Subjectivity and Educational Interventions to support the development of Mathematical Resilience: a study carried out at a girls' school.

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Declaration of Inclusion material

The pilot study referred to in Chapter 3 formed the basis of a conference presentation referenced herein as Nyama (2016)

I declare that this thesis is my work, and I have not submitted it for a degree at another university.

Abstract

Poor mathematics performance is a big issue in the UK, attributed to systemic failure (Boaler, 1997). The UK mathematics education landscape has recently increased focus on equipping students with skills for 'solving problems in a variety of contexts, increasing sophistication and breaking down problems into a series of simpler steps to support resilient working' (GOV.UK, n.d.). At the same time, anxiety in mathematics lessons is prevalent. This thesis explores the construct of mathematical resilience as one of the vehicles that could both deliver the UK government's goal and enable students to manage their learning of mathematics safely. This thesis draws together two significant research areas, Q-Methodology and its *subjectivity* attribute and Interventions, to highlight the role of subjectivity in intervention programmes. The association between subjectivity and intervention has been lacking in mathematical resilience intervention literature so far. I used Q-Methodology to draw out students' subjective views of themselves and their learning journey. I then used these personal views to select intervention candidates who might not be mathematically resilient. I also used these views to understand, and design, intervention strategies that I deemed could support the development of mathematical resilience in students by addressing 'unhelpful' subjective beliefs. Q-Methodology revealed several distinct views that I considered symptomatic of non-resilience. Subjectivity (personal viewpoint of own learning capabilities) also emerged as a key and advantageous (but often overlooked) selection criterion for intervention candidates. This study provides some useful insights, particularly into how educators might be more sensitive to students' needs across all achievement backgrounds by taking the subjectivity approach described in this study and how learners interact with some of the proposed interventions. It also highlights how students pay attention to their relationship with mathematics in ways that might help them become more resilient. It offers a fresh insight into 'students' views' in this field.

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Keywords: Q-Methodology, intervention, mathematical resilience, students' views.

Chapter 1 – Introduction

1.1 Purpose of this study

Since coming to the UK from Zimbabwe in 1999 and working in English secondary schools as a teacher of mathematics since 2006, I observed the expectation that many thousands of students in schools cope with challenging academic demands within the English education system. In recognition of these demands, there has been a considerable increase in research and literature around how students manage and cope with their learning (Sotardi, 2017) and suggestions for supporting students in achieving positive responses and adaptations (academic resilience) to challenges they face (Martin et al., 2013). This body of research has also shown that learners in some subjects develop domain-specific anxieties and maths is one of these subjects (Daker et al., 2019; Goetz et al., 2006). Being a mathematics teacher, I became interested in exploring the construct of maths-domain anxieties.

I was interested in approaching this construct from the students' standpoint. Therefore, I began by eliciting students' views and interpretations of their learning based on literature (Bandura - Self-Efficacy, Dweck - Self Theories). This literature indicates that the views and interpretations students hold about themselves play a crucial part in how they participate in and engage with their learning. I then researched, selected and utilized intervention strategies that the literature suggests might help students learn successfully during situations perceived as challenging or threatening. Conclusions drawn from this study will inform my practice and provide suggestions of what other teachers might do to support students' development of their mathematical resilience. As a teacher of maths, students' resilience has become a high priority for me because of the reasons outlined in the next sections.

1.2 Personal Interest

My experience as a student and teacher in Zimbabwe was utterly different from what I observed in English schools. This experience had not prepared me to realise just the sheer number of 'subjects' English students were required to cope with schools. The literature review I undertook suggests that mathematics has historically been viewed as having an inherent special challenge. It is readily acceptable in Western society to say, 'I am not good at mathematics' or 'I am not a mathematics person'. This utterance quickly became something that I heard more prevalently in England than I had ever experienced before coming to England. It was almost taboo to vocalize that you were not good at mathematics in my country. You would bring shame not only to yourself but your family, resulting in stigmatization and name-calling. So, my interest was derived partly from my experiences working in mathematics classrooms in England and just trying to understand the mindset that encourages the thinking and the open vocalization of being 'not good at maths'. With my interest reinforced, I began to read more extensively about attitudes to mathematics learning and interventions that I could use to support students' positive attitudes to mathematics learning. In my reading, I came across an article written by Johnston-Wilder and Lee (2010) that introduced 'mathematical resilience'. I focused my reading and, subsequently, my research on exploring resilience specific to mathematics, which seemed most relevant to my practice as a mathematics teacher.

More importantly, I wanted to understand the experience and the 'thinking' that evokes the 'I am not a mathematics person' attitude. To understand this 'I am not a mathematics person' phenomenon and make it relevant to my work context, I wanted to adopt an approach to my research that enabled me to draw out the students' pre-held viewpoints. These pre-held views would partially inform the selection of intervention strategies for this research. Therefore, I

needed to find a platform where students could express their perception of their own experiences and reactions to their mathematics learning. The medium I chose was Q-Methodology (Watts & Stenner, 2012), a methodology designed to elicit subjective views of the desired population of interest on their experiences and reactions to the subject. Distinct subjective views emerged, as detailed in Chapter 4. I used these to select and re-design intervention strategies that I deemed could help my intervention participants to become more resilient in mathematics learning.

1.3 Context, Setting and theoretical background of the study

It is necessary to situate this research in the broader context of the UK education system. It is well-recognised in the UK education system that poor mathematics performance is a concern, attributed to systemic failure (Boaler, 1997). The Government is continually introducing initiatives to address this 'systemic' failure in school and college education (Fallis & Opotow, 2003; Jones & Thomas, 2005; Siemens & Matheos, 2010; Mockler, 2014; Department of Education, 2016; Blausten et al., 2020). In mathematics attainment, the UK was ranked 27th out of 40 countries (Pisa, 2015). Furthermore, the UK had one of the biggest gender gaps in mathematics and science, adding another aspect that needed addressing about performance in mathematics: gender differences.

1.3.1 Context: Government Intervention Initiatives

One of the government's primary responsibilities is to provide quality education to its citizens to serve the country, agencies, business, and industry (Ahmad, Pervaiz & Aleem, 2010). There is, therefore, a clear widespread interest by the UK government to improve levels of all education, but particularly mathematics achievement (Table 1.1), in schools.

	A	O	P	Q	R	S	T	U
1	Table S2b: GCSE and equivalents (ate-funded schools (percentages)[3]							
2	Year: 2017/18 (revised)							
3	Coverage: England							
4		*rcentage of pupils at the end of key stage 4*						
5		GCSEs only						
6		Percentage of girls achieving grades A*-C or 9-4[4]	Percentage of boys achieving grades A*-C or 9-4[4]	Percentage of all pupils achieving grades A*-C or 9-4[4]	Percentage of girls achieving grades A*-G or 9-1[4]	Percentage of boys achieving grades A*-G or 9-1[4]	Percentage of all pupils achieving grades A*-G or 9-1[4]	
7								
8	Any Subject	90	82	86	99	97	98	
9	English & Mathematics	68	61	64	97	94	95	
10	Mathematics & Science	63	58	60	95	93	94	
11	English, Mathematics & Science	62	54	58	95	92	94	
12	English Language	76	61	68	98	95	96	
13	English Literature	78	62	70	97	92	95	
14	Mathematics	71	69	70	97	95	96	

Table 1.1: Revised Subject Tables (DfE 2018, www.gov.uk)

Mathematics as a discipline is essential in many areas of academic, professional and daily life (Can et al., 2017). Performance in mathematics by some UK students has been persistently low and has been a priority concern for schools and the UK government (Sturman et al., 2012). So, improved performance in mathematics is crucial. More recently, there has been a surge in interest in the 'science of targeted intervention' (Harackiewicz & Priniski, 2018). Harackiewicz and Priniski (2018) argue that "well-crafted interventions have proven remarkably effective because they target specific educational problems and the processes that underlie them" (p. 409).

In recent years, several initiatives were pioneered by the UK Government and government institutions. Some of these initiatives, designed to support existing mathematics teachers, are Mathematics Hubs, Shanghai Exchange Program, National Centre for Excellence in the Teaching of Mathematics (NCETM), Further and Core Maths Support Programmes (FMSP & CMSP) and STEM: Your life. Most of these initiatives aimed at addressing poor performance in mathematics in general while others introduced a gender focus. I describe these in the following sub-sections.

1.3.1.1 Mathematics Hubs

A network of 35 Mathematics Hubs has been established across the country to support current mathematics teachers by emphasising collaborative, exploratory, and evidence-based professional development and research (Department of Education, 2016) for improving the quality of teaching and learning in maths classrooms across the country. This network brings together mathematics education professionals with a common goal of developing and sharing excellent practice to benefit all students. Two of these Maths Hubs have undertaken projects dedicated to building Mathematical Resilience (Lee, 2016; Johnston-Wilder & Moreton, 2018). I have been a participant in one of these hubs.

1.3.1.2 Shanghai Exchange Program

Shanghai tops international league tables in mathematics performance with students on average three years ahead of UK students (OECD, 2012). This success has led to the 'Shanghai Exchange Program' launched in 2014. In September 2014, 60 teachers and leaders from 45 English primary schools visited Shanghai schools. This visit was followed by 59 mathematics teachers from Shanghai being hosted by 22 English schools from 3rd to 28th November 2014 and then by 26 schools between 23rd and 20th March 2015 (Department of Education, 2016). The report on this exchange states that the program aimed to "foster a radical shift in primary mathematics in England by learning from Shanghai mathematics education-a mastery approach to teaching and learning." (ibid, p. 7). The UK Prime Minister confirmed she would extend the programme to 2020 (Department of Education, n.d.). Evaluations of this endeavour seem to indicate some evidence that for some of those schools involved in the Mathematics Teacher Exchange Cohort 1 exchange, there were positive impacts on pupil KS1 mathematics attainment (Boylan et al., 2019).

1.3.1.3 National Centre for Excellence in the Teaching of Mathematics (NCETM)

The NCETM is Department for Education-funded with the main aim of raising levels of achievement in mathematics. On its website, it states that "our specific task is to try to ensure that all teachers of maths…have easy access to high quality, evidence-based, maths-specific continuing professional development (CPD) at every point in their careers." (Tribal Education Limited, n.d.). Among its duties are also to manage the Shanghai Exchange Program and the Maths Hubs initiatives.

