for Analysis

The data analysis process happened at two levels and at different times and locations. Participant observations and discussions occurred at allocated and occasionally unplanned times at the school site. This led to some collaborative data analysis between teacher and researcher, but the data analysis was predominantly the responsibility of the researcher. This is referred to as the schoolwork data stream. As previously mentioned, pre-lesson and post-lesson meetings were negotiated between researcher and teacher and used as the main forum for student data analysis.

A protocol guided the agenda of these meetings:

1. Looked at journal entries from last week's lesson and provide any necessary feedback before the next lesson. This was an important time for the teacher to demonstrate what he/she has learnt or believes needs to be done in the future.
2. Each participant provided quick verbal summation and views in how this week's lesson went. Participants then wrote down notes of the views as initial journal entries. Journals were then taken home for these commentaries to be expanded or provided with more depth.
3. Looked at the output of students together from the lesson and came up with inferences as to what was achieved. The researcher took notes of these findings.
4. Both teacher and researcher used these findings to either refine or substantiate the course of the next lesson. Teacher and researcher then had some time to allocate duties or do preparation prior to the next lesson.

The journals were electronic based. A paper-form copy of the journal was also brought along to meetings, however, teacher-participants emailed their weekly entries to the researcher. The purpose of this, was to allow the researcher to keep a separate ontological account of the teacher's journal for the other stream of data which is referred to as the ANT data stream.

The researcher had the teacher's journal, observation notes from lessons, along with feedback from meetings as to the development of the participant teacher's professional learning

network. Although this data analysis was largely completed by the researcher, it was not devoid of teacher input.

The teacher had the opportunity to voice as to why or how certain behaviours or actions took place, which may have a varying ontological view to that of the researcher. The teacher may question the insertion or value of an element within their PLN, but the initial placement of the element is at the discretion of the researcher.

Both researcher and teacher had equal input in regards to the school work data stream. However, as a result of the reflective journal instrument and personal initiative of the teacher, this input may be greater than that of the researcher. In regards to the ANT data stream, the researcher expected to have a far greater input than that of the teacher. This is a result of the assumed theoretical skill and knowledge of the researcher to at least build the initial network for the teacher. This seems commonsensical to cater for the time and organisational requirements of the study.

This demonstrates the management and mentoring role of the researcher, in keeping the teachers in check by following protocols in gathering data, and meeting and attaining milestones in their professional learning journey. The researcher outlined to the participant-teachers:

- The saturation point of data from designated lesson activities.
- Some behaviours or relationships from the 'emerging' data that the teacher may not be aware of.
- Developmental markers and milestones expected from both the school work data stream and ANT data stream, even though there may be minimal input from the teacher-participant in terms of the latter.

This allows the dual framework of data analysis to be clear to both teacher and researcher.

Data analysis was a key feature of the PLN, as it allowed the teacher to learn from 'emerging' data:

1. Content analysis of student data and a degree of performative analysis in how students respond to language and gestures used by teacher and researcher took place. All student data was interpreted by both researcher and teacher participant as part of the 'professional learning process' with teacher participants having the opportunity to

provide a number of reflections. This improved the triangulation of data interpretation, and thus the authenticity of teacher participation.

2. A framework (thematic) analysis with a degree of interactional analysis (dialogue between teacher and researcher) occurred separately from the above process. The researcher became familiar with the saturation of data and started the process of summarising and categorisation to establish the professional learning networks and demonstrate relationships that may reside within or be seen across the case studies.

From the described case studies, the researcher looked at the emotional and attitudinal responses to the intervention protocol of the teacher participants, along with linguistic and behavioural markers to the student cohort as well as towards the researcher.

Due to the complexity of intertwining qualitative and quantitative data that had been collected, the researcher decided to conduct the interpretation solely through data work sheets using EXCEL software. Coding was therefore, done manually as the researcher went through the inductive process. Units analysed were not only thematic (relationships) but referential (person/event) and physical as well (how the classroom or intervention strategies should be presented).

The three main case studies were analysed in-depth by using the initial thematic concepts of relationships, network, organisation, and professional learning development. These themes were looked at and analysed at key time markers over the course of the intervention period. This helped influence possible comparative analysis across the case studies which identified similarities or incongruences.

The researcher realised that other themes may emerge during the intervention period and afterwards, according to the dynamic work amongst actors and actants in the professional learning network. The researcher shared and referred his work with other researchers, in order to check the consistency and quality of the coding used throughout the investigation.

CHAPTER V

V. Results and Analysis: The Professional Learning Networks of Participant-Teachers

I. Introduction

There are many ways that researchers can write up and present case studies. The writing up and presentation of case studies can be supported by two key ideas of 'fitness of purpose' and 'fitness for audience' (Robson, 2002, p. 512-513). The audience for the case studies are primarily professionals in the education sector. Consequently, the presentation and discussion of the theoretical framework of the PLNs (professional learning networks) needs to be in a language and format that teachers can understand to a reasonable degree

This inquiry has two objectives: the emerging development of dyadic professional learning networks and uncovering the professional learning journey of teacher participants as they learn to work with the incidence of Mathematics Anxiety within their classrooms.

These two objectives fulfil the basis of the following research question:

> How can the gradual introduction of an educational specialist, the researcher, into a classroom impact teachers' knowledge and pedagogy?

Time, relationship structures and accomplishment for students and teacher become key elements in the development and analysis of the PLNs. Initial descriptive data will be presented via tables and infographics that show the relationships between elements. Actor Network Theory (ANT) provides the theoretical language and processes to describe the PLNs.

Case study results are therefore presented by what Robson (2002) calls a theory-generating structure. Data from the three case studies is drawn upon to support and expand upon the idea of a dyadic professional learning network. This involved an examination of the relationship structures and use of tools (i.e. curriculum and teaching aids) within classrooms to make this work.

The subsequent section has a time-based component to demonstrate the development of teacher-participants and emergence of new ideas that came from collaboration and classroom practice. This rich ethnographic data follows Robson's chronological structure for case

studies (Robson, 2002). However, as a professional learning structure developed to specific teacher needs, this structure will focus primarily on the accomplishment of key events and milestones of the teacher-participants.

II. Developing the Professional Learning Network

Throughout this section, each case study will focus on a single teacher participant and their individual classroom. Case studies will be presented individually at first, as it is important to view each case study as an independent bounded system (Merriam & Tisdell, 2016). The presentation of the case studies, however, is determined by their two units of analysis: the professional learning network and the teacher-participant.

Information delivered from the completed initial questionnaires of teacher-participants, along with further conversations prior to the start of the intervention period, will provide the basis of the initial professional learning networks. In the presentation of these professional learning networks, concepts, and processes from the already described Actor Network Theory (ANT) will be used.

This will help provide some common markers between the three case studies. Cross-study foundations need to be described to provide some universality as well. The provision for suspected 'at-risk' students who have Mathematics Anxiety provides congruent aims between the teacher-participants. This element demonstrates the common objective among teacher-participants to learn about and address the issue of Mathematics Anxiety within their classroom.

III. Setting Up the Classrooms

Prior to the start of the intervention, all teacher-participants notified the researcher of how many students they perceived as at risk of Mathematics Anxiety.

Classrooms	CASE STUDY A	CASE STUDY B	CASE STUDY C
Class Size	24 Year 6 students	25 Year 7 students	23 Year 8 students
No. of At-Risk Students	4	4	5
Probable Mathematics Anxiety Incidence:	16.6%	16%	21.7%

Fig 5.1 Case Study Break-down Table

The above numbers not only reflect the literature review's prevalence of Mathematics Anxiety to be in the order of 15 to 20% of the adolescent population, but that by high-school age if the learning difficulty has not been properly addressed in class the prevalence escalates (Ashcraft & Moore, 2009; Johnston-Wilder, Brindley & Dent, 2014).

Prior to the start of Lesson 1, both researcher and teacher-participants checked off necessary requirements for the intervention

- Students had clear view to the front where the teacher and interactive whiteboard were positioned, and that the adults also had clear view of all students.
- The researcher and teacher-participant had clear and easy access to all groups within the classroom to ensure interactivity.
- All students had their own folder-portfolio which was always brought out at the beginning of mathematics lessons.
- All students understood the role of the researcher during the intervention period.
- All students understood that the intervention consisted of three key elements of mind-set training, working memory drills and biblio-therapy.

IV. Presentation of Case Studies

In this chapter, the following case studies will begin with a detailed description of each of the teacher-participants. Information from an initial questionnaire, conversations with the researcher, help define each professional learning network. The agreed learning objectives will be outlined by individual professional learning tables and an initial network infographic.

Key relationships between actors and actants will be outlined via the variables highlighted within the methodology which may affect the course of the professional learning:

- Moderating variables
- Mediating variables
- Dependent variables
- Independent variables

All teachers who took part in the study have been appropriately participant coded for confidentiality purposes as pseudonyms. Appendices E and F show that all schools, classes and students have been coded. However, for readability purposes the pseudonyms of key actors in each case study take on fictitious names. Actors of less frequency and importance will be coded according to class and site (see Appendix E & F). Occasionally the participants will talk directly to the researcher. In transcriptions, the researcher will be coded as R.

i. CASE STUDY A: Sue

a) Description of Teacher-Participant

In this case study, the teacher-participant will be named and coded as Sue. Sue's class will be referred to (see Appendix E) as SPC1. Sue is a relatively new teacher of four years teaching practice at a primary school who believed that she could get a lot out of the proposed professional learning. Sue teaches a class of Year 6 students (SPC1). She believes that she has a highly developed understanding and command of mathematics but has little knowledge of Mathematics Anxiety and other related mathematical learning difficulties. Sue was concerned that her advanced understanding of mathematics may hinder the initiative or engagement of her students to experiment or collaborate with each other. She sometimes provided efficient short-cuts for students to reach answers accurately, without providing the necessary in-depth understanding behind a mathematical concept. Sue was worried that her explanation may be above the receptive understanding of her students. This is reflected in comments in her initial questionnaire:

> I don't want to be a spoon-feeder to my students. I have provided some good strategies for my students to accurately complete tasks in class and homework activities. However, this is not reflected in tests that they do. Some of my good students do not seem to fully understand the concepts that I teach. While they can complete examples of learnt equations well, when it comes to problem-solving questions in test conditions, they seem to get anxious and make wrong decisions.

Sue also revealed a personal difficulty that school staff and parents of her students are aware of – she has a diagnosed form of ASD (Autism Spectrum Disorder). Sue's characteristics, as described by herself and her Principal (STP1), are mild.

> STP1: When I first observed Sue in action ... I had no idea that she had Asperger's Syndrome. Colleagues have told me that Sue can get stressed at times which requires some help and assistance from them. Her year level team has set up some friendship groups within class which have proven useful...

Sue, when stressed, has low non-verbal awareness of her students' needs. She relies on friendship groups within class, as set up by herself and her line manager, to make Sue aware of and respond to emerging behaviours that could disrupt class. This structure, as supported by her Principal (STP1), has worked very well over the last couple of years.

Sue relies a lot on routine and structure to get through the day. Her students comply well with this. Any new element that is introduced into the class takes time for both teacher and students to adapt to. This shared adaptation was witnessed throughout the intervention period where students and teacher supported each other very well.

At the revelation of her disorder, I personally asked Sue if her decision to be part of the intervention was entirely her own or precipitated by her school management.

> This was my decision... I know that I can have some problems seeing and understanding things happening in class. I have always been fascinated by psychology... When I approached my boss, she thought that this was a great idea on my part.

Sue saw the intervention as an opportunity to open more about her needs in the classroom:

> Well I hope we can do some great things... I like this school and the way they help me. Many teachers see me as the Maths expert! Then I tell them, that this is not always reflected in my class grades which they laugh at. I hope to become a better Maths teacher with you...

When I approached her Principal (STP1), the Principal told me that I could communicate with her only if there were any real concerns like establishing a working relationship or adapting to the intervention:

> I have the utmost confidence in Sue as my school has been with her since she left university. Sue is one of the most motivated teachers I know – she always wants to learn and do the right thing by people. Some of my staff had concerns four years ago, but Sue has grown so much and works so well with people.

b) <u>Translation of Description to a Professional Learning Network</u>

The purpose of the professional learning table is to describe the learning objectives of each of the teacher-participants and to project what they want to get out of the professional learning.

Teacher Participant	Sue's PROFESSIONAL LEARNING TABLE
Learning Objectives	1. To understand the complexities of Mathematics Anxiety. 2. To effectively use the strategies from the intervention package for the students in my class. 3. Learn some useful practical ways to implement differentiation and group-based strategies.
Personal Forecast	I think Jan and I will get a lot out of R in the coming weeks. It is helpful that Jan and I are quite close together in terms of classes so that we share our ideas and experiences.
Reflection / Feedback	The extra pair of hands has been really useful, and I really like how the professional learning is set up with the feedback boxes and questions that we can use throughout the week. Looking forward to the next 8 weeks!

Fig 5.2 Sue's Professional Learning Table

The above table (Fig. 5.2) illustrates the specific attributes of Sue's professional learning network. At this stage, the strong personal and professional relationship between Sue and Jan portrays potentially strong mediating and moderating variables between the two. However, it will be interesting how this relationship develops as each teacher has their own professional learning needs to be addressed by the researcher.

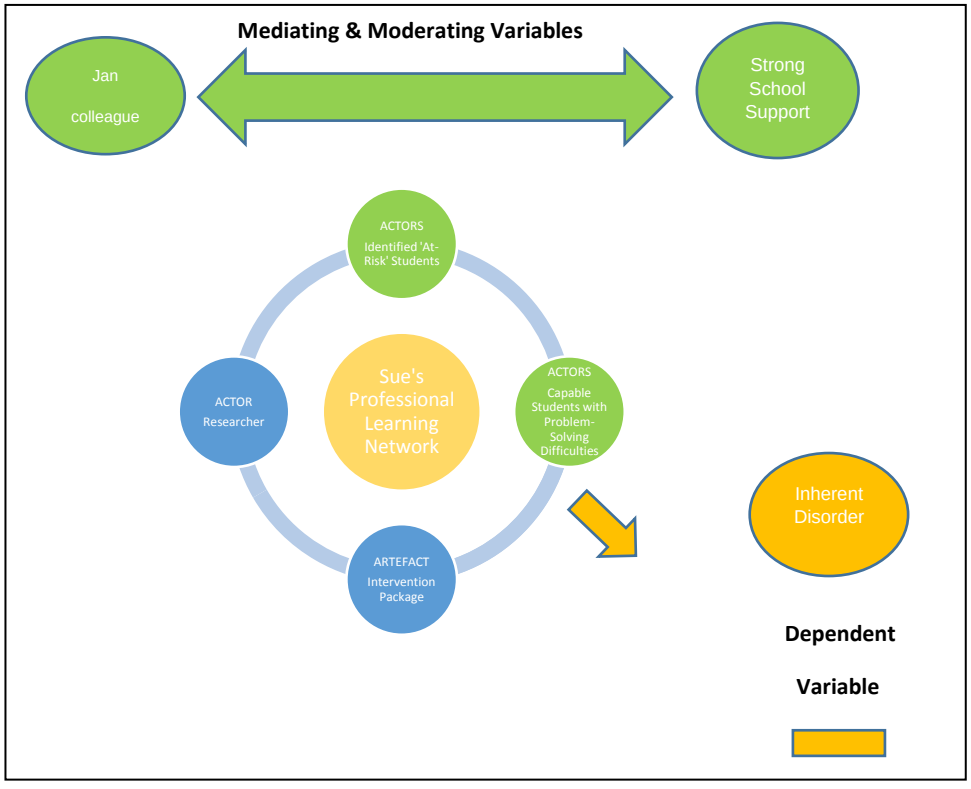


Fig 5.3 Sue's Initial Professional Learning Network

Sue's network (Fig 5.3) demonstrates reasonably strong mediating and moderating influences from school support and a colleague named Jan. However, the degree of communication and support from the outside influences at the outset, reflects Sue's positive and expectant views about the upcoming intervention.

ii. CASE STUDY B: Jan

a) Description of Teacher-Participant

In the second case study, the teacher-participant will be known as Jan. Jan is a colleague of Sue's at the same primary school. Both teacher-participants were accepted by the Principal and researcher in taking part in the professional learning package. Jan has been working at the school for over ten years now, working at the upper primary school level. She has taught Year 6, Year 7, and occasional hybrid classes between these two-year levels. This year, Jan is teaching a straight Year 7 class.

After my first observation of Jan's teaching, I told her that the class demonstrates high respect towards her as a person and a teacher. There were a couple of students with diagnosed ADHD in Jan's class.

After questioning a variety of students, many of them really appreciated the amount of time and effort Jan had put into making mathematics fun and interesting. Comments from the students included:

> Ron: Jan always asks lots of different questions.
>
> STUD2: I like how we can make things in mathematics lessons.
>
> STUD3: We don't just do bookwork. We are using Maths to make our own dream house.

Jan relayed to me that there were as many as six to seven students that she had concerns about and wanted me to keep an eye on, in terms of at-risk behaviour.

Jan was keen to be part of the study, as she felt she could learn a lot from an experienced teacher coming in regularly into her classroom. She knew that students could get anxious with mathematics but did not know that there was a condition named Mathematics Anxiety.

> Jan: I have a great bunch of kids R (researcher), but it would be useful having someone with your skills in the classroom. I do have a couple of students struggling in mathematics, but I do not know if I would say that they have Mathematics Anxiety...
>
> R(Researcher): Mathematics Anxiety can be a condition by itself or a compounding co-morbid condition to learning difficulties like ADHD and dyscalculia. In some ways, the anxiety is

symptomatic of all of this. The strategies that we will use will hopefully lower the anxiety and improve the maths ability...

Jan: So, in some ways the strategies are more important than the 'labels'?

Jan understood all her students' capabilities and had read up on what Asperger's Syndrome and ADHD were. When I asked some questions about these conditions, Jan demonstrated that she was quite knowledgeable and articulate.

R: So, Jan do you understand the difference between ADD and ADHD?

Jan: Yes R. ADD tends to be more noticeable in girls with passive characteristics. ADHD is more prevalent in boys with the hyperactivity element. However, both do demonstrate a problem in executive functioning – a lack of attention.

Although Jan has no SSO support within the class, it has been fortunate that another colleague Sue is also undertaking the same professional learning. Sue is a Year 6 teacher (already mentioned as Case Study A) who happens to be on the same floor at school. In our initial meeting we all met together which provided useful mutual support between the two teachers.

The researcher outlined to both teachers that this was fine but that they both had very different student cohorts. As a result of this, most of our meetings will be one to one with the researcher. Jan was fine with this, as she could confer with Sue over a few things when I was not there.

b) Translation of Description to a Professional Learning Network

According to Jan's records, there are seven 'at-risk' students in her class, and an overall student group that demonstrates some difficulty translating work done in class to improving their problem-solving skills.