1.3.1.4 Further and Core Maths Support Programmes (FMSP & CMSP)

The Further and Core MSP, which is now superseded by the Advanced Mathematics Support Programme (AMSP), was initiated to increase uptake and participation in the study of mathematics beyond the compulsory GCSE level. These further studies would include AS/A level Mathematics, Further Mathematics and, Core Mathematics. The project's other objective was to facilitate improvements in teaching these level 3 maths qualifications (MEI, 2019). On the project's website, it is further stated that the projects provide "national support for teachers and students in all state-funded schools and colleges in England." (MEI, 2019).

1.3.1.5 STEM: Your life

This three-year campaign aimed to ensure young adults in the UK have the mathematical and science skills needed to succeed in the current competitive global economy (STEM Learning Ltd, n.d.). On the official website, is stated that the activities "look to inspire young people to study mathematics and physics as a gateway into wide-ranging careers whilst also triggering employers to recruit and retain this talent" (STEM Learning Ltd, n.d.). The campaign has also produced a collection of case studies that describe how schools and colleges have promoted

the uptake of STEM subjects and awareness of STEM careers, to girls in particular. This STEM drive resonates with Warrington and Kiragu (2012)'s article "It makes more sense to educate a boy: Girls 'against the odds' in Kajiado, Kenya", reporting on what they termed the 'unfreedoms' girls in Kenya are faced with.

This discussion is by no means an exhaustive list of UK Government initiated intervention initiatives, but this sample gives a general indication. The government would have introduced intervention programmes to address issues identified by prevailing research or through political pressure. In the next chapter, I review the literature on research that could have influenced these intervention initiatives.

1.3.2 Setting: Place of Research

The research for this thesis took place in a school setting, at my place of work, in an all-girls school located in an area of high deprivation. Based on Government indices, the school was situated in a ward ranked in the top 7% in terms of poverty. In the 2011 census, the data showed that the rate of unemployment in the ward was higher than the city's average and higher than the national average. The rate of claiming benefits (including in-work benefits) was more than 25% higher in this ward than the national average, suggesting that many people may have been underemployed or on a low salary. The neighbourhood had a lower level of residents born in the UK compared to the national average and a higher rate of residents either born in other EU countries or outside the EU; it had a significant immigrant population. The ward also had 20% fewer high and intermediate managerial, administrative or professional households than the national average.

Furthermore, the ward had a significantly lower homeownership rate than the national average, which confirms that it was a relatively economically deprived area. Since

homeownership was lower than the national average and rented accommodation levels were higher than the national average, this indicated an area of economic deprivation (source: ilivehere.co.uk, 2020). The school population, and my study group, was representative of this demographic.

Although the ward's demographics provided some helpful insight into my study group, I held these constant in this study, focussing predominantly on the subjective views students held of themselves. The participants who took part in the research followed the Key Stage 4 Mathematics Curriculum (www.gov.uk/national-curriculum/key-stage-3-and-4, n.d.), preparing participants for their GCSE examinations. The pilot students were at the end of their GCSE course (Year 11), and the main study students were at the start of their GCSE course (Year 9).

1.3.3 Background: Theoretical background for the focus of the study

My study's theoretical background is grounded within **self-efficacy theory** (Bandura, 1977) and **self-regulation theory** (Bandura, 1991; Vohs & Baumeister, 2016). The careful consideration of these theories as being the best suitable for my research is based on the literature reviewed in Chapter 2.

At the inception of this research, I identified students' historical perceptions of self and their reactions as they interacted with their learning. Past experiences play a central role in the exercise of personal agency by their strong impact on thoughts and subsequent actions. The crux of self-efficacy theory (Bandura, 1977) is that the initiation of and persistence at behaviours and courses of action are determined primarily by subjective judgments and expectations concerning personal skills and capabilities and the likelihood of successfully coping with challenges. Self-efficacy theory also maintains that these same factors play an

essential role in an individual's adjustment when faced with challenges (Maddux, 1995; Brockner et al., 2004; Schunk & Dibenedetto, 2016). Based on Q-Sorting, an activity provided data on the subjective judgments and expectations within my participants. It enabled descriptive and inferential statistics to be applied, especially when considering students' subjective feedback on their experiences.

In addition to this, I carried out a systematic inquiry to discover and examine the students' reactions to their learning when exposed to strategies that, through literature review, I deemed could support or actively encourage further development of self-regulation and coping skills, and ultimately resilient learning. Research has indicated that developing self-regulation skills that address unhelpful 'self-efficacy' views are critical to students' success. Self-regulation theory is described as a conscious personal management system that involves guiding one's thoughts, behaviours, and feelings to reach desired goals (Bandura, 1991). Self-regulation consists of several stages, and individuals would benefit from functioning as contributors to their motivation, behaviour, and development within a network of suitable intervention influences (Baumeister, 2018). The intervention strategies I selected for this research aimed at supporting students' conscious personal management of reactions to challenges.

As well as the literature review on self-theory and self-regulation, two other vital factors influenced the direction of this research. These were based on the prevailing state of affairs in the education system and setting where I was working. The first key influencing element was derived from the UK Government's assertion that teaching should ensure that all students can 'solve problems by applying their mathematics to a variety of routine and non-routine problems with increasing sophistication, including breaking down problems into a series of simpler steps and persevering in seeking solutions' (GOV.UK, n.d.). To facilitate 'resilient learning' development, education programmes whose focus is to enable students to persevere

or work resiliently (Williams 2014) in finding solutions are crucial. The second was my school's most recent Ofsted inspection in 2017. The school was graded 'Good', but to improve on this rating, the school needed to 'strengthen further the early identification of pupils' specific needs, arrange suitable interventions, including by subject teachers, and check its impact with greater frequency.'

In light of the prevailing state of affairs (poor performance in maths in the UK), the setting I was working in (a school in a disadvantaged area) and the literature that pointed to possible low self-efficacy levels and possibly self-regulation. I set out to equip students who identified as susceptible to non-resilient tendencies with skills that could enable them to manage their learning more effectively.

1.4 Research Questions

My study was an undertaking to nurture skill sets in students that would enable them to manage challenging learning situations better and encourage students to persevere in seeking solutions to challenging problems. I set out to achieve this by firstly identifying subjective views that students held about their learning, and these became the selection criteria for the intervention group. Secondly, I selected, re-designed and implemented intervention strategies I deemed, through these subjective views and literature review, would address any unhelpful personal beliefs and reactions to challenges. Finally, through different data gathering points, I evaluated the interventions' subjective impact on students' management of their responses to challenges; I sought to develop my practice and offer suggestions to other educators and researchers. The objectives of my research, therefore, were multi-fold.

The overarching research question addressed by this research is:

How can understanding and facilitating change in the students' subjective judgements of self be utilised to support the development of mathematical resilience in students?

To address this, I sought to answer a series of underpinning sub-questions:

1. What are the girls' subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions?
2. As indicated by the subjective views and literature, what educational intervention activities might I devise to address negative subjective views, and how might I implement the developed activities?
3. What is the impact of these activities on students' management of reactions to challenges, towards developing mathematical resilience?
4. What are the implications of these findings for practice and policy?

Finally, I sought to suggest future research directions on subjectivity and mathematical resilience.

1.5 Research Contribution

Existing research on interventions that mitigate affective factors in general, and develop mathematical resilience in particular, provides several important insights, especially regarding measuring affective factors and highlighting their effects on an individual's learning journey. Most of the research devotes scant attention to the candidate's subjectivity or to addressing the construct through the participant's experiences. When conducting this study, research on understanding mathematical resilience through student experience was notably lacking. The participant's subjective viewpoint is conceptually intriguing because it is

the student's subjective interpretation of mathematics learning that ultimately influences their participation in the mathematics learning journey (Wheeler & Montgomery, 2009). Also, for teachers, an awareness of the student's subjective interpretation may better inform the choice of an appropriate intervention (Dickerson & Graebe, 2018) that may help support the development of coping mechanisms, including mathematical resilience.

My research fills this gap by using students' self-reported subjective reactions to and experiences of mathematics learning to inform intervention strategies that support mathematical resilience development. Self-reporting provides fresh insights, pinpointing individual areas of 'weakness'; these insights can inform planning for strategies that will help build and develop mathematical resilience, an area of inquiry that was relatively understudied in the literature about affective factors in mathematics. My research adds to this emergent literature the importance of understanding students' subjective experiences as a selection criterion and their relevance in selecting intervention candidates and appropriate intervention strategies.

Therefore, this study provides a platform for some useful insights, particularly into how educators might be more sensitive to students' needs by taking the subjectivity approach I describe in this study. Furthermore, it provides insights into how learners interact with proposed interventions designed to address their specific views and pay attention to the relationship of the interventions with mathematics, primarily how they might help them become more resilient. It offers a fresh insight into 'students voice' in this field.

1.6 Guide to the rest of this thesis

Chapter 2 covers a review of the concepts of affective factors, subjectivity, intervention strategies and mathematical resilience, drawing on a wide range of theoretical and empirical

literature. The first section covers the development of the 'affective factors' construct. The second section covers literature that reports on studies where the focus is on educational approaches that could transform subjective views and concludes by explaining the strategies I used. The third section covers a literature review that reports on existing studies on developing mathematical resilience and concludes by describing how I chose my intervention participants. Chapter 2 concludes with a discussion of tensions and difficulties in how subjectivity, intervention strategies and mathematical resilience have been studied in isolation and argues for a more unified modus operandus, which is developing throughout this study.

Chapter 3 covers the research methodology and research methods I utilised to achieve my research aim. I discuss the research framework I chose and explain why this research framework is suitable for my research. I also discuss the research methods I utilised and explain why they were ideal for my research. Finally, I explain why Q-Methodology was valuable in my research, including how I used Q-Methodology's Q-Sorting activity to explore and understand students' subjectivity. I explain how I used student subjectivity within the action research process. I explain what design and analytic steps I took to do this. I conclude by describing how the subjective views played a role in selecting and designing intervention strategies used in the subsequent Action Research Cycles (ARCs).

Chapter 4 reports on the ARCs undertaken and the results collected during subjective evaluation feedback sessions and other data collection tools. I also present my interpretation of these results. I conclude with a discussion that draws together the key points raised in the chapter.

Chapter 5 is my discussion chapter. It gives a discussion of my findings from the ARCs. These findings are reported under the themes of subjectivity and the role and impact of

intervention strategies on mathematical resilience, which emerged from the study. Here my findings relate to and are structured by the research questions.

Chapter 6 is my conclusion chapter and focuses on how I addressed the Research Questions. I make it clear what my contribution to literature is. I discuss the strengths and limitations of the study, as well as recommendations. Finally, I describe what I have gained from undertaking this study and what impact this study has had on my view of prevailing interventions programmes and my practice.

1.7 Chapter Summary

In this chapter, I have given an overview of my research project, and how I came to be inspired to conduct this study. I explained how I contribute to the literature and offered insight into my research context, theoretical background, and issues I address. In the next chapter, I present the research climate in which this study nestles. I discuss prevailing research, how this literature has influenced my research and how it sits within it.

Chapter 2 – Literature Review

Introduction

As mentioned in Chapter 1, one of the top priority concerns in educational policy discussions in the UK has been the overall poor performance in mathematics achievement (Sturman et al., 2012). Also, the low uptake and pursuance of STEM subjects beyond compulsory age, especially among girls, is well documented (STEM Learning Ltd, n.d.). Many government initiatives have been introduced and undertaken to address these issues in the UK (Section 1.3). An influx of research on possible causes of low mathematics achievement and possible solutions has become prominent (Section 2).

Historically, research on mathematics performance focussed on negative affective factors and sought ways of treating or reducing the effect of these negative affective factors (e.g. Hembree, 1990). Over the last 30 years, the focus has gradually shifted to investigating positive psychology variables to support and nurture the learners' strengths while managing weakness. This focus seemed to indicate better outcomes and more opportunities for flourishing than does the sole focus upon repairing personal weaknesses or deficiencies (e.g. Dweck, 2006). This chapter provides an overview of the prevailing literature, and I discuss it as shown in Figure 2.9. I conclude this chapter by looking in greater detail at the interaction between resilience, learning theories and students' voices.

2.1 Mathematics Performance: Affective Factors

A substantial part of the associated research on learning theories recognised the prevalence of affective factors and their critical role in teaching and learning mathematics (McLeod, 1994; Dowker et al., 2016). It is, therefore, well established that many affective factors influence

learner performance in mathematics. The next sections will discuss these factors in greater detail.

It is worth noting that any learning, especially mathematics learning, involves a complex interaction of different affective factors. In partially explaining individual differences in learning mathematics, this interaction is well recognised (Fennema & Sherman, 1976) by some, at least since Aiken's (1961) work. A large body of research reflects the diverse and complex nature of factors associated with mathematics performance, with factors ranging from the dynamics of individual cognitive processes to social and environmental factors that affect students' daily lives (Skouras, 2014). The body of research focused on internal factors has sought to understand these affective factors, among others: students' attitudes (Fennema & Sherman, 1976); self-theories (Bandura, 1997; Dweck, 1999); anxiety (Richard & Suinn, 1972; Hembree, 1990; Ashcraft & Ridley, 2005); mindsets (Dweck, 2008, Heslin, 2010)); mathematical resilience (Johnston-Wilder & Lee, 2010; Rickets et al., 2015; Chisholm, 2017).

External factors are also in the spotlight as factors affecting learning in mathematics. Lamb and Fullarton (2002) put forward that school, teacher, and classroom factors affect mathematics achievement. They found that classroom organisation differences accounted for about one-third of student achievement variation in the USA. Henrickson and Wester (2000) also support the consideration of external affective factors; they go further by arguing that even the format of a test item, whether it is multiple choice or open-ended, contributes to variation in achievement. This variation, they claim, becomes more apparent when a gender comparison is made.

While all of these assertions are valid in and of themselves, my research contributes to the former body of research, whose centre of attention is understanding internal reactions to learning challenges.

Besides, learning has been shown to elicit a range of feelings, behaviours and emotions including avoidance (Ashcraft & Ridley, 2005); fear and dread (Lewis, 1970); disaffection, absenteeism and disruptive behaviour (Nardi & Steward, 2003); tension and stress (Richard & Suinn, 1972); nervousness and discomfort (Hoffman, 2010); maths phobia (Tobias, 1978); apprehension (Henschel & Roick, 2017) and pressure (Ader & Erktin, 2012). While some of these studies adopted a purely cognitive orientation and some a behavioural orientation, my research focuses on addressing students' cognitive orientation. What is crucial is that while educators might observe behaviours that could be assigned to any one of the affective factors, giving exigency to the students' voices should take priority (Williams & Portman, 2014). That is one of the areas I spotlight in this research. The next paragraphs explore different findings on the impact of affective factors on learning and performance in mathematics. I start with the negative factors, through to the factors that could either have a positive or negative impact before I draw attention to factors that are deemed would have a positive effect.

2.1.1 Negative Affective Factors

In the previous sections, reviewed literature established a strong consensus within the education sector in general and mathematics education. Some students might not currently be able to reach their full potential because of various affective factors. One of these factors that have received increased attention is mathematics anxiety.

Earlier research on mathematics anxiety can be traced back over six decades (Aiken, 1961). The construct of mathematics anxiety has evolved in terms of what exactly it refers to. Aiken considered mathematics anxiety to be part of a general 'attitude' towards mathematics. Other researchers felt that 'attitude' was not an adequate term to describe the intense feelings students experienced when required to perform mathematically. In the 1970s, researchers used phrases such as tension, helplessness, and mental disorganisation (Richard & Suinn, 1972; Tobias, 1978) to describe mathematics anxiety. Richard and Suinn (1972)'s research on mathematics anxiety culminated in the Mathematical Anxiety Rating Scale. In the following decade, vocabulary increased to include fear, worry and phobia (Buxton, 1981; Wigfield & Meece, 1988; Hart, 1989). By the 1990s, researchers broadly described mathematics anxiety as a 'state of emotion underpinned by qualities of fear and dread' (Hembree, 1990; Hackworth, 1992) directed at the future and out of proportion to the 'threat' (Hembree, 1990), as 'threat' was understood at the time.

Hembree (1990)'s review of research on mathematics anxiety sought to integrate the understanding of mathematics anxiety to include its nature, its effect and its relief. Hembree (1990) found that, across all grades, female students reported higher anxiety levels than males. However, this did not seem to translate into performance that is more depressed or significant avoidance by females. He deduced that one of the possible reasons could be that females cope with anxiety better. Mathematics anxiety alone, according to Hembree, does not seem to explain the gender gap in performance.

A common thread in all the definitions provided in this section recognises the involvement of a person's cognition. There is a consensus within mathematics anxiety research that mathematics anxiety disrupts cognitive processes by compromising ongoing working memory activity (Hembree, 1990; Ashcraft, 2002). Ashcraft (2002) went further by pointing

out that "highly math-anxious students are characterized by a strong tendency to avoid math…." (p. 181).

Hembree's (1990) review suggested various possible treatments that he showed to reduce mathematics anxiety effectively. He categorised the treatments into clinical psychological interventions (i.e. cognitive, behavioural or cognitive-behavioural approaches) and whole-class interventions (e.g. relaxing techniques, teaching the history of maths, etc.) Other researchers who offered suggestions were, for example, Tobias (1987 & 1994; split page); Arem (1993; positive thinking); King et al., (2018; breathing interventions), with varying levels of success.

Students' anxieties can have an impact on their learning. Such research focussed on the negative affective factors and how these can be reduced. As research on affective factors progressed, an interest in positive stances started to emerge (Bandura, 1977; Seligman, 2006). The next sections explore some of the positive outlooks to challenges, but before that, I discuss stances that could either negatively or positively impact learning.

2.1.2 Negative/Positive Psychology Variables

Positive psychology focuses on 'positive' cognitive qualities and states (Tomas & Ivtzan, 2016). This section discusses the emergent field exploring the dialectical nature of 'flourishing', where an affective factor can either have a negative or positive impact. In the next sub-section, I explore attitude.

2.1.2.1 Attitude

Scholarly interest in the role of students' attitude towards mathematics and mathematical achievement has increased (Quaye, 2015) over the years. Schwartz (2006) proposes that to

learn maths takes “developing an attitude, one that includes perseverance, tenacity and fearlessness.” (p. 50) This premise is echoed by Williams (2014)’s confidence, perseverance and persistence definition of optimism/resilience (based on Seligman, 1991) and Thom and Pirie (2002). Psychological theories explain attitude as a tendency to evaluate a particular entity with a certain level of favour or disfavour (Can et al., 2017). Drawing on broader research, Can et al. (2017) explain that “[a]lthough researchers have debated the dimensionality of attitude, one widely accepted model postulates that attitude consists of three basic components: cognitive, affective and behavioural. While the cognitive component refers to what a person thinks or believes, the affective aspect is concerned with feelings or emotions associated with the object. The behavioural component refers to the tendency to react to the object.” (p. 1626). As well as defining and understanding attitude, researchers have developed instruments for measuring attitudes towards mathematics. One of the earliest ones was designed by Aiken (1961).

Utsumi and Mendes (2000) point out that Aiken (1961) designed a scale to measure attitudes towards mathematics that he called the Scale of Attitude Towards Mathematics, which they later revised in 1963. A study by Fennema and Sherman (1976) also culminated in developing an attitude scale, designed not just to measure affective variables related to the learning of maths but also to record the election of further mathematics courses. Fennema and Sherman (1976) reported that they found an increasing number of students, qualified intellectually, who were deciding not to study maths beyond the compulsory minimum secondary level. They also found that attitude was a vital enough affective factor to be used on its own in deciding whether to pursue mathematics courses or not. Their study highlighted that there are more variables to the ‘attitude’ construct. They pointed out that the primary purpose of their project was to “gain more information concerning females’ learning of mathematics as well

as information concerning variables related to the election of mathematics courses." (p. 325). They found few gender-related cognitive differences but many attitudinal differences (Fennema & Sherman, 1977).

In other research, entitled 'Students' Conception of the Nature of Mathematics and Attitude towards Mathematics Learning', Amirali (2010) introduced the idea that if educators are to help change students' attitude towards learning mathematics, they need to explore the students' existing perception and attitude towards mathematics. Amirali says "[i]n order to facilitate students to possess a positive image of mathematics there is a need to explore the existing conceptions and attitude towards the subject. Once educators are aware of their conceptions, then they can address their alternative conceptions through designing appropriate mathematical teaching and learning programmes." (p. 28). This assertion is supported by Borthwick (2012) in her article 'What do the pupils think', where she used drawings to explore students' view of maths and their attitudes to maths. She found that "[w]hile a range of emotions were exhibited towards mathematics by the children in the study, already early elements of disaffection were beginning to show from younger boys." (p. 19). She went on to say that data collected revealed potential issues for negative attitude towards mathematics manifesting as early as in primary schools (see also: Hill et al., 2016; Bezuk, 2017). Pollitt et al., (1987) view this attitude phenomena from the societal point of view, where they expound that society's attitude towards girls' education should also be considered. The studies sampled, by argument, accentuated the negative or positive impact of attitude; the next affective factor follows along the same course.