Teacher Participant	**Jan's PROFESSIONAL LEARNING TABLE**
Learning Objectives	1. To understand the complexities of Mathematics Anxiety. 2. To effectively use the strategies from the intervention package for the students in my class. 3. Learn some useful practical ways to implement differentiation and group-based strategies.
Personal Forecast	I am hoping that with R's experience that I can develop some strategies that help students with Mathematics Anxiety and also use differentiation strategies more effectively.
Reflection / Feedback	I really appreciate the time and help that R has been providing at this stage. It all very well organised and I am looking forward in learning some things from him.

Fig 5.4 Jan's Professional Learning Table

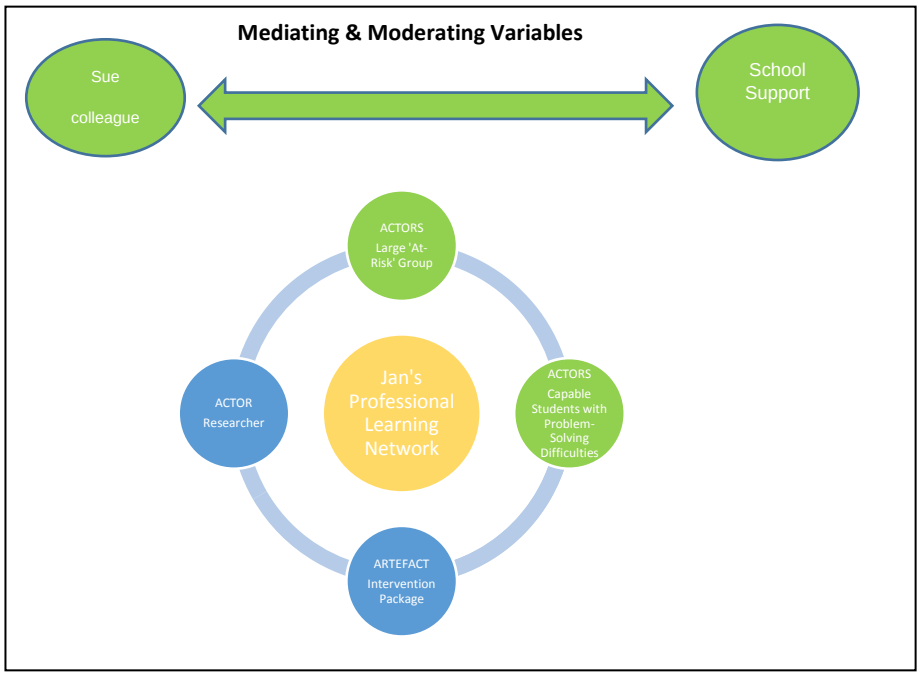


Fig 5.5 Jan's Initial Professional Learning Network

Jan's network (Fig 5.5) has the mediating and moderating influences from school support and Sue as a colleague, but they are not as pronounced as Sue's network (Fig 5.3). School support is assured but more so for Sue's personal situation. Both teacher-participants reaffirmed to me that they would help each other, but it will be interesting to see what types of support Sue can provide for Jan. Especially since, Jan has a greater cohort of students at-risk.

Jan stated:

> ...because of Sue's background she is really good at Mathematics. If she can translate your ideas into language her students can understand, this will really help me out...

iii. CASE STUDY C: Meg

a) Description of Teacher-Participant

In the third case study, the teacher-participant will come under the pseudonym of Meg. Meg is a relatively new teacher of four years' experience at a secondary school and teaches Year 8 to Year 10 Mathematics. The researcher was invited to collaborate with her, in her Year 8 class. Meg's heritage is from a non-speaking English background (NESB). Her Principal informed me that Meg demonstrates a high understanding and skill in teaching the Australian curriculum in mathematics, but that her accent and quick dialogue can at times, confuse some students in class, especially those who may have learning difficulties. Under formal DfE

evaluation there here is a student with Asperger's syndrome, two students with ADHD, and another two with significant behavioural issues. These students have formal individual learning plans (ILPs).

An SSO, who will be known as Sally (see Appendix F), provides learning support for these five students. Sally comes into class when there are at least three of the 'at-risk' cohort comes in for the day.

In our initial meeting with each other, Meg wanted to improve the motivation and attendance of this at-risk cohort, who could also affect the demeanor of the rest of the class. In my first observation, I saw first-hand how two of these students tried to disrupt the lesson by getting other classmates to laugh and react to them.

Consequently, behaviour management became a key objective of Meg's professional learning journey with me. In our first meeting, Sally was invited to attend so that she could learn and understand the strategies that we were going to employ with the students that she worked with. I told Sally that these meetings were primarily for Meg's professional learning, but that at times she may be invited to attend to help with the running of the class. The fact that we had another adult in the class, could help in developing small group structures and better regulate students' affective and cognitive contributions.

b) Translation of Description to a Professional Learning Network

Although Meg's professional learning network posed some difficulties in terms of motivation and management of the students, this demonstrated a significant need to focus on re-evaluating the relational structures within Meg's network. There was an issue in terms of respect towards the teacher due to some communication difficulties; a lack of motivation and regard amongst the student cohort towards each other, and a lack of confidence in students' attitudes towards their ability and performance in mathematics.

It was agreed amongst the researcher, Meg and Sally, that by having more of a focus on the social-emotional affective aspects of the intervention, that it may help repair the relationships within Meg's classroom environment.

Teacher Participant	Meg – PROFESSIONAL LEARNING TABLE
Learning Objectives	1. To improve the mindsets and learning behaviours of students. 2. To effectively use the strategies from the intervention package for the students in my class, especially for my 5 at-risk students. 3. Improve the motivation and attendance of my at-risk students. 4. To understand the complexities of Mathematics Anxiety.
Personal Forecast	This year's Year 8 group is very challenging. I am hoping that R can provide me with some good ideas and ways to better manage my class. I have been working with SSO2 for a while now, and we both think that things can only get better.
Reflection / Feedback	I understand that R only wanted 3 learning objectives, but the way we have ordered and written them above, shows that I want to affect the learning behaviour of my students. This may help with their performance and attitude towards mathematics, and maybe any Mathematics Anxiety that they may have.

Table 5.6 Meg's Professional Learning Table

As demonstrated above in Meg's proposed professional learning outline, there is a strong focus on changing the emotional/affective mindsets of the class and improving the attitudes towards Meg and mathematics. Meg outlined to me that even her better students had been affected by the negative behaviour of a few at-risk students. Meg's group of better students had good grades in Term 1, but due to the negative influence of the at-risk group, had stagnated or flat-lined in overall grades. This had also affected Meg's own attitude in class, as demonstrated in her reflection in Fig 5.6. Sally, to a degree, reiterated this view:

> R, I've been with these students since the beginning of the year. They have improved a bit in some of their subjects, but in regard to mathematics, they are quite apathetic. Good luck with your work!

This initial attitude by both staff members demonstrated the first real signs of scepticism towards the intervention package. However, in the meeting, the researcher fully outlined the stance that he was going to take accompanied with the supporting views of a few academics:

> I understand that this group is going to be challenging for all of us over the coming weeks. However, I have the confidence from the work of people like Dweck (2012) who you have mentioned SSO2, in terms of growth mindsets, can give us some inspiration. Off the top of my head, I can also list off a group of people like Ashcraft, Beilock, and Immordino-Yang, who all believe affective skills can help change perceptions and improve performance in mathematics. Look I'm a part of this learning journey with you, and anything could happen.

The purpose of this statement by the researcher was to take on the part of inspirational coach and to provide a positive affective rudder for all participants as to how they could perceive their journey together (Kimsey-House, H., Kimsey House, K., Sandahl, & Whitworth, 2015; Morris, Cranney, Baldwin, Mellish & Krochmalik, 2018).

In the previous two case studies, based in a primary school setting, the cognitive and affective strategies were conducted in relatively equal unison with each other. In Case Study Three

however, there was a significant negative relationship in overall student morale and performance.

Meg's network (Fig 5.7) below, demonstrates a skewed relationship between the small at-

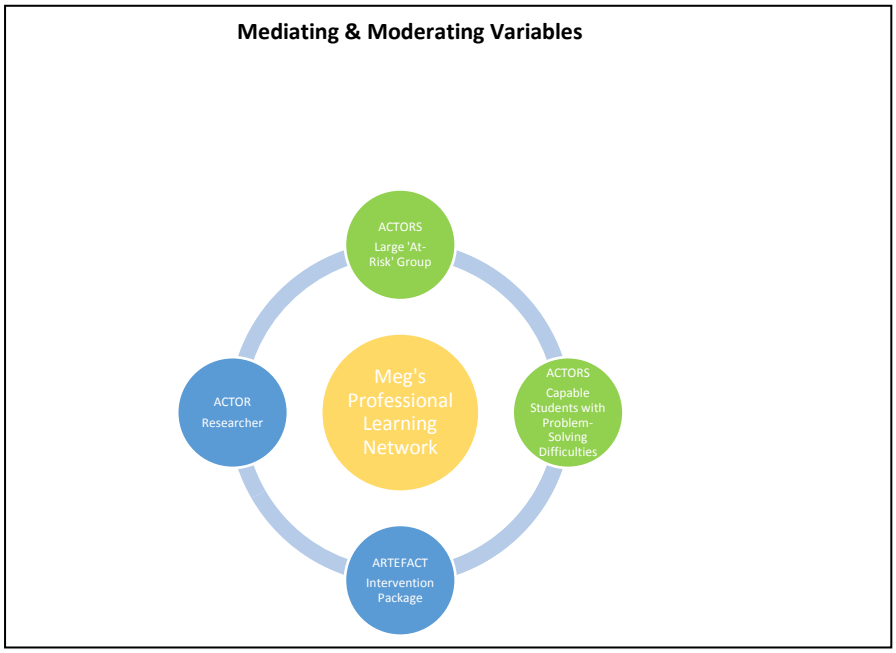


Fig 5.7 Meg's Initial Professional Learning Network

risk student group and the rest of the class. This small group took up a lot of effort and time by both Meg and Sally, reducing their impact on the rest of the class. Effort and consistency are part of a moderating variable. It will be interesting to see how the two groups react to the changes in effort and time by the classroom staff and researcher over the intervention period.

The better use and deployment of Sally within the class to help the at-risk group could help facilitate Meg to meet the needs of the rest of the class (mediating variable). Noticed improvements in affective and cognitive output by the at-risk group will help strengthen their relationship and classroom situation with both Meg and Sally.

A key dependent variable in ensuring the development of both student groups, is the capacity of both teacher-participant and researcher in developing overall well-being and engagement during the intervention period.

Although the professional learning network infographics were not constructed during this time, the professional learning tables were. The feedback from teacher-participants were constructive and positive when they looked at their initial issues, objectives, and direction.

V. Mid-Point in Development of Professional Learning Networks

Teacher-participants were made aware at the beginning of the investigation that events or processes may emerge, that could influence the direction of their work due to possible developmental attributes of the investigation. The micro-ethnographic case studies are focus students agreed upon by both researcher and teacher-participant, that represent a microcosm of the work that they have done together.

These micro-ethnographic case studies in turn, not only become an important snapshot of the teacher-participant case studies themselves but help demonstrate the developmental growth of the specific professional learning networks.

i. Emergence of the Micro-Ethnographic Case Studies

The developing connection between researcher and teacher-participant is vital in the building of the professional learning networks. Teacher-participants invited a researcher into their classrooms to learn about the issue of mathematics anxiety and improve the learning conditions and outcomes of their students. Both teacher and researcher collaborated in this constructed professional learning network in sharing and implementing ideas and strategies, and analysing student work and their development. Networks are effective when they articulate and maintain focus on a clear purpose and distribute quality information (Smith and Wohlstetter, 2001).

During their meetings with the researcher, the teacher-participants were exposed to a large degree of data from their student cohort. It was the responsibility of the researcher to help guide the teachers in ways as to how to look at the data which were both efficient and effective. Tools to look at and describe the data, as outlined in the methods chapters, were observations, reflections on teaching practice, student work, and student reflections on their work. This resulted in some meetings being more than forty-five minutes, which teachers found time-consuming, given that they came to meetings with reflections that they needed to complete as well.

By Week 3/4, all teacher participants alluded to the need to stream-line this work by doing some cross-sectional study of certain students. There was always one commonly selected student by each of the teachers to look at during the meetings. The researcher agreed for the three teachers to select one student who was struggling most with mathematics instruction.

The mini-ethnographic case study design element did not change the methodological direction nor research purpose of the investigation. Instead, the way it became embedded into the analysis of data, provided better clarity for researcher and participant-teacher in interpreting what was in front of them. Consequently, each mini-study is a focus student agreed upon by both the individual teacher-participant and researcher. They will be described and used to build upon what the teacher-participant's final professional learning network would look like.

a) Case Study Sue (Focus Student Grace)

For readability purposes, focus student A will be known as Grace (see Appendix E). Grace was brought to the attention by the teacher-participant to the researcher in Week 1, as a key student to look out for. Grace has had a history in not properly participating in mathematics lessons, as she demonstrated fear and anxiety towards the subject, as confirmed by her parents in student-teacher meetings in the early part of the year.

During Week 1 and Week 2, Grace tried to maintain her previously developed habits of passivity and limited work and participation. In Week 1, she tried her best not to make eye-contact with the researcher but was fine in writing down her feelings about mathematics in the first biblio-therapy exercise (see Table 5.8 next page). The purpose of the exercise was to uncover some of the emotional vocabulary Grace regularly uses, and for teacher and researcher to uncover initial aspects of Grace's social engagement system. By delving into Grace's social engagement system (Cozolino, 2014), teacher and researcher could now start to identify and positively affect key relationship structures for Grace (Siegel, 2012; Cozolino, 2014; Siegel & Bryson, 2018) and attend to her perceptions towards mathematical concepts.

Grace's description was more than what was required – it took up over half a page explaining her beliefs that she could only do basic arithmetic. She found long division, fractions, ratios, and problem-solving difficult. She understood that problem-solving skills were important but could not understand the relevance of the other concepts. She performed poorly in the working memory tasks throughout the lesson, but she was also confused by their purpose.

Table 5.8 Grace's Biblio-therapy Entry Week 1

Affective Vocabulary in a 264-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (3)	can do okay understand	can do (2x) okay (2x) understand (1x)	Around general arithmetic / Relatively short phrases & sentences
Negatively Affective Words / Passive Word Segments (11)	difficult /hard / too long /don't understand / wait / don't know / not easy / confusing /stressed / can't / no longer	too long (2x) confusing (2x) wait (2x) don't know (3x) other words (1x)	Around long division, ratios, fractions & Problem-solving / More developed sentences.

Before the Week 2 lesson started, Grace requested help from the teacher and not the researcher. The teacher explained to the researcher that Grace took a degree of time to trust new people. However, the newly installed dynamics of researcher into the classroom, meant that Sue was accessing the teacher more often than she had in the past. At the end of the lesson, the teacher brought written comments back to the researcher saying that she liked spending more time with the teacher and was satisfied that she understood most of the work. Feedback was also relayed to the researcher that she enjoyed writing about how she was feeling, and that this calmed her a bit. Both the teacher and researcher explained the concept and reasoning of the working memory tasks better to the whole class. This made Grace happier, but she still required the teacher to sit by her. Having the teacher sit by her, allowed her to perform the working memory tasks better this time round.

The table below outlines a course of six working memory tests over two weeks. The scores reflect how many items the student could recall from one iteration of seven unrelated items compiled by the researcher.

Table 5.9 Grace's Working Memory Results (Weeks 1 & 2)

Week ONE	**SCORE**	**Week TWO**	**SCORE**
Working Memory (1)	3	WM (4)	4
WM (2)	4	WM (5)	5
WM (3)	3	WM (6)	5

Unfortunately, Grace did not turn up to the Week 3 lesson. Feedback from the teacher was that once she thought that something was getting too hard for her, that she would stay home and state that it was illness. As a result of this, the teacher rang up the parents and told them

of Grace's written responses and that she was spending more time with her. This helped encourage Grace to turn up to the next lesson.

Week 4's lesson was partly interrupted by a school event, with some students wanting to go. However, it was encouraging to see that Grace wanted to stay and attempt the work. Grace only managed to write up and answer three of the five questions presented but showed satisfaction that she got those correct. For Grace's reflective journal entry that week, the teacher requested that she write up another 3 questions before next lesson. The teacher also gave Grace notice, that she would be teaching most of the next lesson, with the researcher sitting back to observe. For the biblio-therapy task, Grace did ask for the teacher to sit next to her, even though she did it independently, and performed better than previous weeks in balancing positive and negative thoughts.

Table 5.10 Grace's Biblio-therapy Entry Week 4

Affective Vocabulary in a 213-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (4)	can do okay fine better understand	can do (2x) okay (2x) fine (2x) better understand (1x)	Around general arithmetic & area concepts / Longer phrases & sentences
Negatively Affective Words / Passive Word Segments (7)	difficult / /don't understand / / don't know / not easy / confusing /can't / no longer	difficult (2x) confusing (2x) no longer (2x) don't know (2x) other words (1x)	Around ratios, fractions & Problem-solving / More developed sentences.

In Week 5, Grace's verbal input and interaction were better than in previous weeks. The researcher sat at Grace's table, which did not seem to bother her if he helped everyone else as well. Grace showed some positive confidence in doing some fraction exercises that she thought that she could not do before. Grace was fine in completing her biblio-therapy task by herself.

It was a milestone that the teacher was not required to come over at all, for Grace to perform her key tasks, including the working memory exercises. Grace happily told the researcher in how she went with her work, as she did a bit better than the previous week.

Table 5.11 Grace's Working Memory Results (Weeks 3 & 4)

Week THREE	SCORE	Week FOUR	SCORE
Working Memory (7)	Absent	WM (10)	4
WM (8)	Absent	WM (11)	5
WM (9)	Absent	WM (12)	5

The following week (Week 6), Grace did not turn up to the specified lesson day. The teacher revealed that the class were going to do a summative assessment on mathematics later in the day, which made Grace decide not to attend.

Table 5.12 Grace's Working Memory Results (Weeks 5 & 6)

Week FIVE	SCORE	Week SIX	SCORE
Working Memory (13)	5	WM (116)	Absent
WM (14)	6	WM (17)	Absent
WM (15)	4	WM (18)	Absent

In Week 7, Grace was in class. She wanted the teacher to sit by her again to help her try and regain her confidence. In group discussions, Grace used more language than she had in the past but did get a few mathematical concepts confused from feedback with her teacher. The teacher requested for the researcher to come over and explain the idea of equivalent fractions. The researcher showed equivalent fractions on circled diagrams which Grace could colour in to see the size. Grace smiled and asked the researcher to do some more with her. This was a milestone event for Grace as she now felt comfortable in talking and working with the researcher at length. The teacher moved away to allow the researcher to take advantage of the situation and talk extensively to the student. Grace's working memory results were the same as the previous week's, but Grace was satisfied in how her work and progress was going.