2.1.2.2 Self-Efficacy

Self-efficacy is broadly defined as a person's belief about their capabilities to produce defined performance levels (Bandura, 1977). Self-belief determines how people feel, motivate themselves and act. It functions as a multi-level and multifaceted set of beliefs that influence how people behave during various tasks (Truebridge, 2016). In 1977, Albert Bandura, an influential social cognitive psychologist, became interested in and explored the idea of human self-efficacy as an affective factor. He proposed that people with high confidence in their capabilities tackle difficult tasks as challenges to be mastered rather than as threats to be avoided.

Conversely, people with low assurance in their capabilities approach difficult tasks as threats to be avoided. He hypothesized that people's beliefs in their powers to produce desired effects by their actions play a crucial role in people approaching and applying themselves to a task. Self-efficacy also affects an individual's choice of activities, effort and persistence. In his research, Bandura forwards the notion that self-efficacy is developed through mastery (own experience), social role models (vicarious experience), social persuasion (verbal assurances) as well as emotional state (mood). Bandura further classifies four psychological processes that affect self-beliefs of efficacy and human functioning. He says these self-beliefs are mediated by cognitive, emotional, affective and selection processes to generate actual performance. Much research has been conducted on these processes (Kavanagh & Bower, 1985; Hackett & Betz, 1989; Schunk, 1991), establishing strong links between these processes and performance.

Most courses of action usually initiate from thoughts. Thoughts about self-belief or efficacy also tend to shape what goals individuals set for themselves and what they are willing to

tackle in all areas of life, including learning. A study by Hackett and Betz (1989) investigated the relationship between mathematical performance and mathematics self-efficacy. They found that mathematics performance and mathematics self-efficacy were significantly and positively correlated. This finding was supported by Ferla, Valcke and Cai (2009) who also refer to thoughts concerned with learning as academic self-efficacy. They described this as an "individual's knowledge and perceptions about themselves in academic achievement situations." (p. 499). Ferla, Valcke and Cai (2009) investigated the constructs of academic self-efficacy and academic self-concept. They found that students' academic self-efficacy was a better predictor of achievement while academic self-concept was a better predictor of motivational variables. Motivational variables can include value (students' goals and beliefs about the importance of and interest in the task) and affect (students' emotional reaction to the task). The research discussed suggests that elevated levels of self-efficacy result in improved cognitive performance, and by arguments, the converse is true.

Furthermore, self-efficacy plays a crucial role in the self-regulation of motivation (Bandura, 1991; 1993), and most human motivation is usually cognitively initiated. People can motivate themselves and guide their actions anticipatorily by the exercise of forethought. According to self-efficacy theorists (Bandura, 1977; Schunk, 1991), low self-efficacy causes motivational problems. Drawing on broader research, Schunk (1991) proposes that self-efficacy predicts motivation and achievement across all student ability levels. If students believe they cannot succeed in a specific task (that is, they have low self-efficacy), they are highly likely not to be motivated to attempt the task at hand. They will sometimes superficially try the task, give up quickly, avoid or even resist it (Margolis & McCabe, 2006). Any or all of these actions cannot lead to optimum achievement. As mentioned earlier, motivational processes activate activity, and this motivation is usually cognitively initiated. Skaalvik, Federici and Klassen (2015)

conducted a study ‘Mathematics achievement and self-efficacy: Relations with motivation for mathematics’; they reported that mathematics self-efficacy was positively related to all motivation measures that they included in their study. Motivation is a crucial component, not just for engaging with the learning, but for continued engagement. When students engage with their learning, they have a greater chance of improving their performance and achievement.

People’s beliefs about their capabilities determine how much stress they experience in difficult situations. Stress is the emotional mediator of self-efficacy (Bandura, 1993). When people try to cope with problems they believe they cannot cope with, their stress and anxiety increase, and trigger avoidance behaviours. Such emotional reactions can affect action both directly and indirectly, by altering the nature and the course of thinking. The stronger the sense of coping self-efficacy, the bolder people will take on taxing and challenging activities. Therefore, this implies that people who have depressed self-efficacy are more prone to choose the action of the least stress. Kavanagh and Bower (1985) expanded on the role of emotional states in determining self-efficacy judgments. They stated that “increased self-efficacy when the person was in a positive mood would be likely to accelerate the acquisition of new skills by promoting engagement in learning activities and investment of effort and persistence in practice.” (p. 521). Therefore, this research suggests that elevated self-efficacy levels determine how much people are prepared to take on challenging tasks. Recently, Srisupawong et al. (2018) provided evidence of a strong linkage between emotional states and self-efficacy judgement.

Furthermore, it is well established that people are partly a product of their environment (Bandura, 1977; Cunningham, 2008). Therefore, their self-efficacy can be influenced by their environment, which will subsequently influence the choices of activities they partake in and

the environment in which they choose to engage. Lorbach and Jinks (1999) stated that "[u]nlike most belief systems which can be highly personal, academic self-efficacy is generally a belief that is addressable in a classroom context. Therefore, understanding more about the reciprocal relationship between the learning environment and students' academic self-efficacy beliefs should be a fruitful focus for learning environment research." (p. 157). This argument seems to suggest a strong link between levels of self-efficacy and the environment. Closely linked to self-efficacy are self-theories proposed by Carol Dweck. The next section explores these self-theories.

2.1.2.3 Self-Theories

From over 30 years of research on belief systems, Dweck (1999) became interested in how people's beliefs about themselves can create different psychological worlds that influence how they think, feel and act in any given situation. Dweck (1999) asserted that she was not trying to define intelligence. Her research focused on how people's implicit theories about their intelligence can impact their thoughts, feelings and behaviours. Her particular interest was on what attributes lay behind students' behaviours, where some students persisted in the face of frustrations while others quit as soon as they met difficulties. She found that the 'self-theories' students held of their intelligence played a crucial role (Dweck 1999). She came up with two theories of self: the 'entity view' (intelligence is fixed) and the 'incremental view' (intelligence is malleable).

On the one hand, students who held what she called the 'entity view' tended to avoid academic challenges. On the other hand, students who had the 'incremental view' would not avoid challenges, because part of this view is that intelligence is malleable and changeable. She went further to say that significant others can manipulate students' views of their

intelligence; in other words, people can transform what they think about their intelligence. Dweck (1999) raised that theories of intelligence can predict (and create) differences in achievement. She pointed out that "students' theories of intelligence affect achievement in their ability to cope effectively", where a belief in fixed intelligence creates "anxiety about challenges….and helpless behaviour" (p. 37). A belief in malleable intelligence creates a framework where setbacks become an "expected part of long-term learning." (p. 37-38). Considering this argument, it is feasible to conclude that intelligence theories can be learned or unlearned (transformed).

2.1.2.4 Mindsets

By 2006, Carol Dweck's study on self-theories had evolved. During her ongoing research, she noticed that 'some students rebounded easily in the face of challenges while others seemed to be shuttered by even the smallest challenge. Dweck became interested in students' attitudes and responses to failure instead of her previous interest in students' attitude and responses to challenges. This interest resulted in the development of the Mind-set Theory. Dweck (2006) proposed that students will hold either a fixed mindset or a growth mindset. The students who have a fixed mindset believe their intelligence set; they avoid challenges as they feel that failure suggests that they lack the intelligence required and that effort is fruitless. They think that getting things wrong and receiving negative feedback reveals their limitations (Dweck, 2006). Those who subscribe to a growth mindset believe that they can develop their intelligence; they do not avoid challenges and think they can improve at any task. They see effort as a pathway to mastery. They believe getting things wrong and receiving negative feedback is positive as it guides them to further improvement (Dweck, 2006). Then this raises the question "Is everyone capable of great things with the right mindset?" (Dweck, 2006, p. 54). Many of our students, our most precious resource, are stuck

in a mindset where limitations are easily acceptable; for example, 'I am not a maths person' is readily uttered and acknowledged. This mindset promises a lifetime of 'comfort' but not necessarily learning. Dweck's work suggests that it will take a lot of work to transform a learner's fixed mindset into the growth mindset where a fixed mindset has taken root. Dweck clarifies that it is vital to encourage the growth mindset rather than praising intelligence and ability; her research showed that praising intelligence and ability does not foster a growth mindset.

There have been numerous studies on applications in schools of this concept with varying degrees of success (such as Esparza et al., 2014). One area of concern raised more recently by Dweck (2015) was that in most of the reported applications, she noticed the prevalence of equating the growth mindset to effort (persistence). In this paper, Dweck offers further clarification on this by saying "Certainly, effort is key for students' achievement, but it's not the only thing. Students need to try new strategies and seek input from others when they are stuck (*perseverance*). They need this repertoire of approaches - not just sheer effort - to learn and improve." (p. 20). She also uses the term 'the power of yet' to explain growth mindset for children. Inspired by a high school in Chicago where students who did not pass were given the grade 'not yet' instead of fail, Dweck coined the expression 'The Power of Yet'. The 'not yet' grade, she points out, gave students a pathway forward. 'The Power of Yet' focuses on students being encouraged to luxuriate in the power of yet (future learning) instead of being left to focus on the 'now' (Dweck, 2014). Having a 'this is not the end' mentality or looking forward to a 'better' future, and 'I can come out of this' can positively impact students. Dweck's work seemed to indicate that educators can educate students to adopt the 'I can come out of this' attitude. This school of thought shifted the spotlight to studying and

understanding stances that enable students to thrive amid challenges. The next sections explore these stances that would allow students to succeed, starting with grit.

2.1.3 Positive Psychology Variables

The discipline of positive psychology and its study primarily aims at empowering the inner self. Its goal is to raise, among other things, positive feelings, positive cognitions or positive behaviours. Laursen (2015) points out that "[t]he science of positive psychology provides promising new approaches to develop inner strengths that foster success in school life." (p.19). Overcoming setbacks is a desirable character trait in any situation but perhaps more so in education, to enable students to be recover from a setback. One such characteristic is grit.

2.1.3.1 Grit

Angela Duckworth (2007) grew up labelled as 'no genius' by her father. Later in life, when she got awarded the MacArthur fellowship, it set off a chain of thoughts that led to her wanting to determine whether what individuals achieved depended not on their talent or giftedness. Observing the UK's army recruitment process and dropouts levels consolidated her belief that individuals needed more than just giftedness or talent to succeed. These thoughts led to her investigating other fields where there were high dropout rates. She points out that "it was in the classroom … that I begin to see that talent is not all there is to achievement." (p. 101). Over a period, while teaching maths, she noticed something that intrigued her: the most successful students were not always the ones who displayed natural aptitude. She was fascinated by this idea of success and talent, wondering why naturally talented people frequently failed to reach their potential. In contrast, the far less gifted individuals achieved amazing things or some individuals accomplished more than others of apparently equal intelligence. She concluded that the most plausible explanation for

outstanding achievement was not talent, but a passionate persistence that she referred to as grit.

Duckworth et al. (2007) defined grit as "perseverance and passion for long term goals." (p. 1008). They explained that grit "entails working strenuously towards challenges, maintaining effort and interest over the years despite failure, adversity and plateaus in progress." (p. 1008). Although there seems to be an interchangeability between 'persistence' and 'perseverance' in Duckworth's work, I do not think it takes away from what Duckworth is trying to convey. Other researchers such as Dweck (2006, 2014) and Williams (2014) distinguish between these two constructs, taking perseverance to mean trying alternative strategies or recruiting support, while persistence referred to trying the same thing over and over again. Duckworth et al. (2007) further assert that the gritty individual approaches learning (including challenges) as a marathon; their advantage is tirelessness, where disappointment or failure 'signals to others that it is time to change trajectory and cut losses, the gritty individual stays the course'. Duckworth concluded that "[w]hen you consider individuals of equal talent, the grittier ones do better", (cited in Perkins-Gough, 2013, p. 16). Duckworth asserts that grit can be cultivated and grown in two ways: the inside-out and the outside-in. She proposes that individuals can cultivate their grit from within by developing and working on interests that are beyond current capabilities. Externally, parents, coaches, teachers, mentors and friends can be critical in developing grit.

This finding was echoed by Arias (2016), who offered recommendations for building grit, such as developing positive relationships as well as having a positive attitude (akin to Seligman (2006)'s optimism). Fornaciari (2017) also studied this construct in education settings and offered suggestions on grit-building classrooms' characteristics to include high expectations, growth mindset and passion. Christensen and Knezek (2014) expanded on this

construct of grit. They pointed out that "[i]t is possible that one type of grit is related to persistence and perseverance to accomplish a goal while another type of grit is related to being consistently interested in one thing over time - a breadth versus depth of interest." (p. 27).

These sampled studies on grit all seem to attribute 'staying power' to grit, and they all seem to suggest that people can learn and develop grit. In particular, Duckworth argued that 'grit' offers a fresh and motivating way to climb to heights far beyond what natural talent would predict; it is a significant predictor of success in various sectors (Duckworth, 2007). She proposed that cultivating passion and perseverance for long-term goals was critical and that building grit using the growth mindset was vital. This premise was extended upon by Perkins-Cough (2013), who, like Christensen and Knezek (2014), added the element of depth. Perkins-Cough (2013) concluded that grit was, therefore, not just having resilience (which she defines as a positive response to failure or adversity) in the face of failure, but having deep commitments too. What is not explicitly addressed by this literature is whether grit includes coping when things go wrong, but, thus far, it seems evident that grit (persistence and perseverance over a long period and deep commitment) in young people is desirable. Any intervention that can help them grow their grit could not be encouraged enough.

Various researchers have followed on from Duckworth's work (Tough, 2012; Hoerr, 2013; Farrell, 2014; Laursen, 2015), with multiple findings on helping students develop their grit. Laursen (2015), for example, suggested different strategies for teaching grit. These suggestions include talking about grit. If grit is not a familiar concept, they suggest asking students 'to research and report on people who have demonstrated perseverance in the face of hardship'. They also advise assisting students in developing and working on long-term goals and developing a growth mindset, as useful strategies to build and strengthen grit. However,

Laursen's report does not offer any evidence on the impact of these strategies. Similar to grit, tenacity also provides students with the ability to overcome setbacks.

2.1.3.2 Tenacity

Dweck et al. (2014) forwarded the notion that academic tenacity must also do with the "non-cognitive factors that promote long-term learning and achievement" (p. 4). They explained that academic tenacity is about working hard and working smart for a long time at its most basic level. They argue that academic tenacity is about mindsets and skills that allow students to "look beyond short-term concerns to longer-term or higher-order goals and withstand challenges and setbacks to persevere towards these goals." (p. 4). They pointed out that good teachers and good schools foster academic tenacity by challenging their students with high standards, scaffolding students' cognitive learning, scaffolding their motivation to learn, cultivating students' feelings of belonging, and enabling the development of fellowship with peers and teachers. Dweck et al. (2014) came to this finding when they became interested, not in the school curriculum or classroom pedagogy, but the students' psychology. They argued that research that focused only on the curriculum and pedagogy was insufficient. Instead, students' psychology offered levers for improving student achievement. They stipulated that student 'psychology' focused on motivational factors and non-cognitive factors. These factors included students' beliefs about themselves, their feelings about school or their habits of self-control. They asserted that, if educators put educational interventions and initiatives targeted at these psychological factors, they could transform students' experience and achievement in school (Dweck et al., 2014). They went further and suggested educational interventions that could be used to this end, for example, facilitating social belonging and value affirmation. They concluded that concerning all motivational and non-cognitive factors, participants were able to improve academic performance significantly.

Before this research, other studies looked at tenacity within the education system. In their research on adults who had come back to academia, Hensley and Kinser (2001) coined the phrase 'tenacious persisters'. They use this term to describe those individuals whose academic path did not follow the 'persistent track' as defined by Carroll (1989). Drawing on broader research, they explained that they used the 'persistent track' to identify which students are likely to earn a degree relatively quickly although at risk of never completing it. This 'persistent track' they say, described the most efficient way for a student to complete his or her undergraduate education. But Hensley and Kinser (2001) argued that "[t]he majority of undergraduates, however, enrol and re-enrol, overcoming significant barriers while pursuing their educational goals. Theirs may not be a direct path, and it is certainly not the quickest. When looking at it from students' perspectives, however, they are persisters. These are adult students who may keep a goal in mind for years attending part-time when they can, quitting when they are frustrated or when they have to prioritise other demands. Eventually, they return for another try." (p. 6-7). In other words, these candidates may not follow the 'persistent track', but they certainly are persistent, so are not just persisters, they are also tenacious. They have a determination that is probably not so evident in the 'persistent track' route students. This study's findings seem to suggest that students with tenacity achieved equally good results, earning a degree. All the adults involved in this research ended up earning a degree, whether through the relatively quick and longer routes. Even though they conducted the study with adults returning to education or academia, tenaciously persisting is a trait that could be cultivated and be beneficial to younger people.

These studies evidence the value and the utility of grit and tenacity in education. Participants could procure considerable gains through a rigorous, supportive learning environment that

cultivates, encourages and promotes student tenacity by understanding the underlying attributes that enable people to be tenacious or gritty.

2.1.3.3 Learned Optimism

The role of emotions in learning has long is acknowledged but often overlooked (Scoffham & Barnes, 2011). Martin Seligman (2006), a positive psychologist, has been interested in the construct of helplessness and ways to increase belief in personal control on outcomes. After extensive studies dating as far back as the 1990s, he proposed two ways of looking at life: optimism or pessimism. He explained that both constructs have a place in some realms of life, but states that optimism would be the more desirable outlook as, among other things: it can protect against depression; it can raise achievement; it can enhance physical wellbeing and is a far more pleasant mental state. Pessimism, on the other hand, has mainly contrary effects.

Based on his study on the prevalence of depression in America, Seligman (2006) claimed that, unlike many personal qualities, basic pessimism is not fixed and is changeable. He asserted that individuals could learn a set of skills that allows them to use optimism when they choose to; one of these is explanations people give themselves when faced with failure. For example, Seligman (2006) talks about the three ABCs (Adversity, Belief and Consequences), where adversity sets an explanatory cognitive cycle in motion, quickly solidifying thoughts into beliefs that generate your feelings and responses. This chain of events determines if individuals will respond by acting constructively (optimistic) or falling into despair (pessimistic). He says “When we encounter adversity, we react by thinking about it. Our thoughts rapidly congeal into beliefs. These beliefs may become so habitual we don’t even realize we have them unless we stop and focus on them. And they don’t just sit there

idly; they have consequences. The beliefs are the direct causes of what we feel and what we do next. They can spell the difference between dejection and give up, on the one hand, and well-being and constructive action on the other." (p. 211). This assertion is expanded on by Gordeeva, Sychev and Osin (2017). Drawing on wider research, Gordeeva, Sychev and Osin (2017) reported that children who tend to think optimistically have certain advantages compared to their pessimistic thinking peers. They say they are less likely to suffer from depression and establish more positive relationships with peers. They also demonstrate higher academic achievements. These are some of the optimistic thinking skills that Seligman claimed could be learned.

From the arguments presented, three things are particularly noteworthy:

i. All the sampled studies seem to agree that all the negative affective factors are changeable;
ii. Some of the studies sampled seem to champion the reduction of negative affective factors by trying to treat them;
iii. Other studies seem to suggest 'unlearning' the negative affective factors and learning positive affective factors in the place of the negative ones.

The indications from these studies are that all of these suggestions have merit in their own right. However, instead of reducing or unlearning negative affective factors, teachers support students in learning and increasing mitigating strategies. Therefore, my study aims to develop and improve students' mitigating strategies, particularly mathematical resilience, which, by argument, should help the students cope with and manage the other factors better. This shift in research direction underpinned my exploration of literature that reports on some of these mitigating strategies. I decided on resilience because of its inherent nature of positive

adaptation to adversity. The next session explores the construct of resilience, from generic resilience to mathematical resilience.

2.1.4 Resilience

One of the key drivers of my research is developing resilient thinking and traits in students. Studies with a neurological foundation (for example, Siegel, 2011) or psychological foundation (for example, Dweck, 1999) have shown that any positive thinking skill, including resilience, can be learned and developed. In this section, I explore the resilience movement through different paradigms. The other key drivers of this study are equipping students with an understanding of how the brain works (neurology, e.g. Siegel 2011) in a learning scenario and the vital role their 'voice' plays in learning. I also cover gender and its relation to resilience.

2.1.4.1 Different forms of resilience

Resilience, and similar concepts such as tenacity, is receiving an increase in interest from researchers and educators (an EBSCOhost search of the term 'resilience in education' yielded over nine thousand results and google scholar over seven million), so resilience is not new. Resilience research emerged more than 40 years ago (for example Garmezy, 1971, 1974; Murphy & Moriarty, 1976; Rutter, 1979; Werner et al., 1971) and underwent a series of 'waves' that started with researchers investigating invulnerability, which researchers described as immunity to harmful influences.