Table 5.13 Grace's Working Memory Results (Weeks 7 & 8)

WEEK SEVEN	SCORE	Week EIGHT	SCORE
Working Memory (19)	4	WM (22)	5
WM (20)	6	WM (23)	6
WM (21)	5	WM (24)	5

In preparation for Week 8, the researcher asked the teacher to start off the lesson so that he could sit and talk with Grace during the main class activities. As this was the last lesson, the researcher spent the last half demonstrating some mathematics games that the class could do in the future when he was away. The teacher requested that the final biblio-therapy exercise was to be a reflection in how the researcher had helped throughout the last eight weeks, and what they enjoyed most. Grace's entry was personal in that she said,

> I liked it that my teacher liked R. When Sue could not help me, R could do it. I feel happy with fractions and area now, as we played some cool games and could talk more about maths. I wish R could stay more, as my maths is getting better.

However, the above paragraph was also endemic of a greater positive affective vocabulary and response from Grace. Although this only came in Week 8, as a response to the researcher leaving, Grace's written descriptive output was greater as well. It was a 287-word response which was longer than Grace's Week 1 negative entry, and she took over twenty minutes to finish it.

Table 5.14 Grace's Biblio-therapy Entry Week 8

Affective Vocabulary in a 287-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (7)	can do could do it liked it / liked not so hard feel happy getting better better understand	feel happy (2x) could do it (2x) getting better (2x) better understand (1x)	Around concepts learnt during intervention / Longer phrases & sentences with supporting positivity.
Negatively Affective Words / Passive Word Segments (5)	difficult / don't know / not easy / confusing /can't /	difficult (2x) don't know (2x) other words (1x)	Mainly around problem-solving now / phrases more succinct

There was no work the following week so the teacher requested the researcher to send an email message for both her and Grace (but only directly to teacher's account), to keep up the connection and to ensure that Grace's progress didn't deteriorate.

In two of Grace's emails to the researcher, she showed some despondency that he was no longer there. This demonstrates that Grace's social engagement system had changed because of the researcher being within the classroom. In the latter weeks of the intervention, Grace had mentioned to both Sue and the researcher in that she sometimes felt intimidated by one of the male students at her table (STU2) as he was very bright at mathematics.

> Email 2 Excerpt: As I am staying in Sue's class next year R, is it possible you can come back to help?
>
> Response Excerpt: Sorry Grace, but I need to return to my school next year. However, I will talk to Sue to help set you up better with your new class.

Email 3 Excerpt: Thank you R for talking to Sue to change my table a bit ... Since STU2 has moved to the front I am happier with my group.

Response Excerpt: This is great news Grace. I am so happy to see you being more assertive for yourself and asking for help. You will do great next year!

The final email from Grace which Sue forwarded to the researcher had no new developments directly from Grace regarding her social engagement system. However, Sue did outline some important changes that helped Grace prepare emotionally for the new year.

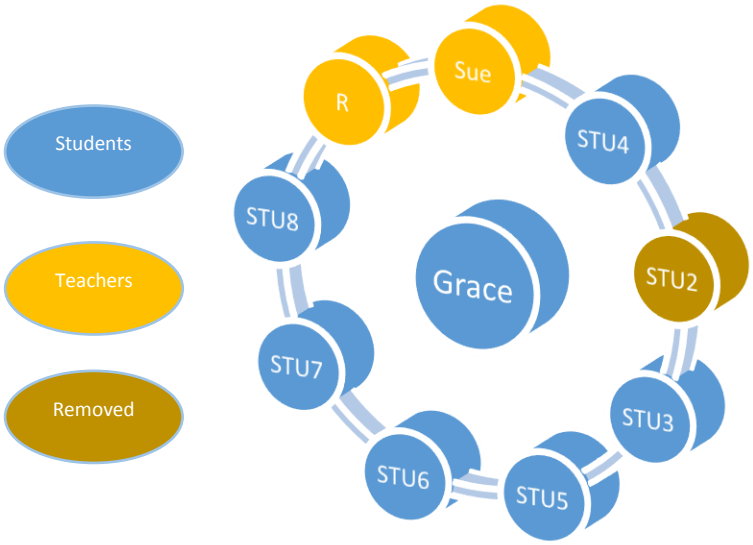


Fig.5.15 Grace's Social Engagement Network

Email 4 Excerpt: Hi R, you will find Grace's email attached which is basically just a thank you again, along with wishes over the Christmas break… I continue to see positive change amongst that small group, we talk about... The effect of this, is that they are talking more and asking for help from both myself and their friends in mathematics. The rest of the class unfortunately are not so eager about doing the journal. However, at least they see the importance of mindset at the beginning and end of the lesson with their biblio-therapy responses. They can now see that positivity affects their results!

The final email response from Sue demonstrated that influence and change with social engagement networks can be sensitive, complex, and long. The extra contact between teacher-participant and researcher helped bring closure to a personal situation for the focus student Grace.

b) Case Study Jan (Focus Student Ron)

For readability purposes, focus student B will be known as Ron. Ron was brought to the attention by the teacher to the researcher also in Week 1, as a key student to observe. Ron has diagnosed ADHD and had a history in finding it difficult to concentrate and participate in

mathematics lessons. Jan established a habit throughout the year that all students have a planned break mid-way through the morning mathematics lesson, to have a five-minute fruit break. This has been reasonably successful for all students, but Jan found that she then needed to provide even more breaks for Ron. If Ron did not get sufficient breaks, he would sometimes swear and negatively affect others.

During Week 1 and Week 2, Ron was quite restless with the presence of the researcher. Jan allowed him to sit at her desk which he enjoyed doing, as he had some sensory toys in her bottom drawer, which he could access. By being placed at her desk, Jan could easily watch him and ask him questions the minute he started being distracted.

Ron was intrigued by the Week 1 biblio-therapy task, as it involved finding some emotional words that he was associated with (emotionally primed by) that day.

Ron demonstrated that he had reasonably expressive language skills, so the researcher took out a spare activity that consisted of groups of emotional vocabulary words. Table groups had to stand up and move around a bit to help place words into either negative or positive word categories. Ron and his friends showed that they enjoyed this, along with other groups discussing where words should go.

It was quite easy to delve into Ron's social engagement system and work out his positive relationship structures within the classroom. While other groups were happy just to start writing their first biblio-therapy task, the researcher went up to Ron's group and expressively talked about the task. Jan witnessed this and applied the same technique to a group that had low expressive interaction. After talking, Ron's group willingly completed their writing tasks, and generally had positive perceptions towards mathematical concepts. Even though Ron's contribution was less than half a page, it was concise and to the point. He found book-work boring and tiring but after the activities that he had done with the researcher, wrote down quite a few positive words.

Table 5.16 Ron's Biblio-therapy Entry Week 1

Affective Vocabulary in a 178-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (8)	can do building understand fun	can do (3x) building (2x) understand (2x) fun (1x)	Around general arithmetic / Short phrases & sentences
Negatively Affective Words / Passive Word Segments (9)	Boring / hard / difficult lots of writing / forget	boring (2x) hard (2x) lots of writing (1x) difficult (2x) forget (2x)	Around long division, ratios, fractions & problem-solving

In Ron's first biblio-therapy entry there is not much difference between positive and negative words – they are quite even in nature. However, the language is quite representative of Ron's ADHD. Word segments like difficult and forget, demonstrate Ron's need to write short passages due to his attention difficulty.

Table 5.17 Ron's Working Memory Results (Weeks 1 & 2)

Week ONE	**SCORE**	**Week TWO**	**SCORE**
Working Memory (1)	3	WM (4)	3
WM (2)	4	WM (5)	5
WM (3)	4	WM (6)	4

Ron's working memory was reasonably low in comparison to other students, but there were possible signs that if he was fully prompted in what was about to be done, that he may be able to score 4 or 5, as demonstrated in his Week 1 & 2 Results table above.

After the lesson, the researcher made some comments to Jan that Ron had high expressive skills and understanding, and that if the students (especially Ron's group) weren't always sitting, that they may be more engaged. Jan was rather pleased with this and wrote down some observation notes about this. Also discussed, was the need to ensure that there was enough signposting (prompting and schedule cues) for students like Ron. Ron's lack of attention and distracting behaviour was noticeable in the first lesson, but the researcher highlighted Ron's positivity towards the tasks.

In the Week 2 lesson, one of Ron's first comments were:

> Ron: So, R when are going to do the games?

> R (Researcher): The games are good, aren't they! However, the games have a special purpose. While I'm here we are going to do many little tasks like what we did last week, that help the mathematics that we do with each other. Sound good?

The reaction from Ron and the class in general was with affirmative smiles and positivity. The only behavioural point that the researcher brought up was:

> R: The only thing with this plan, is that we ALL only have one 5- minute fruit break in the middle. I know that this is a double lesson, but I think that the different types of activities we do make sure that we don't stay seated all the time!

While everyone seemed fine with this when it was announced, Jan had a few issues throughout this lesson in enforcing this. Ron and one of his friends (STUD3) wanted to go to the back of the room after 15 minutes of work. The researcher helped reinforce Jan's actions with positive encouragement, but it did take a lot of work in terms of behaviour management, to get through the lesson.

Despite the continual positive realignment of student behaviour, Ron and his friends got through the lesson quite well. Ron's results demonstrated a slight improvement over his Week 1 efforts, and when prompted to share work he was quite positive to interact.

Week 3 demonstrated far more stability as Jan had given Ron's group a degree of positive preparation before the lesson, by outlining what they were doing and going to achieve. It was good to see that some of Ron's friends who had greater attentional ability, were willing to steer him back to work.

Week 4's lesson was partly interrupted by a school event, with some students wanting to go. It was good to see that Jan had some motivational measures to organise Ron's group and friends to stay back for the mathematics lesson. Ron's Week 4 biblio-therapy entry reflects this as well. His response was longer and had a positively skewed ratio in terms of positive words used.

Table 5.18 Ron's Biblio-therapy Entry Week 4

Affective Vocabulary in a 207-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (7)	can do building interactive better understand	can do (2x) building (2x) interactive (2x) better understand (1x)	Around general arithmetic & area concepts / Longer phrases & sentences / Ryan needed a friend to spell interactive
Negatively Affective Words / Passive Word Segments (3)	difficult / / don't know	difficult (2x) don't know (1x)	Around ratios, fractions & Problem-solving / More developed sentences.

With some of the class out of the room due to the school event, the researcher observed that Ron seemed to be at his most settled. After the lesson, it was suggested that next week during the writing tasks, that Jan took Ron's group out to the Activity Room which is adjacent to the classroom.

In Week 5, Jan could see the researcher well from the Activity Room during the main part of the lesson, and everything seemed more positive and settled. In fact, after the lesson, the researcher pointed out that with Jan's group next door, that the engagement and interactivity amongst the rest of the class was higher. It was agreed that Ron's group had taken up a lot of the teacher's time and input. However, this work, and moving the group at certain stages of the lesson, proved to be beneficial in helping develop Ron's working memory.

Table 5.19 Ron's Working Memory Results (Weeks 3 & 4)

Week THREE	SCORE	Week FOUR	SCORE
Working Memory (7)	3	WM (10)	4
WM (8)	4	WM (11)	4
WM (9)	4	WM (12)	4

Table 5.20 Ron's Working Memory Results (Weeks 5 & 6)

Week FIVE	SCORE	Week SIX	SCORE
Working Memory (13)	5	WM (16)	4
WM (14)	5	WM (17)	6
WM (15)	4	WM (18)	5

Week 6's lesson was the first week that Ron did not attend as he had a medical appointment to attend to. Feedback from Jan to the researcher, was that Ron was annoyed that he could not be there for the mathematics lesson. So, at Recess time, the researcher was prepared to give Ron his working memory test even though this was under one to one conditions.

In Week 7, Ron was quite happy to see the researcher again. The researcher told the class that Jan would take much of the lesson and that the researcher would take out Ron's group during the writing tasks. Ron was quite happy and settled with this arrangement and demonstrated to be highly interactive with the researcher and group. His on-task behaviour was amongst the best the researcher had seen. It was good to see that Ron was asking his friends to check his work, as the researcher had indicated earlier in the intervention that

students needed to rely more on each other, as after Week 8 he would no longer be there for support. Ron's working memory had now seemed to peak with the results below, but it had also demonstrated that under the right conditions, Ron had a reasonable working memory load. Ron knew due to his high expressive skills and interactivity, that he could rely on his friendship relationships to help him remain more engaged in mathematics lessons.

Table 5.21 Ron's Working Memory Results (Weeks 7 & 8)

WEEK SEVEN	SCORE	Week EIGHT	SCORE
Working Memory (19)	4	WM (22)	4
WM (20)	6	WM (23)	5
WM (21)	5	WM (24)	5

In preparation for Week 8, the researcher asked the teacher to nominate a friend of Ron's who could lead the group in the Activity Room tasks. Jan recommended STUD3 (a classmate who had reasonable leadership skills) to help mentor the group during the writing exercises.

Just prior to the writing exercises, the teacher requested that the final biblio-therapy task to be a reflection in how the researcher had helped throughout the last eight weeks, and what they enjoyed most.

Table 5.22 Ron's Biblio-therapy Entry Week 8

Affective Vocabulary in a 216-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (7)	can do could do it liked it / liked getting better better understand	feel happy (2x) could do it (2x) getting better (2x) better understand (1x)	Around concepts learnt during intervention / Longer phrases & sentences with supporting positive words.
Negatively Affective Words / Passive Word Segments (4)	difficult / don't know /	difficult (2x) don't know (2x)	Mainly around problem-solving now (especially comprehension).

Ron's social engagement network, in part, had now also become his learning network. Roles had been assigned to students like STUD3 to lead the group, and STUD2 to sit by Ron to help keep him on-task. STUD4 was one of the brightest students, so Ron could ask him for help. As a result of the strong friendship group, the interactivity (talking) did not diminish. Instead, the interactivity amongst the boys was seen to be more productive.

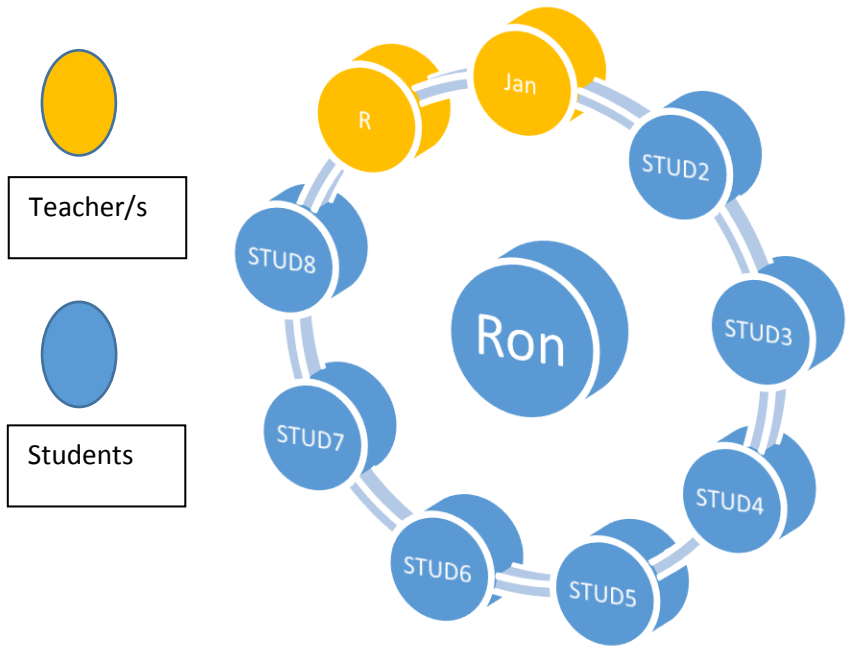


Fig.5.23 Ron's Social Engagement Network

c) Case Study Meg (Focus Student Dan)

For confidentiality purposes, focus student C will be known as Dan. Dan was brought to the attention by Meg to the researcher in Week 1, as a key student to look out for in terms of behaviour and not liking mathematics. Sally the SSO, also approved of Dan being one of the focus students in class. Dan had an ILP (individual learning plan) and was diagnosed with ADHD. Both Meg and Sally indicated that Dan was probably their most challenging student as he tended to show little respect towards female staff in other subjects. In Physical Education, Science, and Technical Studies he had male teachers and had shown better behaviour towards them. Meg and Sally thought that my presence may help change his behaviour and attitude towards mathematics.

Dan had been suspended a couple of times by Meg earlier in the year for yelling out remarks like:

> Can't understand the f _____ what you are saying?
>
> Can I please have a f____ Australian teacher who can speak English!

Meg had told the researcher that over the course of the year Dan's attitude had changed a bit towards her due to behavioural intervention from senior staff at the school. Sally (SSO) had been introduced into the class (SCL2) to do remedial one to one work with Dan. This collaboration had helped Dan calm down a bit over the year, but that he was still susceptible

to occasional outbursts. It had also led Dan preferring to work and receive instructions from Sally, rather than communicate with Meg.

Sally reported to me that if he could not understand how she explained mathematical concepts that he would get angry, throw things, and storm out of the room. Most of the time Sally worked with Dan was in an adjacent room close to the Mathematics faculty office.

With Meg and Sally providing quite an in-depth appraisal of Dan and some other students in class, the researcher asked to have an introductory chat with Dan before the beginning of lessons which they thought was a good idea.

First chat (conversation) between the researcher and Dan went like this:

> Dan: Are you here to replace our teacher?
>
> R: No Dan, I am here to help. Help change some things. Help Meg. Help students if they are willing.
>
> Dan: No one can understand Meg and she gets loud, and everyone goes off.
>
> R: ...including you?
>
> Dan: ...sometimes. SCMC (the Maths Co-ordinator: see Appendix F) is far better at explaining stuff than her!
>
> R: He's the Mathematics Co-ordinator, isn't he? How are you with Sally?
>
> Dan: ...She's alright but she's just an SSO. Why can't I go into SCMC's class?
>
> R: Too many students. SCT2's class is only 23 students. How about we try out some new stuff to see if it calms things down in class?
>
> Dan: ...yeah, I'll try.

During Week 1 and Week 2, Dan and some of the other students laughed at the idea of the biblio-therapy task but showed some better resolve when the researcher talked about the psychological science behind it, like how it can improve cognitive acuity and affective understanding (Wilson & Thornton, 2006; Wilson, 2009a; Betzalel & Schechtman, 2010).

All the students were intrigued by the personal manila folders that they had to record all their results for biblio-therapy, working memory and task performance. The researcher reiterated that it was to allow students to personally know where they were, and that it was not a test against each other.

Dan willingly did the biblio-therapy task, but like some other students, could not really see the benefit or significance at first. The researcher showed some clips of interviews with Bargh (2018), a famous psychologist in priming, and Gladwell (2005), a science commentator, in discussing social priming experiments at New York University. This went

down quite well with the student cohort, but the teacher was a bit annoyed with the researcher afterwards that this time took the class away from the work being learnt.

> Meg: It's great that you are building a rapport with the group Simon, but we hardly got through the work that I wanted to do today.
>
> R: I understand that Meg, but remember, we converted the work into homework tasks, which I said I would help mark.
>
> Meg: ... I know but this is a mathematics lesson, not a science lesson.