Hanewald (2011) pointed out that, essentially, researchers in the 1970s were initially concerned with a person's shortcomings and their remedy. They expound that this "deficit approach focussed on investigations of children and adolescents who were classified as being at risk of negative life outcomes [*some of whom unexpectedly performed well*] … However,

the researchers did not explain why some children did and others did not exhibit resilient behaviours in the face of adverse life circumstances." (p. 23). Subsequently, instead of focusing on young people who became casualties of these negative factors, the new wave of studies focussed on those who did not succumb, those who were termed 'resilient'. The question researchers were attempting to answer was 'why do some children exposed to high-risk environments successfully adapt while others do not?'

Research shifted from 'risk factors' to 'protective factors' (Masten & Garmezy, 1985; Rutter, 1985; Benard, 1991; Werner, 2000; Carmel, 2008). The studies suggested that protective factors had a more profound impact on the life course of children who grow up experiencing adverse conditions than did the life experiences themselves. The move towards a developmental system approach became evident, exemplified by Seligman (2006), optimism; Duckworth et al. (2007), grit; Dweck et al. (2014), tenacity etc. These have been discussed in more detail in previous sections. Once positive psychologists focused on supportive and protective factors and preventative intervention, an upsurge of research was undertaken, such as Yates and Masten (2004). Yates and Masten (2004) proposed three types of resilience promoting intervention approaches: risk-focused approaches, asset-focused approaches and process-focused approaches. They attributed the risk-focused intervention to reducing or preventing risks and suggested that it be the first strategy. However, when evading threats is not possible, or these threats cannot be changed, they suggest other strategies be considered. These strategies could include their asset-focused intervention, which emphasises the availability of resources that enable adaptive functioning to counteract any adversity. Yates and Masten (2004) explain that "[a]ssets refer to resources in a population that enhance the likelihood of positive development and outcomes independent of risk status (e.g. good schools, problem-solving skills family cohesion)." (p. 523). Their process-focused

interventions aim to protect, activate and restore systems to support positive development. Yates and Masten (2004) presented this multifaceted approach to understanding and supporting positive development or resilience. They further proposed identifying assets, risks, protective factors, and vulnerabilities as an essential first step in identifying and understanding resilience. Still, to apply a resilience framework effectively in practice or policy, it is necessary to know more about resilience processes. The next sections will attempt to shed light on this understanding of the processes involved in resilience.

2.1.4.2 Resilience in general settings: Views of resilience

The study of resilience has gone through many 'phases of discovery, identifying aspects of both the person and environment that appear to serve as protective or mitigating variables to the impact of adversity' (Prince-Embury & Saklofske, 2013). Much of the previous resilience research examined the interaction of protective factors and risk in high-risk populations. The focus of modern research has become identifying evidence of 'processes' present in the lives of those who both survived and thrived in the face of adversity compared to those who did not. Modern resilience studies originated among psychologists and psychiatrists (Flemming & Ledogar, 2008). Some of the early studies of resilience described it, implicitly or explicitly, as a personality trait or set of traits (Beardslee & Podorefsky, 1988), while other resilience studies have come to describe it as a process (Flach, 1980; Rutter, 1987; Jacelon, 1997). For my research, I have adopted the view that resilience is not something an individual does or does not have but is a process that an individual can learn. It is unavoidable that an individual will face negative circumstances and feel negative emotions (fear, anger, distress, anxiety, sadness, hopelessness). Still, the key is to respond to these negative circumstances or events by taking action or stances that enable coping with the possibilities.

As mentioned earlier, I take the view that resilience is the process of adapting well in the face of significant sources of challenge. I refer to this adaptation as 'bouncing back' from setbacks or difficult experiences or keeping going despite challenging situations. It is worth mentioning that being resilient does not mean that a person doesn't experience difficulty or challenge. The road to resilience is likely to involve considerable challenges and adversity. The behaviours, thoughts and actions needed to deal more effectively with these challenges can be learned and improved by anyone (Seligman, 2006). More recently, the definition of resilience has evolved to identify two distinct dimensions: significant adversity and positive adaptation (Luthar, 2006). This idea of a two-part construct has been referred to by other researchers (Masten, 2001; Yates et al., 2003; Sroufe et al., 2005).

Further development of the concept of resilience came from Fleming and Ledogar (2010). Drawing on broader research, they point out that, among psychologists, resilience is referred to in three general usages: good developmental outcomes despite high-risk status; sustained competence; and challenging situations and recovery from trauma. This view, by argument, could be equally applied to education settings.

2.1.4.3 Resilience in academic settings

As alluded to in the preceding section, resilience, described as requiring positive adaptation and sustainability in the face of adversity, sounds like something educators could utilise in their classrooms. Effective learning requires, among other things, students who can adapt in a healthy way to challenging work and be able to sustain this positive adaptation. By definition, resilience is, therefore, the ability to adapt and transform to overcome adversity and develop confidence in problem-solving skills with autonomy and a sense of purpose (Ricketts, 2015).

This same adaptation process needs to be developed in school environments (Camel, 2008). In their book *Resilience in Children, Adolescence, and Adults: Translating Research into Practice*, Prince-Embury and Saklofske (2013) recognise the growing need to strengthen the links between theory, assessment, interventions, and outcomes to give a more robust empirical base, one that results in more effective interventions and strength-enhancing practice. Their comprehensive volume clarifies core constructs of resilience in the other upsurges it has undergone. One of these upsurges involved efforts to test ideas about resilience processes through interventions designed to promote resilience, which my research addresses in the specific context of mathematics.

2.1.4.4 Resilience in mathematics classrooms and Mathematical Resilience

Most people think of mathematics as one of the most logical, impersonal branches of knowledge, yet it inspires more emotions than any other school subject (Zaslavsky, 1994). The effects and treatment of affective factors in general, and in mathematics particularly, have been well researched by several researchers (e.g. Richard & Suinn, 1972; Fennema & Sherman, 1976; Hembree, 1990; Nardi & Steward, 2003; Dweck, 1999; 2008). An approach to maths anxiety rooted in positive psychology - mathematical resilience - was first proposed by Johnston-Wilder and Lee (2008) over ten years ago. Based on positive psychology studies, mathematical resilience can significantly affect students' day-to-day encounters with mathematics and subsequent performance in this important subject.

One of the first studies that introduced the construct of mathematical resilience was undertaken by Johnston-Wilder and Lee (2008) while researching the role of articulation in learning mathematics. They revealed that "increasing the articulation that pupils are required to undertake in mathematics will increase their 'mathematical resilience' and therefore their

ability to engage as life-long users of mathematical skills, thinking and reasoning." (p. 58). Interestingly, at the conception of the term 'mathematical resilience', Johnston-Wilder and Lee (2008), made an association between an aspect of the student's voice (articulation) and mathematical resilience. Johnston-Wilder and Lee (2010) further clarified the construct of mathematical resilience by explaining that the term mathematical resilience "is used to describe a learner's stance towards mathematics that enables pupils to continue learning despite finding setbacks and challenges in their mathematical learning journey" (p. 38). They further drew from the literature, four aspects that need to be present for the development of mathematical resilience, which they suggest are:

- having a growth mindset,
- recognising the personal value of mathematics,
- understanding and acknowledging that mathematics involves struggle
- and knowing how and where to find support when pursuing mathematics learning.

This exposition has led to a growth in research seeking to develop mathematical resilience in students (McGee, 2009; De Geest et al., 2013). One of these studies was undertaken by Thornton, Statton and Mountzouris (2012) when they reported on the Australian 'Make it Count' project as it unfolded. They described the processes of mathematisation (i.e. the use of mathematical models and representations of real-world contexts) and contextualisation (i.e. the embedding of mathematical ideas into a meaningful context) as vital aspects of students' mathematical learning. They suggested that an intentional focus on mathematisation and contextualisation helps make mathematics meaningful, particularly for Indigenous students. In particular, they offered that such a focus can enhance the mathematical resilience of Aboriginal students. They reported that they had gathered data about Aboriginal students'

mathematical resilience throughout the project through structured observations of indicative behaviours and fortnightly student reflections. These fortnightly student reflections introduced the student's voice as a component. Their study suggests that if mathematics learning is contextualised, students have a reasonable prospect of developing their mathematical resilience. This contextualisation seems to concur with Johnston-Wilder and Lee (2010)'s 'personal value' aspect.

Another study, Lugalia et al. (2013), explored the role of ICT in supporting mathematical resilience for students in Kenya. At their place of research, mathematics teaching had reportedly been primarily based on the traditional textbook approach, inherently teacher-centred, and digital technologies were yet to be embraced. They reported that by utilising this software, interactions in the lesson helped to dispel any feelings that any students might have brought to the class that algebraic ideas were inaccessible. They reported that using technology afforded the students spontaneous, accessible and effective learning through collaboration and reflection. This report seems to corroborate the 'support' aspect of developing mathematical resilience, as described by Johnston-Wilder and Lee (2010).

Chisholm (2017)'s work on developing mathematical resilience in KS4 students utilised split-screen lesson objectives, one related to a mathematical skill and the other related to a learning skill, to focus the learner's attention on each skill. This split-screen technique is akin to Tobias (1994)'s split page and Pauk (2014)'s 'Connell Notes' work. Chisholm reports that he chose these learning skills to encourage a particular group of learners to gain confidence, persistence and perseverance with the main focus of the research being to change the way the learners approach learning, particularly the development of 'mathematical resilience'. Over what he called 'teaching episodes', his work demonstrated that self-efficacy levels increased; some girls showed more confidence that they could solve problems and examine questions

based on the topic under study. As the research progressed, Chisholm reports that students spent more extended periods working resiliently, which he defined as ‘students being’ encouraged to leave the Comfort Zone and move towards the Growth Zone. At the same time, he took care to ensure that learners were supported within this zone to avoid entering the Anxiety Zone. He reports that although the students were seen to struggle, he saw that the learners were not giving up as quickly when the learning got more challenging, indicating that they were more willing to push themselves, characteristic of persistence and perseverance as defined by Williams (2014). This willingness to push themselves was demonstrative of students understanding that mathematics learning entails some struggling sometimes.

While research on this construct was gaining momentum, the idea of measuring ‘mathematical resilience’ emerged. Kooken et al. (2015) proffered one of the first instruments for measuring mathematical resilience. In their study ‘Development and Validation of the Mathematical Resilience Scale’, they proposed the Mathematical Resilience Scale to measure students’ attitudes toward studying mathematics, using three correlated factors: Value, Struggle, and Growth. They reported that they developed and validated the Mathematical Resilience Scale using exploratory and confirmatory factor analyses across three samples. The results provided a new approach to gauge the likelihood of student participation and persistence in mathematics. They suggested that the Mathematical Resilience Scale could help identify reasons students lack persistence in mathematics while simultaneously providing informative ideas for interventions to improve the students’ mathematical resilience.