This conversation demonstrated that there was somewhat of a divide between researcher and teacher initially. Meg saw the researcher more in a support role initially, and wanted to take greater charge of the lesson, in Week 2. This response was also in reaction to seeing Dan's first biblio-therapy results. Meg seemed quite defensive when the researcher pointed out that a lot of the language written by Dan seemed to be around communication and comprehension, which may implicate her.

Table 5.24 Dan's Biblio-therapy Entry Week 1

Affective Vocabulary in a 158-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (6)	can do okay understand	can do (3x) understand (2x) okay (1x)	Around general arithmetic
Negatively Affective Words / Passive Word Segments (9)	Don't understand / hard / doesn't make sense / Can't keep up	Don't understand (4x) hard (2x) can't keep up (1x) doesn't make sense (2x)	Mainly around algebraic and trigonometry areas.

However, to foster the fragile relationship, the researcher allowed the teacher to facilitate the lesson in a greater role in Week Two. During the lesson, the researcher intervened to slow-down the language down at points with the intervention activities but moved aside when Meg taught the lesson's main curriculum activity.

Table 5.25 Dan's Working Memory Results (Weeks 1 & 2)

Week ONE	**SCORE**	**Week TWO**	**SCORE**
Working Memory (1)	4	WM (4)	3
WM (2)	5	WM (5)	4
WM (3)	4	WM (6)	4

When Meg saw the working memory results of her students for Week Two, most of them (as represented by Dan's results above) were weaker than in Week One. This was a flag that the researcher had a better grasp and understanding of the intervention strategies. The researcher asserted that he needed to return to this role. Meg conceded the mistake and asked for general feedback over the lesson.

> Meg: Sorry R if I stuffed things up.
>
> R: Look Meg, you were unhappy last week because I think you probably misinterpreted what I was going to do in class with my activities. Let me stay in charge of them. You do the curriculum activities. The only thing that I would say, is to slow down with your language ... Can we sort of reset for Week 3?
>
> Meg: Yes of course R. I'm sorry.
>
> R: Hey Meg, even Sally said that the majority of students were more on track today with the extra pair of hands. Just realise that yes you can use me as general classroom support but I am here to help influence the dynamics of students like Dan remember?
>
> Meg: Yeah, I understand. Thanks R.

In the lead-up to the Week 3 lesson, the researcher proposed that after teaching the intervention points, that he could take the at-risk group to Room 7. Meg was quite happy with this, until the day before the mathematics lesson. Meg emailed the researcher stating that Dan had been away and that this was a big sign that he was not coming in.

The researcher responded back by email, and said to stick to the plan, and that he could take a group into Room 7 and provide some extra help. Meg was satisfied with this arrangement.

Week 3 went well considering the lack of students and staff. Two of the at-risk group was with the researcher, along with five other students who were flat lining (no improvement) with results since the beginning of term. The response at the end of the lesson was reasonably positive with the following comments:

> ST3: I like this set-up R. I mean that I understand Meg ok but she speeds along too much...
>
> R: You mean Meg doesn't allow you guys to have enough practice time on a topic, or go into greater depth?
>
> ST4: Yes, that's it. But she is a fast speaker too...
>
> ST2: I just prefer being here. It's not as stressful R!
>
> R: Hey ST2, if I can keep the same set-up, do you think that you can get Dan and the others back in here next week?
>
> ST2: Yeah, I think that ST3 and I can do that.

When the group returned to class, they were happy when the researcher quickly talked to Meg about the set-up for next week. She was fine with this, as the new set-up had allowed

her to be more relaxed with her group. With feedback from the main group, everyone had seemed a lot more relaxed when the researcher first arrived.

After the lesson, even Meg admitted to being a bit slower and providing more worked examples. She even showed that all her group completed their biblio-therapy tasks. When Meg said to them that it was important, they complied. This indicated to the researcher that working relationships between the students and the teacher was obviously improving.

In Week 4, the class had virtually everyone back, except for a couple of students on extracurricular duties. Dan was back and was happy to move next door for some of his worktime.

Table 5.26 Dan's Working Memory Results (Weeks 3 & 4)

Week THREE	SCORE	Week FOUR	SCORE
Working Memory (7)	Absent	WM (10)	4
WM (8)	Absent	WM (11)	5
WM (9)	Absent	WM (12)	5

Dan was reasonably happy that his Week 4 scores were better than his Week 1 scores. It also reflected in his work, as Sally did not need to guide Dan at all. Dan understood the trigonometry work to be done and did not want any help. Sally took the researcher aside and commented that Dan had not worked like that since Term 2, when things were going reasonably well for Dan both at home and at school. The researcher wanted to take advantage of this moment, and checked with Sally, if he could give the group an appraisal. Sally was fine with this.

> R: Hey guys, I'm impressed today. Not only by the understanding, but by the attitude. Hey ST2 and Dan, doesn't this all demonstrate that our calmer states of mind make us not only perform better, but get on better with each other.

This caused a bit of friendly laughter, even from Sally. Dan's positive state of mind was reflected in his most recent bibliotherapy entry. The fact that Dan did not like the word 'interactive' but preferred the use of 'feedback' demonstrated that his affective vocabulary was becoming better aligned to his emotional state, and that he started to acknowledge its importance.

Table 5.27 Dan's Biblio-therapy Entry Week 4

Affective Vocabulary in a 192-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (8)	can do getting better feedback better understand	can do (2x) getting better (2x) feedback (2x) better understand (1x)	General arithmetic & Trigonometry concepts / Dan didn't like the word 'interactive' but liked 'feedback' instead.
Negatively Affective Words / Passive Word Segments (3)	difficult / / don't know	difficult (1x) don't know (2x)	Around only 2 concepts in Trigonometry

Again, like in the previous week, Meg was reasonably happy with the new set-up and how things were going. The researcher however, wanted to make things more fluid:

> R: Remember Meg, I won't be here in a few weeks' time! How are we going to fill in the void when I go? Sally's situation is better with that group, but we also need to improve yours as well.
>
> Sally: I think it's a bit early to get Meg in there R. How about you spend less time in there next week, and I take a greater role?
>
> Meg: I'm fine with that R – are you?
>
> R: Of course, I am Meg! Look I know that things haven't been clear between us at times which has caused a few problems, but you are the teacher. What I would suggest though, is that you assign work for Sally and I'll help you with the bigger group?
>
> Meg: I'm more than fine with that…

The following two weeks worked out well with Sally running the intervention strategies with the small group in Room 7. Dan's scores seemed to have peaked, but his behaviour was a lot better. He did like it though when the researcher popped in to check up on everybody.

Table 5.28 Dan's Working Memory Results (Weeks 5 & 6)

Week FIVE	**SCORE**	**Week SIX**	**SCORE**
Working Memory (13)	5	WM (16)	4
WM (14)	5	WM (17)	5
WM (15)	4	WM (18)	5

The researcher, even managed to get Meg to pop in, while he supervised the main class. Meg understood the reasoning behind this, and just made some positive remarks, and then moved out.

In Week 7, the researcher came in to tell the small group that he would only be seeing them at the end of the lesson for some feed-back. The researcher said that there was a concept that he

would like the teacher to go into greater depth with at some point. Dan sulked at this revelation, but with a quick assertive remark from Sally, and a disappointed look from the researcher, he got on with his work.

Meg came in and showed the concept again to the small group. Dan did not look up, but also did not react negatively. When Meg left, Sally helped Dan by showing exactly what Meg had demonstrated. He completed it without much fuss. When the researcher came in, Dan continued with the cold behaviour but didn't show any anger or other negative behaviour.

Sally had shown the researcher his results from the intervention strategies and classwork which were pleasing, as shown below. Dan's working memory was not diminishing which was reflected in performance results in class activities.

Table 5.29 Dan's Working Memory Results (Weeks 7 & 8)

WEEK SEVEN	SCORE	Week EIGHT	SCORE
Working Memory (19)	4	WM (22)	4
WM (20)	6	WM (23)	5
WM (21)	5	WM (24)	5

Whereas Meg seemed quite pleased with how things were going, Sally on the other hand, was worried about Dan and some of the other boys with the final lesson next week. A conversation reflected this:

> Dan: Will you back next year R?
>
> R: Can't mate. But I want us to end on a good note next week. You boys have turned around.
>
> Dan: Still don't like Meg.
>
> R: Doesn't matter. Thing is, is that you are behaving and doing your work. I work with people I don't like, but I don't let it affect me or my work.
>
> ST3: You just do your own thing...
>
> R: Exactly, but the thing is boys, is that you have matured so much and understand how to cope with school a lot better.

The researcher came as planned in Week 8 and helped co-ordinate all students to do their last biblio-therapy entry.

Meg interjected:

I want everyone to think seriously about this and be very reflective. I have organised no further work with you, as agreed yesterday. R we have a little party planned, as we did the test early, yesterday. It wasn't today.

The researcher was taken back by this but was pleased to see the smaller group of which Dan was a part of, be active in picking up all of the biblio-therapy tasks and helping with the party. Some of the smaller group asked SCMC to come in as well from the faculty office.

Table 5.30 Dan's Biblio-therapy Entry Week 8

Affective Vocabulary in a 216-word response.	**List**	**Incidence** (x – how many times)	**Comments**
Positively Affective Words / Active Words and Segments (7)	can do could do it liked it / liked getting better better understand	feel happy (2x) could do it (2x) getting better (2x) better understand (1x)	Around concepts learnt during intervention / Longer phrases & sentences with supporting positive words.
Negatively Affective Words / Passive Word Segments (4)	difficult / don't know / don't want to go	difficult (2x) don't know (2x) don't want to go	Perplexed about situation around Maths for next year and Researcher.

Dan was flat in Week 8 in seeing the researcher go, but this was the main reason SCMC came in. SCMC reassured both Dan and the researcher that the make-up of classes would be a bit different, with Sally following the small group up into Year 9. The researcher and even Meg were quite surprised by this, but not Sally, who apparently had been briefed by SCMC.

The researcher asked for SCMC and Meg to come into the adjacent room. All the boys' thanks were quite subdued, as there was an obvious amount of shame coming to bear over some of their past behaviour. SCMC being a jovial man, reinvigorated the group to come out and join the rest of the class.

After Week 8, Meg provided the researcher with quite a heart-felt email response, but this will be properly covered in the following chapter when we look at the attitudes and reactions of the teacher-participants over their professional learning journey. The importance of this here, is that it demonstrated that being near the end of the year, that there was some closure for both Dan and for Meg. The focus student was a significant personal issue for the teacher. Much of the focus, was not necessarily to repair the relationship between teacher and student, but to come to an accommodation, that allowed Dan to effectively work and appreciate mathematics.

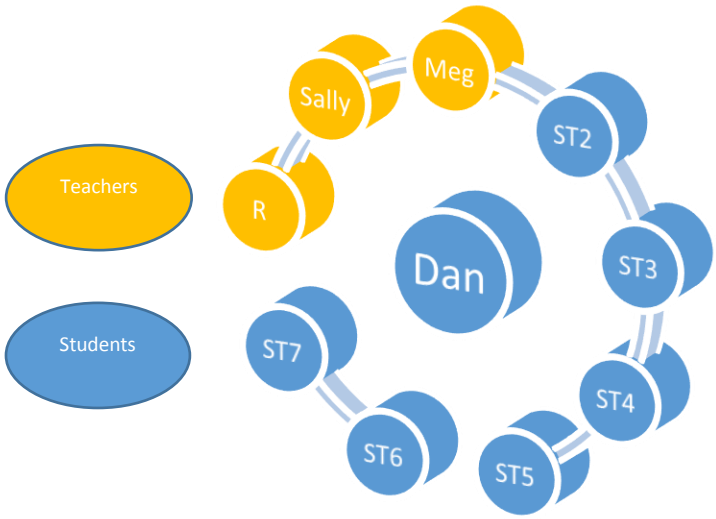


Fig 5.31 Dan's Social Engagement Network

It was evident to the researcher that Dan's social engagement network (Fig 5.31) within his mathematics class was quite strong from when he first entered the classroom. Unfortunately, it also had a negative impact on everyone else in the initial weeks. By the end of the intervention period, it had turned to be more on a neutral level with the rest of the class, but positive amongst themselves.

The individual accounts of three specific focus students amongst the teacher-participants, helps demonstrate the idiosyncrasies of each professional learning network. The variation posed by the three case studies is by no means exhaustive, but instead demonstrates some consistencies by the common elements and prerogatives that they use.

The first key prerogative is that all three teacher-participants sought a common goal to have a professional learning experience with an invited researcher. The other main prerogative is to specifically learn about Mathematics Anxiety. The prerogatives demonstrate that each of the three teacher-participants share and participate in a common phronesis (Thomas, 2010; Spicker, 2011) or naturalized generalization path (Stake, 1994). All teachers were on a professional learning experience with a common basic objective to learn about Mathematics Anxiety, even though there was some divergence along the way.

This common instrumentality shows the reader that the teacher (actor) has a knowledge and understanding of their classroom context from the adaptations, habits, and practices that they regularly do.

The three professional tables outlined in this chapter demonstrate however, the differences and divergence of teachers' individual needs like behaviour management, improving social engagement systems of students, and increased social interactivity in mathematics activities.

In accordance with processes in Actor Network Theory (ANT), themes started to emerge amongst the three case studies (supplemented by their mini studies) in the following areas:

- The Need for Structure (Concept of the Mediator / Reliance on the Researcher)
- Deterioration of the Intervention When not Followed or Used in Another Setting (Activation of the Black Box Scenario)
- Need to Continually Develop & Negotiate Roles amongst Actors (Concept of Interessement)
- Need to Continually Reinforce or Make New Connections in Network (Concept of Punctualization)
- Need to Mobilise Actors and Actants to Make new Supporting Networks (Concept of Mobilization)
- Variables Constructed and Used Were Sufficient (Concept of Nomological Network)
- Translating Professional Learning Ideas is Ever-Present & Developmental (Concept of Translation as a Process Rather Than as a Final Outcome)

VI. Interpreting Case Studies with the Lens of ANT

i. Case Study A (Sue) and her focus student Grace:

Key Characteristics & Elements:

- Professional Learning Network has High Structural Integrity – very little change took place to existing network over the course of the intervention period. No new actors or actants required for the two main actors of Sue and Grace. Only one actor was required to be removed in Grace's social engagement system near the end of the intervention, when she had developed the confidence and initiative to do so.

- Low Interessement reinforces the high structural integrity of the existing network. Roles of actors and mediator (researcher) did not require no significant or dynamic change. Existing discourse and collaboration between all key actors were satisfactory. Professional Learning progress of Sue and learning / affective

development of Grace were developing at a rate commensurate to their individual needs.

- No Punctualization also reinforces the high structural integrity of the professional learning network, as no other intercessions or supports were required to repair or stabilise issues concerning the network.

- Professional Learning Network has Low Mobilization – Requirements for two main actors were highly manageable within existing structure. Professional learning needs were satisfactorily being met for Sue, and the existing classroom structure allowed Grace to develop at her pace. These behaviours ensured slow but assured progress and results, but also demonstrated low initiative by the Mediator (researcher) to push processes along.

- When the Black Box Scenario was activated there was no deterioration. This occurs when the Mediator and Obligatory Passage Points are deactivated (left the classroom). There were no significant 'translational' behaviours emerging in normal mathematics lessons which required Mediator (researcher) or teacher-participant (key actor) to make any supportive changes to the Professional Learning Network. The arrival of the mediator (researcher) always effectively re-activated the start of the Professional Learning Network.

- The commensurate intensity and coverage of work provided to the at-risk students (as represented by Grace), and the rest of the class, demonstrates that all mediating and moderating variables were correctly described and working. Grace's dependent variable (her disorder) was acknowledged and well catered for within the network, requiring no further work.

The possibility for translation was low. Although, everything worked well for the teacher-participant (Sue) and focus student (Grace) within this environment, there was little indication that the teacher-participant was mobilizing strategies and practices to normal lessons in the foreseeable future. The interaction of actors to the researcher, after the intervention period, indicated some possible developments for the new year, but these were

the only signs. The network however, effectively achieved its aims as a site of professional learning.

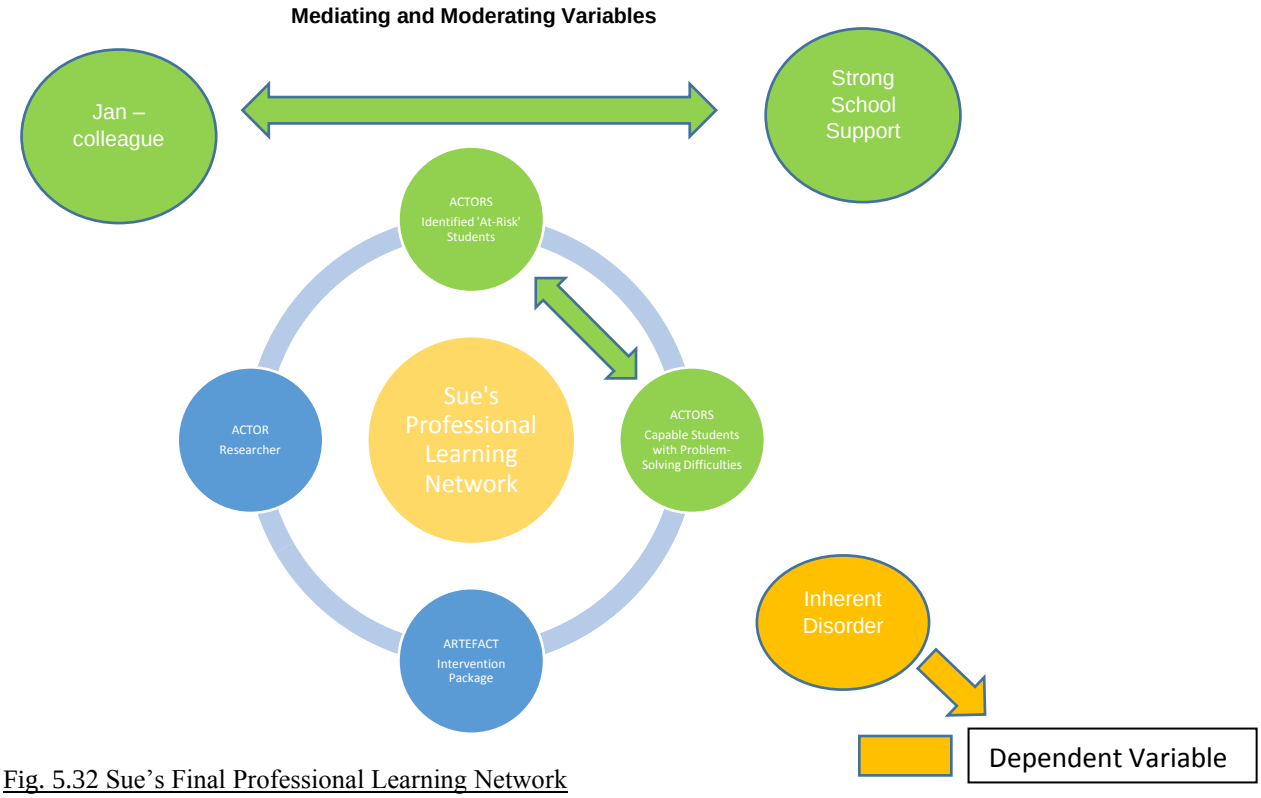


Fig. 5.32 Sue's Final Professional Learning Network

ii. Case Study B (Jan) and her focus student Ron:

Key Characteristics & Elements:

- Professional Learning Network has Moderate Structural Integrity – some significant changes took place to existing network over the course of the intervention period. Half of Ron's social engagement group (of which Ron was one) was composed of 'at-risk' behaviours. The other half were friends who had at least average competency in mathematics. The 'at-risk' component of this group meant that it was a group within the classroom that regularly came to the attention of the researcher or Jan in terms of support in on-task behaviour, interactivity, and completion of tasks. There were no new actors or actants for the two main actors of Jan and Ron, as there were no other resources that the main actors could turn to. This meant that modifying or strengthening the existing structural elements of the professional learning network was the only way change could be employed. Access to the Activity Room provided a locality for the main actors to bring some division and dynamism for the relatively

large class. Near the end of the intervention package, because of high interessement and mobilization, translation started to occur. This resulted in parents/guardians becoming a valuable actor providing mediation and moderation to the resulting network.