Similarly, and more recently, the idea of differentiating between Resilience in Mathematics and Mathematical Resilience emerged. Ishak et al. (2020) proposed these constructs be viewed as demonstrated in Table 2.1

Concept	Resilience in Mathematics	Educational/Academic Resilience in Mathematics	Mathematical Resilience
Definition	Behaviour that results from the process adapting with new situation or risk	An attribute in a person that displays based on the environment.	Positive stance when a person finds mathematics is challenging, and they will find new strategies to overcome it
Process / personal quality	Personal quality	Personal quality	Personal quality
Model involved	• Bourdieu & Passeron (1977) : Relational view. • Resilience concept (31) • PVEST (14)	• Resilience and Vulnerability (18). • The concept of resilience (20)	• Growth mindset theory (26,27)
Issues tackle	• Students at risk (family background, race, identity, family income).	• Student at risk (family background). • School environment.	• Mathematics anxiety. • Learner helplessness.
Approach to tackle issue	• Intervention on teaching use by educators.	• Modifying the school environment from traditional to a more communitarian school model. • Implement good coping skills.	• Coaching (for non-mathematical instruction). • Peer mentoring. • Problem-based learning. • Cognitive behaviour therapy.

Table 2.1: Distinctions between different types of resilience in the context of mathematics

Ishak et al. (2020) acknowledge that studies on resilience in mathematics learning will keep evolving. This evolution might change the interpretation of the three-term use depending on the direction of the studies done. They suggest that future research could focus on exploring how the process of resilience happens in a person and what interventions are needed to boost resilience, especially in mathematics.

To sum up, the studies on mathematical resilience sampled above all seem to indicate that mathematical resilience can be developed through some form of intervention. This intervention could be articulation (Johnston-Wilder & Lee, 2008), contextualisation (Thornton et al., 2012), through ICT (Lugalia et al., 2013) or using split-objectives (Chisholm, 2017). What is also clear from Kooken et al. (2015) is that an in-depth understanding of students' personal stances is quite beneficial, and the differentiations offered

by Ishak et al. (2020) allow for streamlined focus during the conducting of research. In light of this discussion, my research sits well within this body of literature.

2.1.4.5 Mathematical Resilience in this Research

Behavioural psychology-based interventions are commonly employed as strategies that can support improvement in student behaviour and motivation despite decades of research that has consistently found that extrinsic rewards harm students' motivation and achievement (Deci et al., 1999). Research further identifies counterproductive school discipline policies and procedures such as reward/punishment systems and exclusion practices (suspension or expulsion) to have an overall negative impact on student academic and social outcomes (Pane & Rocco, 2014). Improving school and classroom effectiveness requires developing a positive school culture, with more positive and effective practices and procedures. Resilience building, in general, and building mathematical resilience in particular, is one element of such cultures.

Dweck et al., (2014) describe mathematically resilient students as not easily derailed by difficulty, be it intellectual or social. They expound that resilient students see setbacks as opportunities for learning or problems to be solved, rather than as a humiliation. They say neither do the students see it as a condemnation of their ability or their worth, a symbol of any future failures or a confirmation that they do not belong. This view, Dweck et al. assert, is true in the case of a specific assignment as well as with studies in general. They conclude that mathematically resilient students know how to remain engaged over the long haul and deploy new strategies to move forward effectively. This perspective is akin to what Dweck et al. (2014) refer to as tenacity, and Duckworth (2016) refers to as grit.

If students are to expend their effort and energy in school, it is vital that they first believe their effort will pay off (Dweck et al., 2014). Research has shown that students' belief in their ability to learn and perform well in school, their self-efficacy (Bandura 1997), can predict their academic performance level beyond their measured level of ability and prior performance. Learners' belief in their ability to achieve in school can be very fragile. A critical question for resilience researchers is 'how well does students' self-efficacy survive when they confront inevitable school challenges?'. Bandura uses the term 'resilient self-efficacy' (Machida & Schaubroeck, 2011), about individuals with firmly established efficacy beliefs who remain strong regardless of how challenging the situation is. He says they can persist and even thrive in such situations. Based on this argument, poor performance in mathematics is therefore potentially avoidable if resilient self-efficacy is developed in students.

Given these studies and similar initiatives, and considering that UK mathematics performance is still lagging in world rankings (PISA, 2015), more work is needed to improve mathematics performance and prevalent mathematics anxiety. As good as these initiatives and programmes might be, the student's voice is noticeably lacking; there seems to be a lack of eliciting students' input. In their research, 'No One Ever Asked Me.', Williams and Portman (2014) reported that one voice that had gone unheard was that of the students themselves. The authors pointed out that few studies have explored students' perceptions of what they need to succeed academically in the face of exposure to adversity. The lack of students' voices is a severe oversight; a concern corroborated by Garakani (2014), who asserts that "Young people's voices are frequently overlooked in discussions about education development and policy. His article draws on a participatory action research project (2011-2014) in Nunavik on student resilience and school perseverance." (p. 233). Garakani (2014) concluded that "we

were able to catch a glimpse of their multiple identities. We also witnessed their strengths and some of their struggles, their courage and doubts, their determinations and uncertainties, their efforts to meet different expectations, and their hopes and aspirations for themselves and their community," (p. 251).

The arguments presented above clearly indicate the progression in addressing student beliefs. In the next section, I discuss some of the associated research towards transforming unhelpful student beliefs.

2.1.5 Towards transforming subjective views

To transform subjective views that hinder progress, an intervention of some sort becomes necessary. According to Bowen et al. (2009), "by intervention is meant any program, service, policy, or product that is intended to influence or change people's social, environmental, and organisational conditions as well as their choices, attitudes, beliefs and behaviours." (p. 452). My study focuses on supporting the development of mathematical resilience by transforming students' subjective views and their reactions to challenges and setbacks. The student-voice-eliciting tool and the intervention strategies that I chose to use are discussed in greater detail in Chapter 3; in this section, I spotlight hugely overlooked components of this combination, the role of students' understanding of how the brain works and the role of their voices.

2.1.5.1 Zones of Learning Models

Most students find many aspects of mathematics learning particularly challenging, giving rise to classrooms that present extraordinary contexts for students' emotional experiences. A lot of these emotional experiences are generated from the perception of threat more than the challenge. Traditional teaching and learning in the UK have taken on an 'instrumental understanding of mathematics' facet, "rules without reason" described by Skemp (2006, p.

20). This pedagogy can work well for, say, examination purposes for most students, but as the students come across a slightly different problem from ‘what the teacher taught me’, they struggle with what to do. If they are not used to challenges, this can invoke anxious feelings in students (Jamieson et al., 2010).

Previous research has shown that anxious students tend to avoid maths to try and manage their anxiety (Ashcraft & Ridley, 2005). Therefore, it has become imperative for students to develop a ‘management mechanism’ in their mathematics learning journey that will allow them to persist in their learning despite difficulties and barriers and thrive. To do this, I argue, students need to become aware of and acknowledge the different feelings and thoughts associated with their maths learning journey. To this end, researchers have looked to social constructivist Vygotsky (1978)’s Zone of Proximal Development Model (Figure 2.1), as a framework for addressing exploration and awareness of feelings and thoughts.

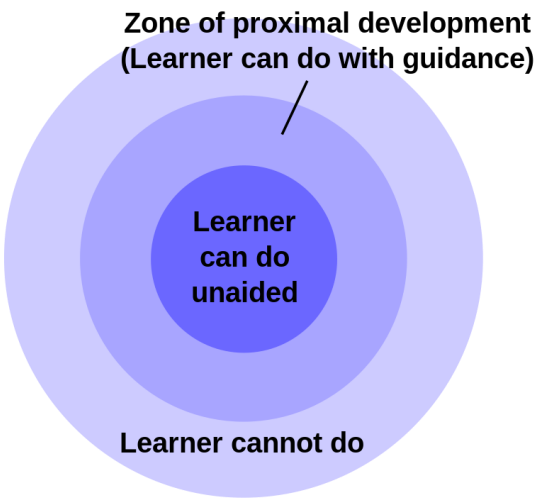


Figure 2.1: Zone of Proximal Development

In Gauvain and Cole (1997), Vygotsky (1978) points out that “the zone of proximal development furnishes psychologists and educators with a tool through which the internal

course of development can be understood." (p. 33), and the same understanding can be made accessible to the students themselves.

Over the years, successive researchers have offered different versions of the Zones of Proximal Development (ZPD) with an affective focus, with varying degrees of using the tool. One of the earliest such researchers was Senninger (2000). He adapted Vygotsky's ZPD model and called it the Learning Zone Model (Figure 2.2).

Figure 2.2: Learning Zone Model

In his study, Senninger (2000) suggested that the role learning zones play in any learning situation may be shown in Figure 2.2. He explained that developing an understanding of the zones model helps practitioners create positive learning situations and avoid situations that can cause panic. Furthermore, he pointed out that it also helps the individual better understand their own behaviour and reactions to different situations and environments and the behaviour and reactions of others.

Akin to Senninger (2000)'s assertion that understanding learning zones is helpful, Johnston-Wilder and Lee (2013) report that a positive teaching environment can help develop a belief that a student can make progress if awareness of the red zone is developed. In the mathematical resilience arena, Johnston-Wilder and Lee (2013) are considered the pioneers in

the UK of utilising a version of Vygotsky's ZPD model that focuses on emotion to underpin their work on developing mathematical resilience in students. They incorporated influences from Dweck (2006)'s mindset work and called their model the 'Growth Zone Model' (Figure 2.3).