- Moderate interessement was regularly enacted in Jan's professional learning network. This was reflected in Jan's positive attitude and willingness to make some significant changes and be part of a positively dynamic relationship with the researcher. The teacher-participant became mediator at times, by reporting back to the researcher of changes made in classroom times outside of the professional learning network, and the affect this had on her and her students in terms of behaviour management and performance outcomes. The continual positive feedback she got from her students in this process that she had taken on board, would become a prime driver. This made the discourse and communication between teacher-participant and researcher in turn, quite positive and dynamic. However, in time, the researcher saw that the dynamic change process between teacher and students would become more pronounced and valuable, than that between teacher and researcher.

- Punctualization came in the form of relocating Ron's social engagement group which now became viewed as a learning group. This small group was given limited periods of time away from the main class to work by themselves and have extra attention from either the researcher or teacher. This allowed either main actor to deliver the intervention package to this small group at a different intensity level to the main group and utilise more alternative hands-on tools and activities for retention.

- The Professional Learning Network had a moderate degree of mobilization – changes were made in terms of general classroom habits and modes of delivery in regular mathematics and beginning in science lessons. The intervention had provided a level of literacy and socio-emotional learning not normally seen in mathematics teaching but had provided an approach which worked well with Jan's teaching style. These practices were mobilized to keep up the engagement and interactivity levels of all students, reduce off-task behaviour, and improve overall performance. This also meant that Jan did not necessarily need to access Sue as a regular resource. The

mobilization of practices outside of Jan's professional learning network would increase the likelihood and evidence of translation.

- The intervention package exposed the teacher and students to an array of teaching and learning strategies that they did not regularly use. This caused the activation of the Black Box Scenario. These strategies were not part of regular classroom culture and practice. Consequently, the teacher participant had to alter classroom practice by saying that for mathematics lessons in general, and in some science lessons, that they would use some of the structures and habits that the researcher had introduced on a regular basis.

- The intensity and coverage of work provided to the at-risk students (as represented by Ron), was having a positive effect on the rest of the class. The well-established working relationship between teacher and students, enabled strategies from the intervention package to translate to their mathematics lessons in general, but also in part to science lessons that was reported by Jan to the researcher.

- The high interessement and mobilization is likely to change the scope, reach and elements of Jan's professional learning network. So much so that Jan's professional learning network could now be called her Teaching & Learning Network for Mathematics. The school and Sue, as actors, were quite supportive of this transfer, that Sue (colleague from Case Study A) and other teachers were now observing her mathematics classes when the researcher was not there.

- Mediating and moderating variables changed. The researcher became a less pronounced actor and moderator, as Jan became more confident as an emerging central mediator and obligatory passage point (OPP). The school, in terms of other teachers, became more pronounced in interest and support for Jan's new network. The two student groups, the main group and Ron's sub-group strengthened as nodes and actors of this new network, because of their positive attitudes, interactivity, and performance results.

Translation was high, evident by the changes made in regular mathematics lessons. The intervention package had now evolved from an artefact to regularly used tokens as part of

classroom discourse in mathematics lessons. Transference of mediator and OPP roles had occurred from researcher to teacher-participant. Not only had professional learning occurred, but changes in regular classroom practice occurred.

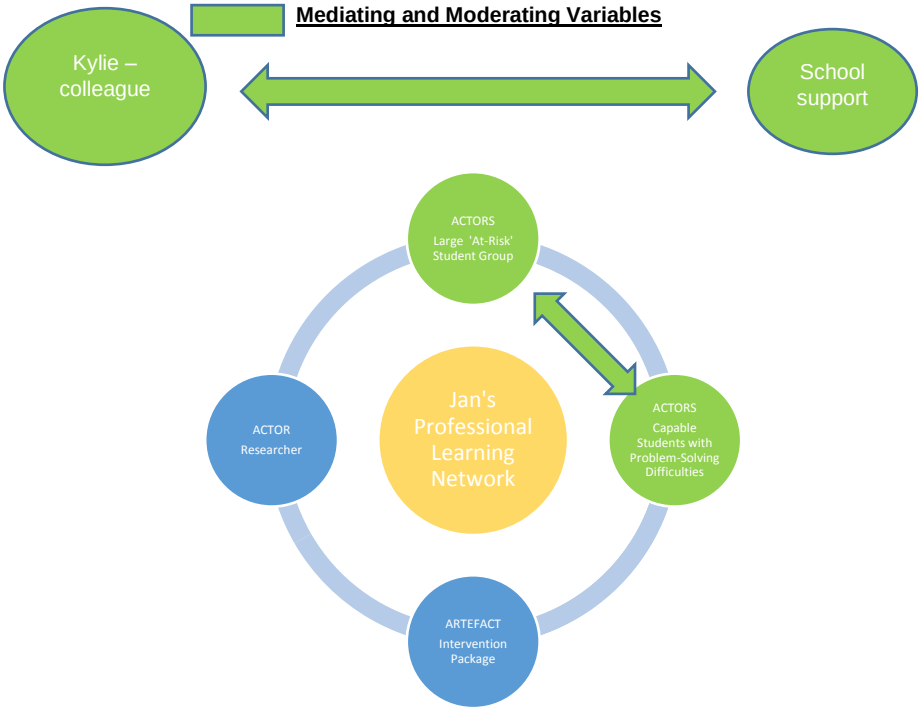


Fig. 5.33 Jan's Final Professional Learning Network

iii. Case Study C (Meg) and her focus student Dan:

Key Characteristics & Elements:

- Professional Learning Network had low structural integrity – there were many misunderstandings and fragile relationships that plagued the network initially. The researcher (mediator) had to use his experience of the other professional learning networks to put help instil confidence and trust into Meg's network. The researcher had to build separate relationships with the focus student Dan and Sally, as the other main actor (Meg) demonstrated some scepticism towards the researcher and the set-up of the professional learning network.

- As a structural ploy, the researcher moved back from obligatory passage point duties to let the activities literally falter in Week 2. The Black Box Scenario is normally designed to work outside of the professional learning network. Instead, by letting the

teacher take charge of the intervention that she had little understanding over, was a calculated risk. However, the low interaction and performance of Meg's students, when she conducted the intervention, demonstrated the importance of the researcher as the mediator / OPP for the network. It also highlighted the importance for the teacher to engage in high problematization – the first stage that initialises what the problems truly are. The convenient thing about this, is that it also helped a minor actor Sally to develop into a more significant actor.

- As the professional learning network was continually being built in an ad hoc manner, high interessement (negotiation and allocation of duties and roles) was required in the first couple of weeks. All three major actors (Meg, Sally, researcher) were using historical evidence over the year to come up with a workable network that sought to achieve a sense of stability for the students, and subsequently, some performance growth. This meant that for the first few weeks, that all actors agreed that the initial and primary objective of professional learning was side-lined to build up the necessary relationships and locations to allow the network to function and progress. SCMC became a new actor, providing significant support for the professional learning network to eventually initialise in Week 3.

- No punctualization was required as revisiting the initial stages of ANT allowed the network to be rebuilt again. Enrolment was not required as all students expected the work to get back on track. With the researcher (mediator) providing a sense of stability, through this transition, students continued to progress reasonably well.

- As the professional learning network was enmeshed in the highly structured schedule of a high school timetable, it indirectly provided a boundary in which to operate. The Black Box Scenario was not required. When the researcher (mediator/obligatory passage point) left the classroom, the professional learning network was de-activated. The lesson was initially being viewed by all actors (including SCMC) as a separate entity, to simply try some new strategies out, with no plans for mobilization or translation outside of this lesson. The arrival of the mediator (researcher) always effectively re-activated the start of the Professional Learning Network.

- However, when Sally and the researcher successfully re-located the small at-risk group to Room 7, the scope of the professional learning network changed. This new configuration provided gradual positive change for the relationships between the teacher and the two student groups, and Sally and the small at-risk group.

- Communication and negotiation between the actors (Meg, Sally, and SCMC) to have the at-risk group in Room 7, not only improved working relationships but also improved the attendance of the group represented by Dan. This new configuration now meant that the researcher was no longer the only main mediator / obligatory point of passage. Six mathematics lessons a week outside of the professional learning network, were strengthening key nodes and relationships at a rate the researcher could not. The professional learning network now became a sub-network of a reasonably strong mathematics learning network, of which now had developed very sound structural integrity. The actors (Meg, Sally, and SCMC) had in effect employed high mobilization from a small network to a larger more permanent network.

- By Week 4, Meg's professional learning network was sound structurally and highly active. New actors (SCMC, and the division of student groups) were allowing mediating and moderating variables to function as designed, to allow Meg to now focus on her professional learning. SCMC, a new key actor, encouraged the professional learning to now be the main objective. The Week 4/5 period was quite busy in getting Meg up to date with all the collected data from previous weeks.

- The utilization of Meg, Sally and the researcher as key actors in the delivery and supervision of the intervention package, allowed the two student groups to work at their own commensurate intensity and coverage of work. This was evidence that the mediating and moderating variables were working. Meg's network finally achieved its aims in being a professional learning network. Despite some initial issues of misunderstanding between key actors, support actors at the school (SCMC and Sally) allowed the network to finally configure in a way that allowed learning connections between teacher and students to be structured differently.

- This structural transformation demonstrated that translation not only works from intended objectives of the key actors to change inherent processes and states within

the network. The initial collaborated objective was to build the professional learning of a teacher. Ongoing interessement (dialogue and negotiation) between the teacher-participant and the researcher, highlighted initial misunderstanding and miscommunication over the objectives of the network. This allowed support structures both within and outside of the network, to help the network re-configure to the requirements of all actors. Translation took place at a whole network level. It was possible that the network could have faltered or broke during these processes. However, the attitudes of all actors contributing equally in the discourse and development of the network ensured its success. This case-study helped reaffirm the strength of ANT as a framework for teachers' professional learning networks.

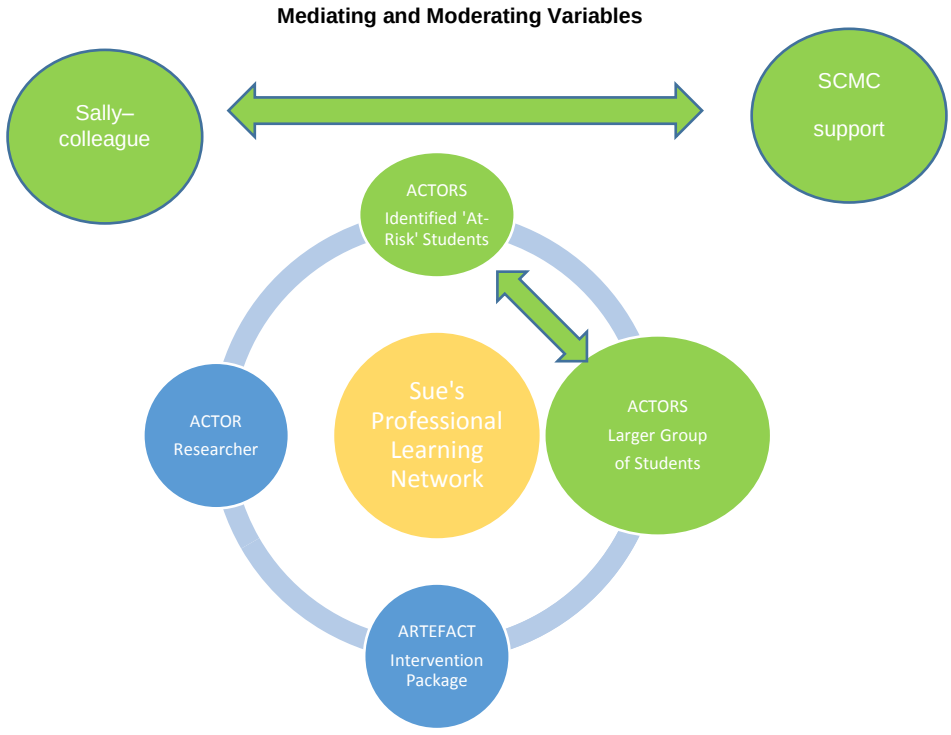


Fig. 5.34 Meg's Final Professional Learning Network

In three school-based contexts, Chapter V described how the professional learning networks (PLNs) of three teacher-participants started and evolved over a ten-week period. Actor Network Theory (ANT) demonstrated itself to be a satisfactory and effective framework in building and describing the PLNs of each teacher-participant. Endemic elements of ANT like problematisation, interessement, punctualization became key processes for actors in building and maintaining the PLNs.

The ten-week time frame demonstrated the significance of time as a professional learning element. Although the assigned time frame was a satisfactory provision for the three case studies, the last couple of weeks (esp. Weeks 9 and 10) demonstrated that further work and intervention could have been done in better resolving some of the issues with target students. This demonstrates the continuous, dynamic, and potentially fragile nature of the PLN.

The initial professional learning need (problematisation) would normally be expected to culminate into the final stage of translation (conversion to regular teaching practice). This is illustrated by the high translation seen within Case Study B. There were new regular teaching practices enacted by Jan, resulting from the intervention, in the last few weeks of the timeframe. This development meant that there was greater likelihood of Jan in being able to sustain these practices into regular daily teaching habits.

In relation to Case Studies A and C, there were obvious positive professional learning gains by the teachers, but these PLNs virtually terminated at the departure of the researcher. This demonstrates another ephemeral attribute of the PLN – the significant dyadic relationship between researcher and teacher over the course of the PLN timeline. The exit of a significant actor, from a teacher's PLN could underscore some teachers' capacities to maintain such a network. This may highlight the need for the actor (researcher) in conducting the professional learning within the PLN to highlight its fragility and ephemeral nature.

The following chapter, Chapter VI, will go into further detail of the professional learning relationship between researcher and teachers. The responses and feedback from teachers will help highlight how the researcher adapted and adjusted the intervention package and his roles to keep the professional learning relationship amicable and productive.

CHAPTER VI

VII. Findings and Recommendations from Study

I. Overview

The previous chapter outlined the structure of the dyadic professional learning networks (PLNs) for the teachers, and how they emerged from the relationships among actors and actants. The sound structure of the PLNs enabled teachers to participate greatly in the delivery of the intervention and change the environment of their classrooms.

In this chapter, the professional learning journey of teachers will be depicted from their contributions and developing perspectives over the intervention period. The professional learning of Mathematics Anxiety focused on what teachers were required to know about the condition to enable them to reduce occurrence and assist those students who demonstrate symptoms. The investigation sought to answer the following key question:

> How can the gradual presentation of new knowledge and skills that has been introduced by an educational specialist (the researcher) into a classroom impact teachers' knowledge and pedagogy?

The teachers brought to the project their specific learning needs, and the researcher his knowledge and skills. Students, in the three classes, would become beneficiaries of the immediate and longer-term changes from the intervention strategies being implemented by the teachers and researcher. The participants ultimately observed changes in learning behaviour and results in mathematics performance, resulting in the lessening of overall Mathematics Anxiety within classrooms.

Teachers, through their initial questionnaires, observations of students and the researcher, guided reading, and discussions with the researcher, had experienced significant change in terms of knowledge and perspective. Through their teaching and implementation of the intervention over a period of time, teachers had also experienced new classroom practices as part of their professional learning, created with the researcher. The experience of learning directly from an educational specialist also provided the teacher with some new ways in accessing and using the skills of a mentor.

What is pivotal to this, is the contribution and attitude individual teachers brought to the professional learning of the study. The teacher is generally viewed as the best source of mitigating Mathematics Anxiety within the classroom (Maloney & Beilock, 2012; Dowker,

Sarkar & Looi, 2016; Mollah, 2017) and this was evidenced in the closing weeks of the intervention. As the researcher reduced input more in Weeks 7 and 8, the teacher needed to translate the professional learning into new or emerging attitudes, responsibilities and practices that they could to some degree, maintain.

II. Findings of the Teachers' Learning Journeys (Week 1 – 8)

In the Week 1/2 period, the researcher had meetings with each of the teachers. Initial questionnaire results demonstrated that at best, teachers only had a limited understanding of Mathematics Anxiety. Meg probably had greater understanding than the other teachers, as a result of her psychology background. However, like with the other teachers, she knew very little about effective strategies for Mathematics Anxiety.

In the Week 3/4 period, teachers were mainly getting used to understanding and implementing the intervention package, and comprehending the environment that they were in. This was an initial issue for Meg, whose learning objectives did not initially align to learning about Mathematics Anxiety, unlike the other two teachers. However, the importance of settling the attributes of Meg's PLN, demonstrated that the contexts and support structures were significant in allowing professional learning to eventually proceed. This period highlighted a need for teachers to have confidence in their own PLN, and to subsequently make the necessary changes to modify or reinforce the PLN. The introduction of the micro-ethnographic case studies of focus students reflects this correction.

Week 5/6 demonstrated a time for all teachers where the researcher needed to lessen input and influence, and allow the teachers to take greater responsibility and action within the classroom. As with all the micro-ethnographic case studies at this time, the successful output of students greatly correlated with the greater interaction and input from the classroom teachers.

This was also a period where the teachers were confidently making modifications to their classroom environment as a result of the intervention package. Like the researcher in the Weeks 3/4 period in correcting the PLN, teachers were confirming with their management about the set-up and use of adjacent spaces to reconfigure learning groups within their classroom. This was a time when Meg modified and better directed the responsibilities of Sally, to supervise a small learning group. These actions by teachers helped enhance their

control, not only over their PLNs, but over their own professional learning. All teachers were completing the readings set by the researcher, and asking sufficient questions at their meetings to clarify what they had read, or enacted on in class. The learnings of Sue and Jan culminated during this period, whereas for Meg it came in Week 7.

The period of Week 7/8 was a consolidation of professional learning for all teachers. There were still some questions asked of the researcher, but it was mainly a time where teachers were preparing for translation (progressing and adjusting their classroom to the period without the researcher).

The professional learning ended in Week 8/9 when the teachers met with the researcher for the last time. The success of the above teachers' professional learning came from four key features, mutually agreed to by both teacher and researcher:

1. The learning objectives constructed in their first meetings with the researcher.
2. The alignment of teachers' learning objectives to their specific learning needs.
3. The effective communication between researcher and teacher, based heavily on review, reflexivity and feedback.
4. The participation and contribution of teachers to the working relationship with the researcher.

These features emphasised the value of effective communication and commitment between the researcher and the teachers. The third case study was an example of where the above four features broke down, so effort had to be made by both teacher and researcher to repair the relationship. In the third case study with Meg, there was incongruence in effectively and honestly communicating all learning needs, and this affected the working relationship between teacher and researcher. This incongruence prompted the researcher to return to an early stage of ANT – problematisation. Returning to this stage, enabled Meg to be more candid about her learning needs. This in turn prompted the researcher to be more explicit and to direct how Meg's professional learning network (PLN) would unfold over time.

In the other case studies, the intervention package shared a role with the researcher as joint obligatory passage point (OPP), and would eventually become the primary OPP as the researcher gradually stepped back in participation and input over time. In Meg's situation,

the researcher did not step back until the final two weeks, to ensure that the structure of Meg's PLN was maintained.

By enhancing the status of Sally within Meg's professional learning network, communication improved, and work commitments was better shared. The capacity to return to an early stage of ANT to rebuild Meg's professional learning network, demonstrated the flexibility and usefulness of ANT, as a sound framework for designing a professional learning model. Without the fundamental processes of communication and review, the reorganisation of Meg's PLN wouldn't have happened. These processes are implied in the ANT stages of problemisation and interessement, but are not unequivocal.

From these examples, the ideas of review and communication became essential attributes and processes of applying ANT specifically to the area of teacher professional learning as indicated by the following academics (Jones, 2009: Fenwick & Edwards, 2010; 2019). With their study of ANT in analysing the politics of policy and curriculum development in India, Sriprakash and Mukhopadhyay (2019) paved the view that reflexivity is a key process that can allow teachers to be 'brokers' and 'translators' of knowledge. This demonstrates the ideal use of ANT within the realm of professional learning, and that the reflexivity performed by teachers determines how well they perform as mediators/brokers and translators of their learning.

The effectiveness of these teacher roles hinged on strong communication between the researcher and teachers. The strong communication however, was characterised especially by the processes of reflexivity, review and feedback. For example, as much of the new professional learning about Mathematics Anxiety came from aspects of the learning sciences, the teachers knew that this would be moderated by how well they participated in discussions and sought regular understanding from the researcher. Similarly, it was important for the researcher to continually check with the teachers, that they understood their learnings, especially since it was an unfamiliar area. Communication aside, the other main contribution required of teachers, was their physical and interactive participation with students in lessons. The playful implementation and experimentation of the intervention strategies in their PLNs, would allow teachers to see emergences (surprising or not) of changed learning behaviour from their students (Thumlert, de Castell & Jenson, 2015).

i. The professional learning relationship between researcher and teacher

The success of professional learning for all teachers developed over the duration of the intervention, were determined by a key group of elements. The following list indicates these elements as important themes that arose from the study. However, as demonstrated in the following discussion, these themes do not stand alone, but can be highly interwoven with each other:

a. Quality of review and feedback.

b. Safeguarding the professional relationship between researcher and teacher.

c. Adapting the professional relationship to specific needs of the teacher and classroom.

d. Ensuring the natural progression of learning and development of the professional learning relationship.

e. Ensuring and encouraging the opportunity for teachers to get and go through the process of translating their learning.

The review and feedback at the teacher-researcher meetings, of teacher's classroom work, helped cement their skill in the implementation and adaptation of the intervention strategies. When the teachers developed sufficient knowledge and confidence with the intervention package, the researcher was able to partially withdraw, and allow the intervention package itself to become the more predominant OPP. This stage was evident by Weeks 6 and 7. Up to this point, knowledge had been the substantial aspect of transmission for all three teachers. Sue (Case Study One) and Jan (Case Study Two) felt a degree of saturation by Week 6, and became more interested in focusing on developing their pedagogy, and the supporting classroom environment.

At this stage Meg (Case Study 3) was experiencing issues in cementing her professional learning network. She did not feel comfortable focussing on pedagogy until the end of Week 7. At the end of the intervention period, Meg was the teacher least likely to see the potential for strong pedagogical change. After the intervention period, Meg reported learning a substantial amount in terms of knowledge, and the mechanisms that could support her with students experiencing Mathematics Anxiety and related difficulties.

In terms of Sue and Jan, both believed that they had sufficient time to make some significant changes to their pedagogical approach and affect the learning environment of their students.

Due to the reasonably large size (25) of her class, Jan focused more on developing efficiencies and heuristics from the intervention. For example, Jan employed a well-being scale throughout the day as a heuristic to better monitor the state of her students. Jan also continued to use the working memory activities in mathematics, based on Miller's (1956) approximate rule of seven +/- two items.

Jan also translated this practice to test preparation situations where students were required to memorise facts. She found this method useful for surveying and pre-testing students' knowledge levels. Jan introduced, as part of students' homework tasks two weekly diary entries. The diary entries included students' reflections of their learning, including what they enjoyed and what they found more difficult.

Jan's students started to make connections between the work that they did not particularly enjoy and the work they had trouble completing. This practice helped improve the affective state of students because students were better aligning their emotional thoughts with their mathematical thoughts and output. Emotional commentary was being used to better describe any problems or disconnect students were having in mathematics. Jan reported that the emotional vocabulary of students was no longer just a red flag to potential mathematical problems but a descriptive commentary to merge emotional and logical thought. As students became more proficient at merging their emotions with logical thought, more students demonstrated greater assertive and interactive discourse in general classroom activities resulting in high understanding and translation for Jan.

As well as her greater strategic approach to teaching, Jan greatly encouraged her students to continually reflect and evaluate what they had achieved and how and why things did or did not work throughout their learning.

Sue's development was not as pronounced as Jan's. Sue, like Jan, also used a well-being scale, working memory activities and check for feedback but preferred to keep the changes limited to her mathematics lessons. She employed Jan's reflective diary strategy. Sue believed that she had developed good skills and understanding from the researcher but was not yet confident enough to translate these practices to other areas of her teaching. She reported that the learning and improved confidence that Jan demonstrated, greatly influenced her capacity to cement her learnings and practices in class demonstrating that the teachers' personal attitudes impacted the success of their professional learning.

ii. The roles of the introduced intermediary

The researcher acted as a solitary intermediary between literature and findings from the learning sciences to the development of the teachers. As intermediary, the researcher needed to be continually aware of the amount and quality of information being transmitted to the teachers. This was evident via continual feedback and communication between the teacher and intermediary which then allowed for possible change and reconciliation.

The intermediary was open to potential changes in participants' learning objectives and needs. Consequently, all researcher-teacher meetings were continually expository and appraisal-based. Advancement from the weekly meetings always resulted from the quality of discussion and understanding of the readings, class results, and observations. The teachers and researcher made inferences from these sources, and then suggested and refined the professional learning journey moving forward. A clear example of this was the transition of multiple student targets to the emergence of single micro-ethnographic case studies within each class cohort.

The literature indicates that the interaction between the learning sciences and education show that teachers can be easily misled or confused with scientific research, if not effectively guided by an intermediary who is well educated in the field (Zambo & Zambo, 2011; Simmonds, 2014; Howard-Jones, 2014; Canosa & Collado Ruano, 2019). With the attentive presence and consistent behaviour of the researcher during intervention lessons, the teachers were provided with guidance to implement and review the intervention strategies, and how to appropriately interpret the research literature behind them.

The intermediary had a solid education background which ensured a good general comprehension of the teachers' capacity to understand and act on the knowledge provided. The teachers appreciated that the intervention was over a substantial period and agreed that there had been sufficient time between lessons for preparation and review.

Two of the teachers (Sue and Jan) were pleased that there was also the opportunity to contact the researcher past the intervention period which helped subdue the predominance of time as a key aspect of the intervention.

This demonstrated a continual transition in the teacher-researcher dyadic relationship between shared collaboration over certain tasks during classroom activities, and the top-down organisation and discourse in terms of time management and delivery of learning. Although

all learning was reasonably monitored and guided by the researcher, the teachers had an active hand in reviewing and directing the course of their own learning. Teaching strategies and learning activities were continually observed and refined by the researcher, as were misinterpretations from the literature.

The researcher was not assigned specific roles throughout the intervention; however, it was outlined that the researcher had the capacity to take on any roles such as mentor, supervisor, or tutor, at any time in accordance with the needs and development of the teacher. All teachers defined the general capacities performed by the researcher throughout the intervention as:

- Supervisor/Facilitator
- Mentor/Coach
- Advisor/Expert
- Co-Teacher/Colleague/School Support Officer (SSO)
- Observer

Interestingly, the capacities of Counsellor and Supporter were added at the end of the intervention by Meg and Sue in their final survey statements. The teachers demonstrated confidence with the flexibility and continual development of the roles of the researcher.

Most of the time, all the teachers viewed the researcher in a supervisory capacity but were glad that they could communicate and utilise the researcher in several ways. This enhanced the professional learning relationship between the researcher and the teacher. The relationship was outcome-based in terms of optimising the best opportunities and avenues for professional learning. This meant that although there were structured times and opportunities for learning, that any problems that did arise within the classroom, were apt for professional reflection.

The teachers reported that during the intervention they felt supported by the researcher through difficult periods with students, students' families, and school staff. At times, however, the teachers were surprised that the researcher assisted in communication with families and others outside of their own professional learning network. The researcher's involvement further instilled confidence and trust which reinforced and maintained the structural integrity of the dyadic relationship.

All three dyadic relationships had different degrees of structural integrity. Maintaining the structural integrity of relationships among actors is a key aspect of ANT. According to ANT, revisiting early stages like problematisation, interressement or punctualisation can help to repair, improve, or consolidate the relationship between the researcher and teacher (Fenwick & Edwards, 2010; 2011).

This revisitation of early stages of ANT showcases an important feedback loop for actors to address the structural integrity of the professional learning network, and to deal with problems that may arise throughout the intervention process. This was evident with some problems that have been described within the third case study with Meg. Both Meg and the researcher needed to revisit early stages of the ANT process to repair their relationship and correct the professional learning journey. In terms of the second case study with Jan, the revisitation of early stages allowed the professional learning network to not only change shape but strengthen. The clear guidelines of ANT had therefore influenced the role and direction of the researcher in the professional learning of the teachers.

iii. <u>The viability of Actor Network Theory (ANT) as a framework for professional learning.</u>

ANT provided effective mechanisms for the researcher to work in a cyclic reflective manner with the teachers, allowing all actors to evaluate and review their learning objectives when needed.

Most of the theory behind ANT was simple enough to allow for solid understanding of key concepts by all actors within an educational setting. ANT allowed the researcher and teachers to look at structures and processes in a relational and utilitarian capacity. As concepts of ANT are reasonably general, all teachers took an active role in writing up and developing their professional learning networks with the researcher. Although the researcher guided all teachers with a relatively consistent framework, all teachers felt that they had ownership of their PLNs, and the capacity to contribute and build them.

Description therefore became a key developmental builder for the actors and their professional learning networks. Being viewed as a professional sensibility and toolkit for the teachers, they worked out that there was no right or wrong way to use ANT (Law & Hassard, 1999; Law, 2004; Gorur, 2015). The teachers realised that their PLN was dependent on the descriptive rationale between actors and actants within their own network.

All elements and processes of ANT, however, are labelled in language not regularly known to the wider education community, and as demonstrated in Chapter Three, there is an extensive specialised vocabulary. Consequently, the researcher was selective and qualified in what was shared with the other actors. The researcher found out that it was more important to involve all actors in the processes of ANT, rather than describing elements in ANT terms.

For example, teachers understood that they needed to identify and follow through with their learning objectives. Any problems that they had with this was subsequently labelled as problematisation by the researcher. All processes were described in terms of mediation, rearrangement, and review – practices that the teachers understood, and which improved the intervention and/or the professional learning of the teachers. These behaviours were overcome by the researcher's ability to unpack and describe what these processes looked like during the intervention for individual teachers, and show how they could contribute in successfully getting the intervention back on track.

These adaptations would come in the form of practices that call for the creation or reassignment of roles and tasks between researcher and teacher and the setting up of complementary settings. An example of this, was when Ron's social engagement group (Case Study Two) was relocated away from the main class with some greater specificity in the activities that they had to do. This practice highlighted the group and the activities they performed (punctualisation), demonstrating that the intervention was working. When processes like this were described back to the teachers, they understood the basis of the concept, but were sometimes bemused by its title. However, the success of these collaborated involvements between researcher and teacher, over time, would give increasing weight to the concepts used. This would be seen in the developing vocabulary of ANT concepts used by the teachers. The greater incidence of ANT words and vocabulary surrounding the intervention increasingly used by teachers reflected the development of their learning.

Some words however, like interessement and obligatory point of passage that could not readily be explained in everyday classroom practice hindered their understanding and usage by teachers. The role of the researcher therefore, was to reconsider what terminology was helpful for the teachers.

However, some of the vocabulary associated with ANT was indicative of jargon and required deep learning and understanding of some of its key concepts. Concepts like problematisation

and punctualisation were very useful for teachers in identifying students struggling with concepts and problems in implementing the strategies. Jan, using problematisation for example, found out that some classmates of Ron, had similar difficulties of comprehending the concept of angles, and subsequently misbehaved with him. When the group got together, away from the main class, their learning behaviours changed. Jan could now use scaffolding and worked examples (punctualisation) to support and correct the students' work.

The researcher was able to restrict the understanding and terminology of ANT philosophy, so that teachers could concentrate on their professional learning priority, Mathematics Anxiety. However, by the end of the intervention, two of the teachers (Sue and Jan) indicated further interest in ANT.

The interest stemmed from the fact that ANT in its fully eclectic form is both a systems theory and a perspective in analysing agreed components and relations (Latour, 1987; Law & Hassard, 1999). This allowed the teachers to contribute significantly to the construction and analysis of their professional learning network, thus understanding in real-time how ANT was working. The After-ANT (post 1999) characteristic resulted in being a significant aspect of teachers' work. It was imperative that all teachers thoroughly understood and described their individual context and its idiosyncrasies.

In accordance with processes in Actor Network Theory (ANT), themes started to emerge amongst the three case studies (supplemented by their mini studies) in the following areas:

- The need for structure (Concept of the Mediator/Reliance on the Researcher)
- The deterioration of the intervention when not followed or used in another setting (Activation of the Black Box Scenario)
- The need to continually develop & negotiate roles amongst actors (Concept of Interessement)
- The need to continually reinforce or make new connections within the networks (Concept of Punctualization)
- The need to mobilise actors and actants to make new supporting networks (Concept of Mobilization)
- The variables constructed and used were sufficient (Concept of Nomological Network)

- Translating professional learning ideas was ever-present & developmental (Concept of Translation as a process and outcome)

The emergence of the ANT-related themes indicated that ANT was a satisfactory working framework for developing the professional learning networks of teachers. ANT offered the researcher and teachers a way of intervening or interrupting education rather than simply being a different way of representing education (Fenwick & Edwards, 2010; 2012).

Through their work with the researcher, teachers had demonstrated that they were able to look at relational structures within their PLN to discern what was working and what wasn't, and use some strategies to fix any issues (Marrero-Guillamon; 2013). Sue, Jan and Meg had demonstrated that they had begun developing some of the relational analysis skills evident in ANT.

In Week 8 for example, Jan used the black box scenario to work out why a working memory task that she had set up for the main class, did not work with the small group. By implementing the same task to a table group in the main class, Jan discovered that she forgot to use or redesign some key scaffolds (worked examples) with the small group. When contacting the parents of her target student, Sue acted as a mediator and translator with the parents in successfully setting up some homework tasks around positive behaviour by herself. Even though it came near the end of the intervention, Meg checked with Sally the language and behaviours that she had been using with the target group. By using similar language and behaviours to Sally, Meg was starting to show a reasonable rapport with the target group.

iv. <u>The success of the intervention package.</u>

One of the key premises of the intervention package presented to teachers, was that "Math anxiety is a learned response, and, as such, it can be unlearned by exploring and understanding the causes that trigger it" (Mutodi & Ngirande, 2014, 293).

This premise demonstrated the educational value and importance of the intervention package. The eight to ten-week duration of the intervention package provided both researcher and teacher time to sufficiently affect a student cohort with positively valanced strategies.

A list of intentions s was compiled as a checklist to view and understand a greater scope and depth of improvement from both teacher and all students during teacher-researcher meetings:

List of Intentions

1. Improved overall student morale towards mathematics.
2. Improved overall student performance in mathematics.
3. Improved overall student participation in mathematics.
4. Mathematics lessons changed in format and setting.
5. The delivery of mathematics lessons changed.
6. Teacher confidence in mathematics improved.
7. Teacher awareness and knowledge of students struggling in mathematics (especially those with mathematical learning difficulties) improved.

Initial anecdotal results from teacher observation notes demonstrated that the positive affect of the intervention on the classroom teacher and students who experienced minimal, or no Mathematics Anxiety had a direct impact on those students who had Mathematics Anxiety.

The explicit use of positive affective measures (mindsets and priming) by the teacher in helping students to identify their own learning status in mathematics demonstrated its importance for all students. Students' self-reflective states and appraisal of themselves performing mathematics tasks were becoming better managed individually. The emotional capacity of students was adjusted to be better aligned to their cognitive capacity during mathematics lessons. Working memory checks provided students with a real-time marker in how well they were learning at the time. This realization helped students to better balance their appraisal of their affective state with their cognitive capacity in mathematics lessons. Students developed their affective vocabulary and reflective skills in the biblio-therapy tasks, and this in turn, improved their ability to express themselves better. The more-able students were early adopters of this practice. These students modelled and demonstrated their expressive skills through better questioning and discussion amongst themselves and the teacher. This increase of expressive communication had a flow-on effect to the rest of the class. All students demonstrated some level of improvement in expressive communication and awareness of their learning status in mathematics.

The above stated seven intentions allowed either the teacher or the researcher to work at a macro level with the class while the other focused on intense remediation with targeted students. All three teacher-settings demonstrated at least partial or reasonably strong positive

change in all seven intentions. Teachers used the intentions list to proactively progress to the stage of translation in their classrooms. The teachers recognised the overall student improvement in their classes, from the strategies that they employed and delivered in their classrooms. It was from this premise, that teachers started to acknowledge their own confidence and ability. The teachers appreciated the initial input of the researcher and were pleased with the classroom results.

Time, as already discussed, was a limitation of this study. Although Case Studies 1 and 2, demonstrated qualified translational success, Case Study 3 established that time was a determining factor of the study. When problems occurred, both researcher and teacher needed to return to earlier stages of the ANT framework, lowering the capacity for the teacher to get to the translational stage.

Some common development markers emerged between the professional learning journey of all three case studies. All three teachers were committed to observing and following the implementation of the intervention completed by the researcher and to establish the initial impact on their students. The positive affective measures implemented by the researcher with the classes had a lasting impact on the teachers, as they saw the gradual delineation of three student groups begin to emerge. In real-time, teachers observed their more abled students being able to quickly link their emotional state to their cognitive abilities through confident expressive verbal discourse with the researcher and each other. Interestingly, these particular students did not define the interplay of these two states to the level of written detail or depth as the other student groups in class. Students of average ability demonstrated greater written expression of their mathematical abilities, as they sometimes struggled in using mathematical notation or concepts in paraphrasing their thoughts. For these students, the interplay between emotional state and cognitive ability tended to have low positive or more negative appraisal.

Students, demonstrating difficulties with mathematics however, were far more disparate in their written expression than any other group. Some students wrote in detail what they could and couldn't do; other students focused more on their emotional views towards mathematics in a matter of a few words or a lot of words with no acknowledgement of their cognitive capacity. From these written results, teachers observed students' understanding between their emotional and cognitive states. As students began to express themselves better, whether verbally or written, the teacher felt more confident in helping students with their mathematics activities.

Over time, teachers began to see students better link and describe their affective state with their understanding of mathematics. As the students began to be better in writing and/or communicating issues or questions about their mathematics, the teachers saw the level of anxiety diminish in those affected students. The teachers began to communicate back to the researcher that class discussion in mathematics could actually alienate some of their students. Opening up the expression of mathematics in a variety of ways, allowed students greater capacity and less tension in communicating their views and experiences in mathematics. Through the observation of researcher-led lessons, teachers saw how easy it was to implement the strategies of the intervention, and start to introduce some of their own interpretations to the strategies used. This increased activity demonstrated increased confidence and motivation of teachers to become more involved in the implementation process. This demonstrated that the teachers expected the specialist/researcher to have confidence and success in his delivery of strategies and purported outcomes, before agreeing to progress further themselves.

III. Limitations of the Study

Time is a clear limiting factor of the study. Time and teacher commitments were often inhibitors resulting in insufficient depth of discussion about issues arising from the professional learning, so changes sometimes had to be made to come to a compromise between researcher and teacher. Teacher commitments were a factor the researcher simply had to adjust to, to ensure the reliability of the working relationship between teacher and researcher. The researcher had no control over existing teacher commitments like pre-planned excursions and meetings, so if lessons could not be moved, lessons had to be postponed to the following week. Consequently, in discussion of results from previous chapters, occasionally there were some omissions of data from weekly lessons. The balance of work to the study's objectives and to classroom lessons in general, was a key limitation for teachers. A clear example of this was the initial focus on multiple student targets within a class cohort. All three teachers found this task highly work intense and time-consuming.

The size of the study limited the capacity to make any clear connections across the three case studies or make valid generalisations that could be necessarily applied to other potential classroom settings. Among only three case studies there were clear differences among the settings and teaching styles and practices of each teacher. The capacity of the researcher to

compromise and be flexible to teacher needs helped preserve the specificity of these individual settings, rather than develop a greater convergence between the three case studies.

The three case studies demonstrated that the theoretical framework of ANT (Actor Network Theory) worked reasonably well with this sample size. The researcher cannot ascertain whether a larger sample size may put more pressure onto the theoretical framework of ANT.

When there were matters crossing all three case studies, the researcher needed to make the necessary conversation and intervention with the teachers. This is illustrated by the fact that all teachers compromised with the researcher to transition from multiple target students to the emergence of single micro-ethnographic case studies within each class cohort. This situation demonstrated that there was obviously strong communication and review protocols in place.

A lack of previous studies and research into this type of extended dyadic professional learning, influenced the design and scope of the investigation objectives. This study encompassed a broad ranging objective in identifying a scope of potential indicators of impact on teachers' knowledge and pedagogy. From the outcomes of this study, future research can now better define and limit this spread of possible and emergent indicators. This would allow for the efficiency of smaller case studies and/or more targeted questioning, enabling potential generalisations to occur.

There is the possibility that the large qualitative spread of self-reported data from the teachers could be skewed or biased to the self-fulfilling need of ensuring that there is professional learning improvement. Even though all meetings between researcher and teachers were open to the need of potential problems and developing their solutions, we cannot truly account the full disclosure by either party.

IV. Developing effectives practices from the theory of the investigation.

Teachers participated in developing, modifying, and adapting well-informed ideas that they learnt into practices that they could regularly use in the classroom. For example, Jan (Case Study 1) made the idea of the reflective diary in mathematics as a regular homework activity. She did not write anything in the diaries but would quickly peruse them to check up on any difficulties or misinterpretations in mathematical concepts that students may have

Sue (Case Study 2) decided to use the idea of reflective diary in her classroom subjects of Science and Social Studies, for students to further develop and present their understandings and personal views. In Science especially, Sue found the diaries useful in highlighting incorrect interpretations of scientific concepts that she could later correct.

Meg (Case Study 3) was very interested in recognising similar language and understandings of student groups in her class, from the diary/journal entries that they submitted to her. Meg used this data to better stream her class into groups of similar conceptual understanding.

These examples highlight that the teacher-participants were largely self-motivated, knew their educational needs, and voluntarily decided to learn something new. These attributes can fall under the banner of self-regulated learning (SRL) (Andrade, 2010; Immordino-Yang, 2016; Ontai, 2021) but requires that the significant other (the researcher) is responsible to help overcome potential emotional slips like fear of failure or misunderstanding. Like the area of intervention being studied, Mathematics Anxiety, the teacher-participants are exposed to the fact that an emotional connection to the learning can help enhances cognition, long-term memory, and deep reflective learning (Taylor & Marienau, 2016; Immordino Yang, 2016; Whitman & Kelleher, 2016).

All three teacher-participants were part of a dyadic professional learning format with a significant other – the researcher. The researcher was not only responsible for the organisation and delivery of learning, but in fostering and building the personal and emotional aspects of the dyadic relationship between researcher and teacher.

The framework devised in this investigation assists in moderating the two ontological views within the key dyadic relationship. One view is that of a regular classroom teacher, while the other is that of an outside specialist with an educational background. However, both actors have shared objectives and outcomes which helps to synthesise the language and discussion of ideas used. The knowledge itself is transformed, as concepts raised by the researcher are presented and subsequently revised and interpreted for the teachers to understand and utilise. This is demonstrated in the research literature list that all teachers read. A glossary of forty words (Appendix G) was created to reflect on the words and concepts shared and discussed by both the researcher and the teachers. Interestingly, all three teachers demonstrated a commonality in the words least used and the words that they continually referred to in the learning, indicating an ontological divide between teacher and researcher.

This emerged from a different initial use of the word lists. The division of words into high, moderate and low-use categories were initially used as an individual teaching and learning point by the researcher for each teacher. The researcher used these categories to help teach key concepts about ANT, and saw the low usage of some key words as potential lack or difficulty of understanding, on part of the teacher. However, over time, the researcher saw a correlation of words used across the case-studies, as a sign of language relevance by the teachers.

Over twenty concepts were regularly used by both the researcher and the teachers in their discourse with each other. Key examples included the high incidence and use of the words 'network', 'mobilization', 'translation', 'biblio-therapy', 'working memory checks', 'positive priming' and 'actors' between the researchers.

Words that were regularly used by the researcher, but not appreciated or used as much by the teachers included 'interessement' and 'obligatory point of passage'. As demonstrated in Table 7.1 on the following page, this vocabulary helps demonstrates the ontological difference between researcher and teachers. Words that did not have any real sense of practical meaning to the teachers, were not used or were cast aside.

However, the success of the professional learning can also be reflected in the selection of words that the teachers regularly sought clarification of meaning from the researcher for their own specific setting. This demonstrated the teachers' successful practice in actively bridging this ontological divide. In comparison to the other two groups of words, this group of words and concepts were moderately used, but were a continual point of learning that the teachers wanted to truly comprehend.

Incidence	Concepts/Vocabulary		Actors
High	Mathematics Anxiety	Mindsets	Researcher
	Professional Learning	Actors	Teachers
	Learning Sciences	Artefacts	
	Network	Mentor	
	Mobilization	Coach	
	Biblio-Therapy	Cognitive	
	Working Memory Checks	Neuro-myth	
	Positive Priming	Relational	
	Self-Reflexivity	Intervention	
	Learning Disability	Learning Difficulty	
	Developmental	(N:21)	
Moderate	ANT (Actor Network Theory)	Actants	Researcher
	Authentic Learning	Black Box Scenario	Teachers
	Cognitive Load	Facilitator	
	Dyadic	Punctualization	
	Affective Vocabulary	Miller's Memory Load	
	Intermediary	Stereotype Threat	
	Structural Integrity	Problemisation	
		(N:14)	
Low	Interessement	Obligatory Point of Passage	Researcher
	Enrolment	Delegate / Mediator	Teachers
	Nomological	(N:5)	

Table 7.1 Language Concepts Used by Researcher and Teachers

Success can also be seen by the construction of new vocabulary or concepts to help bridge the understanding between the researcher and the teachers. These words were jointly constructed and used by both actors:

- Professional Learning Network
- Professional Learning Journey
- Student Reflection Entry/Journal

These constructions demonstrate a degree of development of the researcher into the role of intermediary espoused by Howard-Jones (2010) and Zadina (2015), bridging two disciplines closer together, and making the theory and practice between the two, more congruent.

The developing discourse between the researcher and the teachers was paramount to the success of the professional learning. Success of the intervention was reliant on the researcher becoming part of the classroom. The shared experiences combined with the meetings prior and after the lessons were agreed by all teachers as the most important aspects of their professional learning. Email and SMS communication outside of this was a secondary supplemental support. The reading, although viewed as important from the teachers' perspective was also a secondary aspect. Interpretations were always tabled at the meetings where they were corrected or clarified by the researcher.

All three teachers believed that the success of their professional learning hinged greatly on the timeframe of the intervention and the constant face to face contact with the researcher. They all provided feedback specific to their own contexts, but all teachers indicated that increased time would have been appreciated. They all agreed that the time they had with the researcher, was one of the best professional learning formats that they had experienced.

V. Recommendations

The study demonstrated that through three case studies, that there was a significant degree of success in inviting outside educational professionals into a dyadic professional learning format in classrooms. Teachers' knowledge developed well in terms of depth about the issue of Mathematics Anxiety from the researcher. Teachers' had the opportunity to trial this knowledge in their classroom setting, with assistance and feedback from the researcher. All three teachers in the case studies made changes within their classroom environment and pedagogy, to allow the new practices to eventuate and strengthen. The three teachers all believed that the professional learning framework provided allowed this to happen. Although they all wished the time-frame to be longer, they believed that it was sufficient enough in allowing them to learn.

The following recommendations not only come from teacher experiences and the subject matter, but also features of the ANT-influenced professional learning framework.

Recommendations come from the value of an outside educational professional and how the strategies of the intervention program influenced the professional learning itself.

- The attribute of time is an important aspect of any professional learning format. The convenience of this study was that it was not viewed as a constraint. Instead, time became a constant in how it could best be used between all actors within a particular professional learning network. The capacity of all actors to talk about time as an ever-present feature allowed organisation and collaboration to be better constructed. With this feature promptly addressed, all the main actors could subsequently focus more on the greater importance of the professional learning topic. Therefore, it is recommended that in any professional learning context, time is raised as a constant concern, in constructing the parameters of the professional learning to achieve the agreed learning objectives.

- Some of the research literature behind the intervention strategies, in particular the affective neuroscience and interpersonal psychology that affirmed the significant connection between emotion and learning, in turn had an important effect on the developing relationship between teacher and researcher. All adult participants agreed that the strong emotional and professional connection enabled the success of the professional learning. This is an area that is proposed for educational researchers to do further enquiry into, especially from the research accomplished at the child learner to teacher level. Consequently, face to face learning among the participants and the researcher was paramount to the success of the investigation. There were other modes of learning experienced throughout, but they needed to be directed from the discourse between researcher and participant. All the teacher participants believed that building a rapport and understanding with the person coming into their classroom was key to how the professional learning would work. Face to face learning is therefore recommended as a key attribute of successful professional learning.

- Mathematics Anxiety, demonstrated that as an educational issue that requires in-depth discussion, learning and trialling of various pedagogies can work quite well under a dyadic professional learning structure. The constant dyadic relationship between researcher and teacher ensured the persistent flow of knowledge, feedback and clarification between the two actors, allowing for strong authentic learning to occur. As a result of this, it is recommended that educational issues that requires a lot of

collaboration and development, be taken up by dyadic professional learning structures that can cater for this intensity.

- The researcher was invited into the teachers' classrooms. Even though the topic of professional learning was advertised to Principals of school sites, teachers did not feel compelled to take on the learning. Potential candidates had the opportunity to meet with the researcher and take some responsibility of the professional learning. This ownership allowed the participating teachers to outline key learning objectives and play a key part in the learning design of their professional learning network (PLN). As the teacher experiences their professional learning, the dyadic relationship between trainer and teacher also begins to develop and mature. It is imperative that both participants use the processes of constant review, reflection, and feedback to maintain the correct trajectory of the professional learning and make any necessary adaptations.

- The regular presence of the researcher within the teachers' classrooms allowed for the outsider to have a significant influence on the student cohort and classroom environment. Change was being constructed in real-time and all actors were witnessing this and adapting to this. Although the intervention was designed to be around eight to ten weeks, it is recommended that this is decided on between the two main actors. All participating teachers felt that a whole term or ten weeks may have been a better option for them.

- As a result of the timeframe of the intervention, a degree of reverse mentoring began to occur in later weeks. The growing confidence and skills of teachers in implementing the intervention strategies led to some interesting emergent variations of how the strategies could be employed. This led to the researcher learning from the knowledge and skill base of the participant teachers. The researcher began to alter delivery because of existing effective practices demonstrated by the teachers in class. This reciprocal effect helped strengthen the relationship between the researcher and teacher-participant. The time to experience a classroom environment in depth allows the outsider to adapt as well. This allows the beginnings of new collaborative language and practices to emerge. A longer timespan in the classes by the researcher may have resulted in more changes as the two main actors' relationship further developed.

- Having an outside professional come into a classroom highlights a more specialised and an even larger expanse of potential learning for teachers. When a teacher mentors another teacher, the expanse for learning becomes constrained not only in terms of similar knowledge and practice, but also in terms of similar perspective. To greater improve the skill sets of teachers, they need to be exposed to the wide range of professionals that may work within the space of education. It is therefore recommended that through the work of site and district educational leaders, that they link school teachers to approved related service professionals in education for potential professional learning opportunities.

- The outside intermediary however, that comes into the classroom needs to have a reasonable understanding of pedagogical practices. Zadina (2015) correctly points out that the intermediary needs to have education as a bridge between their discipline and that of the classroom teacher. This background is to enable the intermediary to find commonality with the teacher and subsequently build a professional learning relationship upon this. There will be differences between the two actors in terms of perspective and capacity to learn. It is essential that the intermediary is aware of these differences and helps the teacher ascertain what they want to learn. From this premise, the intermediary needs to continually be aware of the teachers' capacity to learn this new information.

- This investigation has demonstrated that using a diversity of dyadic formats of professional learning (e.g. supervising, mentoring, co-teaching among others) within classroom learning can be more impactful on the potential, immediate or changing needs of teachers, especially in a long-term structure. Therefore, teachers need to start viewing professional learning from another professional within a classroom environment, in a more encompassing modulating form. Teachers need to see that as a result of changing classroom settings, spontaneous and emergent events that can occur, that professional learning in education is rarely linear or predictable within the classroom. Furthermore, teachers need to better aware of the two pathways in educational professional development. One looking at the professional requirements in education is highly directed with clearly expected outcomes. The other, demonstrated within this investigation, provides the potential for greater depth and breadth of professional learning for teachers.

- A structure however, encompassing all dyadic formats of professional learning is required for formation and direction. Actor Network Theory (ANT) has demonstrated itself to be a reasonable template for an intermediary and teacher to jointly establish a professional learning network (PLN). ANT in its post 1999 form has shown that it has the theoretical foundations to address some of the potential difficulties that can occur between actors and actants within an education-based network. This study, has demonstrated that ANT can work well in educational professional learning, an area that ANT researchers have done very little work in. It is suggested that elements of review and feedback are important features to consider in future research of this area.

VI. Conclusion

The purpose of this study was to investigate the use of a specific style of professional learning framework for issues that may require in-depth and complex learning for teachers, over a significant length of time. Mathematics Anxiety was the educational issue used in this study due its highly involved scientific and social features.

Through its research question, this study examined the use and value of a dyadic professional learning framework for teachers with an educational specialist that worked with them. The introduction of an educational specialist into a classroom, over an amount of time, demonstrated significant impact on teachers' knowledge and pedagogy, as shown by results in this study.

The initial changes that occurred, were observed, and shared at the classroom level. Aspects like lay-out, student groupings, with length and intensity of activities were all consolidated and agreed upon by both teacher and researcher. Students also played a minor part in this, in the outcomes and immediate feedback of activities given, providing assurance of the changes being made over the course of the intervention.

This made the changes more worthwhile and intrinsic between teacher and researcher. The collaborative relationship allowed for measured assured change determined by the continual growth and confidence of the individual teacher. The professional learning became more authentic (Webster-Wright, 2009; 2010) as practices implemented led not only to changes in pedagogical approach and understanding for the teacher, but also observed improvements in student learning and outcomes. Consequently, the relationship between teacher and

researcher was pivotal to the success of the teacher's professional learning within the theoretical framework used. The use of ANT (Actor Network Theory) provided the researcher with the mechanisms to build up and repair any aspects of the PLN (professional learning network) for the three teachers involved.

The three case studies demonstrated that the professional learning journey of a teacher can be highly idiosyncratic. The pathways of teachers were therefore investigated individually and internally using an inductive phronesis approach. Aspects like frame of mind, knowledge levels, pedagogical confidence, adaptation and relationship-building all helped determine the internal workings and potential success of a teacher undergoing professional learning. Consistency across the case studies came from the steady support and structure provided by the researcher with the use of ANT.

Recommendations outlined within this chapter, have demonstrated a diverse array of subject matter that will need further investigation and clarification. The recommendations pose scenarios which will not only help improve professional learning in general terms for teachers, but also further develop the array and diversity of professional learning approaches available for teachers. This study has provided key suggestions that can further develop dyadic professional learning over a length of time, and improve the professional learning outcomes for teachers.

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Appendix A

Learning Behaviours Checklist

Behaviours	STUDENT A	STUDENT B	STUDENT C	STUDENT D
Showing positive non-verbals				
(head up/ smiling /eye-tracking)				
Showing negative non-verbals				
(head down/eyes-down)				
Putting hand up to ask question or interject.				
Providing verbal answer with little confidence (few words/compliant manner)				
Providing verbal answer with greater confidence. (more words than normal/willing manner)				
Speaking with at least 3 negative words a lesson.				
Speaking with at least 6 negative words a lesson.				
Speaking with at least 3 positive words a lesson.				
Speaking with at least 6 positive words a lesson.				
Not compliant to show work to another student or adult.				
Compliant to show work to another student or adult.				
Willing to show work to another student or adult.				

Appendix B

Observation Guide / Checklist

Observation	COMPLETION	Descriptive Notes	Reflective Notes
LESSON FOCUS: Evaluating the AREA of a house/building.	Ongoing	ANNA* pointed out to me that AREA was a key curriculum area of the AC (Australian Curriculum) that the class needed to do this term.	Having a 4-week project in designing a house was a great summative task put together by ANNA* to see how students could extend themselves.
Activities: Affective Feedback	√	ANNA* passed out an affective word-a-find for students to complete within 5min.	Students completed an affective word-a-find without any difficulty this week (Week 3)
Activities: Area of a Triangle (Formula / Examples) SHEET work	√	All students managed to follow the formula for working out the area of a triangle. Target students required scaffolds but accomplished this quite well.	This activity proved successful with the extra sheet with scaffolds for the 5 students that required help. ANNA* worked well with these students.
Activities: Working Memory	√	ANNA* presented a working memory activity based on four numbers and then asking 3? s about the set.	ANNA* managed to do this activity this week without any help from the researcher.
Activities: Portfolio – continue working on 'dream house' dimensions	To be continued	This is an on-going activity that requires homework as well as lesson work. Should take students 2-3 weeks to complete. Most students understand what to do except the targeted 5.	2 of the 5 students need to be reminded to ask for help rather than sitting back waiting for help to come.
Activities: Student Feedback	√ (most completed)	This is an on-going activity that requires all students to participate on how they believe that they went in the lesson.	2 of the 5 students continue to not want to do this element, but it is good to see the other 3 do it without any fuss.
AFFECTIVE DOMAIN Did the adult appeal to the affective needs	80% (20/25 students)	ANNA* presented affective task well with no help. She had a calm but decisive tone, and all	It is good to see ANNA* moving around class amongst groups making eye

to the majority of students? State %		students seemed to understand ANNA* quite well, and were happy to put their hands up to ask questions.	contact. She made sure that while some students quickly went onto cognitive task, she allowed all to finish affective task.
COGNITIVE DOMAIN Did the adult meet the learning needs of students? State %	88% (22/25 students)	ANNA* reminded every student to ask for help (ask a classmate first, ask teacher, ask researcher). ANNA* reviewed herself well with worked examples on whiteboard and asking key questions to tables rather than just to individual students.	This practice is getting better from last week. Although some of the targeted students did not want to interact with researcher, they are speaking more to class-mates at group table.
STUDENT BEHAVIOUR	√	Most students followed rules of classroom quite well and did not seem confused or frustrated by presence of researcher.	2 students did not seem too keen to interact today but did not disrupt others. These 2 were quite passive.
Followed INTERVENTION	√	ANNA* followed intervention procedure quite well this week.	Need to speak to teacher that there was too much time spent on working memory task.
CONFIDENCE of Teacher/Researcher	√	ANNA's* demonstrate good control of the lesson structure & overall behaviour in class. She encouraged students at tables to help each other in answering group questions.	It is good to see that the teacher seems more confident in what to do with the intervention. This is reflected in the overall behaviour of the students.

Appendix C

Mathematics Anxiety Awareness Questionnaire

Mathematics Anxiety Awareness Questionnaire

Participant Code _____

Participant School Site _____

PARTICIPANT Background

1. How long have you been teaching? *CIRCLE ONE of the following*

- under 2 years
- 2-5 years
- 5-10 years
- over 10 years

2. Do you teach mathematics? Yes or No

If No do you wish to teach mathematics? Yes or No

If Yes is mathematics your specialised area? Yes or No

3. Describe your personal attitudes towards mathematics.

CIRCLE ONE of the following statements:

I thoroughly enjoy using mathematics.

I am fine with mathematics.

I do not enjoy mathematics.

Explain the reasons for your choice:

4. Ascertain your level of confidence in teaching mathematics.

Low Confidence		Moderate		High
1	2	3	4	5

Please explain.

5. What are your reasons in becoming part of this professional learning investigation?

TOPIC questions

6. Are you aware of or have you heard of mathematics anxiety? Yes or No

If Yes, answer the following:

a) Where did you learn about Mathematics Anxiety?

b) What is your understanding of Mathematics Anxiety? (describe your perception of this-or what does this look like in terms of knowledge).

c) What do you think Mathematics Anxiety might look like in your classroom?

7. Is Mathematics Anxiety a discussion topic among your colleagues? Yes or No

a) If Yes, why do you think it is?

b) If No, why do you think this is not?

8. Have you had any professional development /learning related to Mathematics Anxiety?

Yes or No

a) If Yes, please explain

9. Do you believe that you have some students with Mathematics Anxiety?

Yes or No

If Yes:

a) How many? Male: Female:

b) How did you identify them?

c) How does this impact their learning?

How do you identify this? – what problems may this cause

10. How do you address Mathematics Anxiety in your classroom?

11. Do you use resources to assist in addressing Mathematics Anxiety? Yes or No

If Yes,

What kinds of resources do you find helpful for alleviating Mathematics Anxiety?

in your mathematics program?

12. Do you believe that you may suffer Mathematics Anxiety to some degree? Yes or No

a) If Yes, please circle your perceived level.

Low		Moderate		High
1	2	3	4	5

b) How have you managed your Mathematics Anxiety?

13. Do you have any further comments/information about your experiences with mathematics anxiety?

Appendix D

Final Mathematics Anxiety Questionnaire

Final Mathematics Anxiety Questionnaire

Participant Code _____

Participant School Site _____

PARTICIPANT Attitudes

1. Describe your resulting personal attitudes towards mathematics.

CIRCLE ONE of the following statements:

I thoroughly enjoy using mathematics.

I am fine with mathematics.

I do not enjoy mathematics.

Explain the reasons for your choice:

2. Ascertain your level of confidence in teaching mathematics.

Low Confidence		Moderate		High
1	2	3	4	5

Please explain.

3. Did your reasons in becoming part of this professional learning change at any point during this investigation?

4. Describe your personal attitudes towards your working relationship with the researcher.

CIRCLE ONE of the following statements:

I thoroughly enjoyed my time with the researcher.

I am satisfied with my time spent with the researcher.

I did not enjoy my time spent with the researcher.

Explain the reasons for your choice:

5. Over the course of the investigation determine how much you got in terms of quality professional learning?

Low Quality		Moderate Quality		High Quality
1	2	3	4	5

Please explain.

6. Over the course of the investigation determine whether you had sufficient time to understand the basis of the professional learning presented and put into place some of the key recommendations suggested by the researcher?

Unsatisfactory		Satisfactory		Highly Satisfactory
1	2	3	4	5

Please explain.

TOPIC questions

7. Have your views of Mathematics Anxiety changed because of this professional learning?

Yes or No

If Yes, answer the following:

a) Where did these changes about Mathematics Anxiety come from?

b) What is your understanding of Mathematics Anxiety now? *(describe your perception of this – or what does this look like in terms of knowledge)*

What do you think Mathematics Anxiety might look like now in your classroom in comparison to your original views?

8. Is Mathematics Anxiety a discussion topic that you can now confidently talk about with your colleagues? Yes or No

a) If Yes, why do you think it is?

b) If No, why do you think this is not?

9. Did you do any further professional development /learning related to Mathematics Anxiety while being part of the investigation?

Yes or No

a) If Yes, please explain.

10. Do you now believe that you have some students with Mathematics Anxiety?

Yes or No

If Yes:

a) How many? Male: Female:

b) How did you identify them?

c) How does this impact their learning?

How do you identify this? – what problems may this cause

11. How would you now address Mathematics Anxiety in your classroom because of your professional learning?

12. Do you now believe that you may suffer mathematics anxiety to some degree? Yes or No

If Yes,

a) Please circle your perceived level.

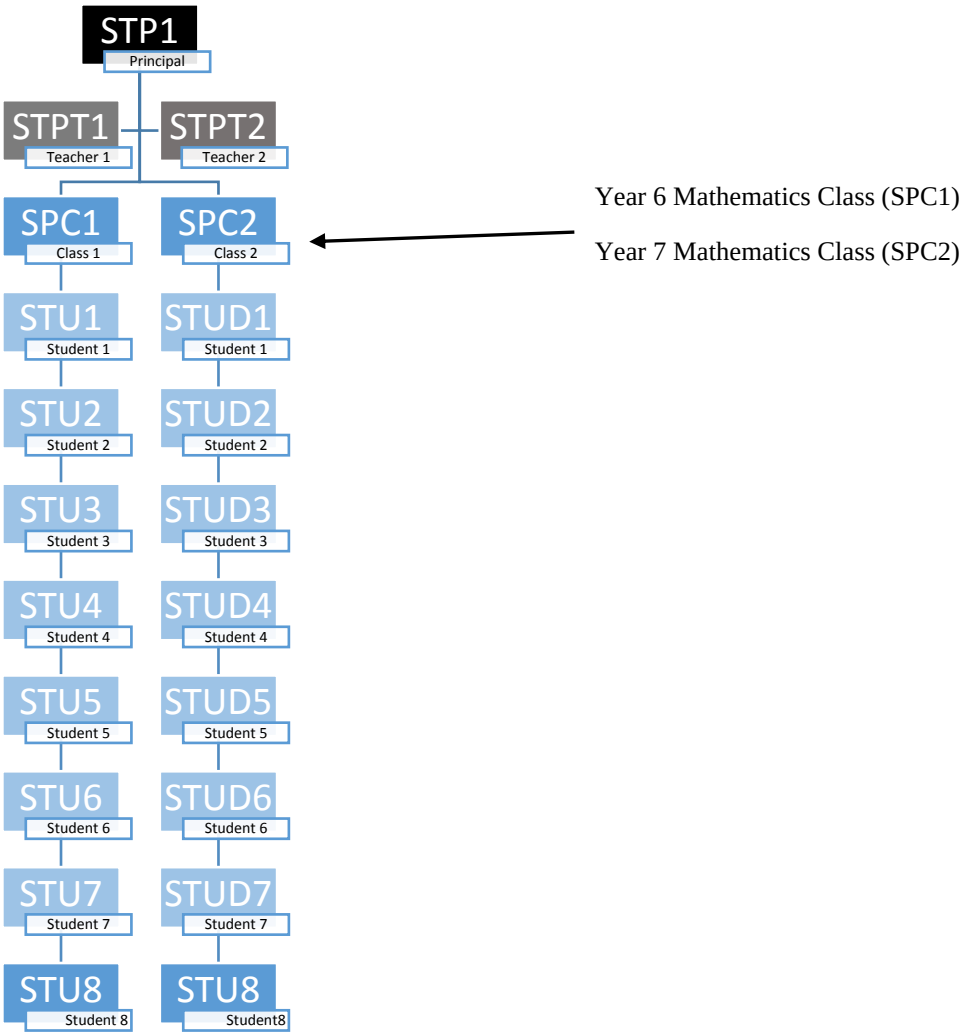
Low		Moderate		High
1	2	3	4	5

b) How have you managed your mathematics anxiety?

13. Do you have any further comments/information about your experiences with the mathematics anxiety professional learning?

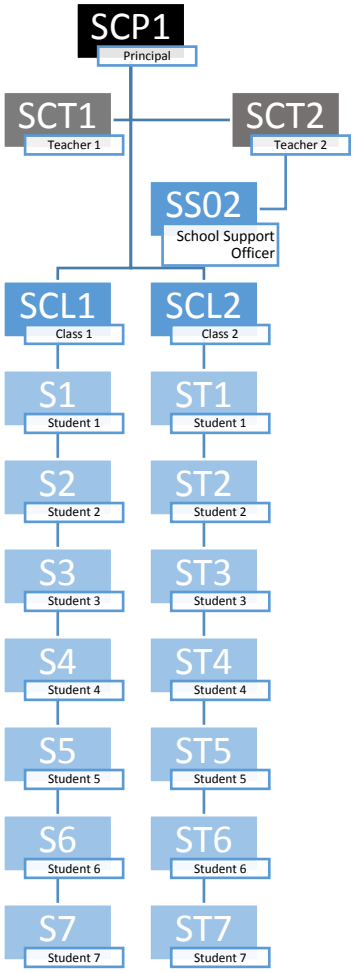
Appendix E

Participant Coding: School Site ONE



Appendix F

Participant Coding: School Site TWO



Year 8 Mathematics Classes

Appendix G

Key Concept / Vocabulary Glossary

Actant	A non-human actor.
Actor	A person/entity that is bound is by the actions and behaviours that s/he regularly performs within a network structure.
Actor Network Theory	It is a both a framework and sensibility as to how to view agreed components (infrastructure) and their relationships with each other.
Affective Vocabulary	In this study, students build up and expand their affective vocabulary list of emotional words and descriptions to better recognise and address their own emotional state. Can be synonymous with emotional vocabulary. However, affective can refer to relating to, resulting from, or influenced by the emotions of an individual.
Artefact	An object of technology of past or current importance in developing the network. The language around the artefact comes from the actors that engineered its importance to the network. e.g., a seatbelt is an artefact of automotive engineers' prescribed safety for drivers.
Authentic Learning	"Professionals learn in a way that shapes their practice, from a wide range of activities from formal PD programs, through interaction with work colleagues, to experiences outside work, in differing combinations, and permutations of experiences" (Webster-Wright, 2009, p.705).
Biblio-therapy	A therapeutic technique that involves story-telling or reading of specific texts for physical healing and mental recovery purposes. In the study, it is used primarily in terms of education and mental recovery – knowledge and understanding from texts helps students connect better with their emotional states with self-awareness and develop their emotional vocabulary.
Black Box Scenario	The black box scenario can be described as a metaphor that can contain or represent a complex category within a network. When taken out of a network, it can demonstrate what worked or didn't work within that particular network.
Coach	An expert within a field that supervises an individual to improve their capabilities with developed tasks.
Cognitive	The capacity of the mind to recognize being and perform thinking processes.
Cognitive Load	The working memory and functional capacity of the mind, at any given time, to perform a cognitive activity.
Delegate	Delegates are actors who 'stand in and speak for' viewpoints inscribed in them. For example, Principals are delegates for the school site.

Developmental	A key theme of this study, that refers directly to how actors and components within a network grow and cement their relationships with each other.
Dyadic	The relationship between a group of two people.
Enrolment	A process in Actor Network Theory, which allows a key actor to attract actors and actants that can function within a network.
Facilitator	A person, who has highly developed skills and knowledge about the relationships and mechanics of a specific group or setting. With this capacity, the facilitator can therefore, help initiate and influence the actions and perspectives of people within that group.
Interessement	Is a stage in Actor Network Theory where activities that encourage cooperation between key actors so that an agreed Obligatory Point of Passage can develop.
Intermediary	An entity that helps control and disseminate the language within a network. Unlike a mediator, they have very little impact on a network.
Intervention	(in relation to use in study) The set of strategies and pedagogical approach to influence cognitively and affectively, students behaviour and performance in mathematics activities.
Learning Difficulty	Difficulties in learning that are a result of specific causes, like emotional, educational, or environmental factors. Learning Difficulties are generally viewed as responsive to educational interventions and are not considered to be life-long conditions.
Learning Disability	A learning condition that emerges in childhood from physical, sensory, and neurological causes that are far less responsive to educational interventions. A learning disability is viewed as a prolonged condition.
Learning Sciences	An interdisciplinary field that gathers and uses knowledge and research from a variety of disciplines to understanding and improve the ideas of instruction and learning. These disciplines can include, but is not limited to, applied linguistics, educational psychology, cognitive science, educational neuroscience, and computer science.
Mathematics Anxiety	A pre-dispositional emotional state that can impair the capacity to perform mathematics tasks.
Mediator	An entity that can influence and multiply difference within a network. The output of a mediator entity cannot be predicted of its input. The distinction between intermediaries and mediators is key to ANT sociology.
Mentor	A highly experienced and knowledgeable person within a field who advises and develops an individual on a relationship level.
Miller's Memory Load	In one of psychology's most cited papers (1956), Miller suggests that memory capacity is not constant and tends to fall in the range of 5+/-2 depending on what the elements are.

Mindset	A strategy used within this study, that is reinforced externally by the classroom teacher. The concept of Mindsets are an internal intervention where the students use and develop positive ideas and vocabulary provided by the teacher to personalize their own positive sensibility.
Mobilization	A later stage in ANT, where innate processes and conventions of a built network are used to build other like-minded networks. Mobilization is essentially restricted by the design and purpose of its actors. In a professional learning network for example, conventions like confidentiality, code of conduct would govern potential actions, as well as its objective to ensure that teachers learn.
Network	A set of actors, actants, and artefacts that are bound together by the actions, behaviours and relationships within this structure.
Neuro-myths	Unsubstantiated accounts by sections of society explaining how the brain works and matures over time.
Nomological network	A nomological network is a visual representation of the constructs of interest within a study, demonstrating the way it looks like and the relationships between all constructs.
Obligatory Point of Passage	It is the agreed point of access into a specified network that shapes and mobilises the actions of actors.
Positive Priming	A strategy used within this study, that is implemented solely by the teachers to positively influence the learning environment of students. It is an external intervention where the teacher uses positive language, behavioural and environmental cues to impact learning. In this study however, it includes explicit (signposting) and implicit (subliminal priming) cues. Explicit cues are not normally associated with priming techniques.
Problemisation	Is a stage in Actor Network Theory where a focal actor identifies a problem in their network situation, in relation to other actors and actants within the network.
Professional Learning	The process by which the participants of a particular profession (i.e., teachers) seek to evaluate and improve their capacities and practice by developing their knowledge and skill base.
Punctualisation	It is a similar process to the black box scenario, where parts are isolated and analysed from the rest of the original network for investigation. Unlike the black box scenario however, punctualisation allows the investigator to intently black box a whole complex network, component, process as a node within another network, to see if it is potentially transferable or operational at a micro-level.
Relational	A key theme of this study and of Actor Network Theory, that refers directly to how actors and components act and respond to each other.
Self-Reflexivity	A reflective process used by teachers, outside of lessons and contact with the researcher, to contemplate and write down what they got out of their lessons and meetings with the researcher.

Stereotype Threat	A potential situation where participants succumb to conforming to stereotypes about their social group. For example, girls do not think that they are good at mathematics in comparison to boys, so their behaviour reinforces this notion.
Structural Integrity	Is the ability of a structure (i.e. the network) to withstand its intended loading without fracturing or deteriorating from outside forces.
Token	An object that gains importance from its transactional value and movement between agents and actants.
Translation	Is viewed as an act of invention developed and shared by common actors and actants to, in turn, successfully operate. ANT revolves around the idea of *'sociology of translation'* where all actors of a network have the authority to understand all its components and relations and how it can be used in similar settings. (Latour & Callon, 1981)
Working Memory Checks	A strategy used within this study, that is implemented by teachers as activities throughout a lesson, to help students evaluate their own performance alongside their own affective well-being.