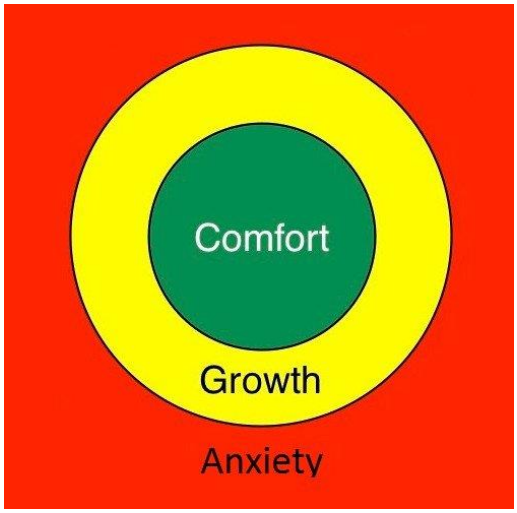


Figure 2.3: Growth Zone Model

Johnston-Wilder and Lee (2013) as well as Johnston-Wilder and Marshall (2017) outline that introducing the growth zone model and feelings associated with each zone can help students to recognise the different emotions involved in learning and distinguish between productive nervousness of the 'growth zone' and disabling anxiety associated with the 'anxiety zone'. Furthermore, and based on Siegel (2010), they point out that understanding and recognising emotions in the zones is a prerequisite to students learning to manage emotions. They point out that many students with mathematics anxiety may initially leap straight from the 'comfort zone' to the 'anxiety zone'. Within a supportive, positive teaching environment, students can learn to change or adjust to this leap and work at mathematics successfully and develop a belief that they can make progress. The size of the 'growth zone', it is worth noting, is thought to be different from one individual to another, and from one domain to another.

In another series of studies, Lugalia et al. (2015), whose original paper was published in 2013, also employed this Vygotsky-inspired concept using the version in Figure 2.4. The research by Lugalia et al. considered using ICT to support the development of mathematical resilience in students in Kenya.

Figure 2.4: Learning 'growth' zones

Like Johnston-Wilder and Lee (2013)'s findings, Lugalia et al. (2015) reported that minimising disabling anxiety associated with learning is of paramount importance. They argued that for effort (*learning*) to be both effective and safe, it needs to be focussed on the learner remaining within the growth zone and recruiting support from 'more knowledgeable others.' (c.f. perseverance; Williams, 2014). They posited that appropriate support would help students to learn whilst avoiding the danger of becoming overly stressed or anxious. Furthermore, they offered that ICT and peers can contribute to the role of 'more knowledgeable other'. Using ICT in pairs or groups can enable the learners to keep themselves safe and ensure that the learning (*and progress*) will be appropriately challenging.

Seth (2016) also proposed the version of the 'zones' idea (Figure 2.5). Seth's version introduced a different zone where, it seems, in the 'alarm zone' and the 'failure zone' students appear to experience similar emotions that seem to differ in intensity.

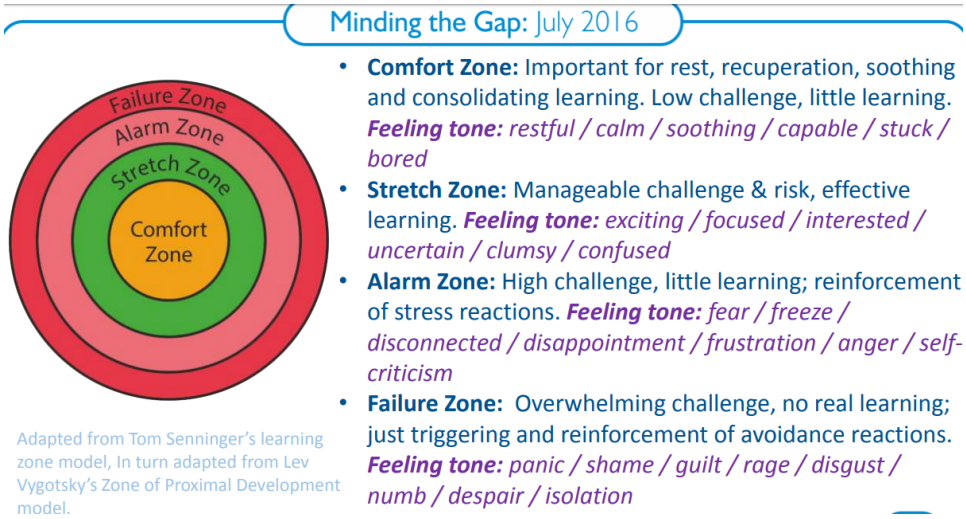


Figure 2.5: Minding the Gap

He identified a space between where an individual is now and when they want to be, ought to be or are capable of being. He pointed out that this gap between an individual's reality and their possibility is where individuals need to navigate, with great care. This is where an individual becomes paralysed and stuck in the situation. He pointed out that the magic of forwarding movement is for individuals to see this space as something that persistent and consistent effort can get them through. Furthermore, he advanced that the paths individuals take are the ones in which individuals can see the steps out of their situation. He posited that the individual's problems are not usually that they are not trying hard enough, but it might be that they see the opportunity in an 'unhelpful' way.

Chisholm (2017) used the model proposed by Johnston-Wilder and Lee (2013) (Figure 2.3). In planning his interventions, Chisholm felt it was essential that students are given a framework to feel sufficiently supported and encouraged to enter the growth zone. He argued

that care must be taken to avoid pushing students too far and too quickly into this zone because confidence and willingness to learn could decrease significantly if the students end up, in the process, entering the anxiety zone as this would limit future progress. Chisholm (2017) reported that he would "carefully consider the strategies [he] used to support the students in the Growth Zone; too much support encourages dependency, but too little support increases the risk of entering the Danger Zone." (p. 56). He reported that he took care to ensure that students were supported within the growth zone to avoid them entering the anxiety zone. He concluded from his research that working collaboratively and developing an active voice helped students work in the growth zone.

There are a lot of parallels that can be drawn from the findings of these sampled studies. These researchers seem to concur in terms of:

i. The need to support the students within some framework;
ii. Care needing to be taken in supporting students to navigate the transition from one zone to another;
iii. The importance of appropriate support within the 'growth/stretch/learning zone';
iv. Helping students manage their getting in and out of the anxiety/panic/aspiration/alarm/failure zone; and
v. Students' 'emotional safety' being paramount.

Although there were differences in the zones' names, the message conveyed by each author is that of highlighting where the focus should be placed. The Zones of Learning Model is the name I called my version because I felt it emphasises all zones of the learning model. It has three zones; the green (comfort) zone, the amber (growth) zone and the red (out-of-depth) zone. The Comfort Zone is where the content is 'easy', and there is no new learning, the

Growth Zone is where learners are introduced to new and 'challenging' material, and there is new learning with the right support. The Out-of-Depth Zone is where the content is too challenging and therefore is no learning at all. I deemed this a useful framework to introduce to the students before administering any intervention for the reasons stated in greater detail in Chapter 4. The Zones of Learning Model was a theme that ran through this study. Another model that ran through the study was the Hand Model of the Brain.

2.1.5.2 Neurology Studies

Interest in how the brain works is increasingly having an impact on numerous research projects about, among other things, education and counselling. Burton (2004) conducted one such study. His study reported on learning styles and neurolinguistic programming. Day (2008) researched classroom interventions that use the neurolinguistic program (NLP) modelling approach. Codrington (2010) also explored family therapists' interpersonal neurobiology and the adolescent brain while Schrag, (2013) reported on the future of neuro-education while Lorelle and Michel (2017) studied neuro-counselling. Schrag (2013) asserts that "[n]euroscience is a new frontier for educational researchers, some calling it, 'neuro-education', others, 'educational neuroscience'." (p. 29). It seems to make sense to hold a notion that a better understanding of the brain should lead to a better understanding of learning and teaching.

As the technology developed in a medical context became more refined and more readily accessible, new techniques emerged to support neural activity studies through non-invasive brain imaging, such as MRI (Alexander et al., 2017). These techniques made it possible to examine the brain activity levels during the mental processing of information and coordination of behavioural responses. Sausa (2017) pointed out that imaging technologies

fall into two major categories, those that look at the brain structure and those that look at the brain's functions. Even though an understanding of the brain structure is necessary to educators, an account of the brain's functions is even more so, as this is the aspect of the brain that affects learning.

There are several technologies used to look at how the brain functions. The use of functional magnetic resonance imaging technologies (fMRI) - a method of measuring areas of increased blood flow in the brain and therefore by inference, areas of more significant neural activity (Sausa, 2017) for example - proved particularly successful as a means of mapping the apparent organisation of brain function. Sausa goes on further to explain that "[t]his technology helps to pinpoint the brain areas of greater and lesser activities." (p. 3) and can therefore inform what different parts of the brain perform what functions. Taking this away from the 'laboratories' and into the classroom, Sausa (2017) points out that "[t]eachers try to change the human brain every day. The more they know about how it learns, the most successful they can be." (p. 4).

This assertion is echoed by Tolmie (2015) who asserts that "interest in the potential applicability of neuroscience to education stemmed initially from the growth of cognitive neuroscience - research on the relationship between the brain function in cognitive activity - during the late twentieth century." (p. 728). This claim resonates with Risley (2009)'s earlier assertion. He stated that brain-imaging technologies of neuroscience had brought neuroscience into the study of cognition in general and the study of teaching and learning mathematics in particular, allowing scientists to determine which areas of the brain are active when the mind is engaged in mathematics.

Studies focussing on the potential applicability of neuroscience to education have surged. A google scholar search in 2019 yielded over 2 million results. These studies are seeking further insights into the relationship between more primitive brain structures in evolutionary terms (e.g. the amygdala, which plays a central role in the processing of emotion) and more uniquely human structures (such as the prefrontal cortex, which is involved in the manipulation of information in the control of other systems).

One such study was proffered by Dr. Dan Siegel, a neuroscientist, well-known as a 'mindfulness' expert (Siegel, 2007; 2010) as well as for his work on how the brain is wired and how it matures through the medium of interpersonal neurobiology (Siegel, 2011; 2012; 2018). Siegel's centre of interest explored interpersonal relationships' role in forging critical connections in the brain, illuminating how promoting healthy interpersonal relationships supported resilience in children. In his book, Siegel (2011), offers insights into the whole-brain perspective. He suggests various strategies for using everyday interactions as opportunities to help children live a balanced, meaningful and connected life. He talks about how adults should undertake every interacting opportunity between a child and an adult with the brain in mind. An adult is conscious of and focuses on integrating the different parts of the brain. His work offers strategies for helping the child's left brain and right brain and the 'downstairs brain' and the 'upstairs brain' work together so that the child can be connected to their logical and emotional self. He also reports on the significance of helping children understand the functions of the brain's different parts and their role in their choices. He asserts that children should be made aware of their "capacity to pause and reflect on their own state of mind" because "[w]hen they do that, they can make choices that give them control over how they feel and how they respond to their world." (p. xi).

With that in mind, Siegel originated a simple illustration for explaining the interaction between ‘upstairs brain’ and the ‘downstairs brain’ that children can easily understand. In this illustration (Figure 2.6) he uses the analogy of a hand, and this is now widely known as the ‘Hand Model of the Brain’ (Siegel, 2011, p. 62-63)

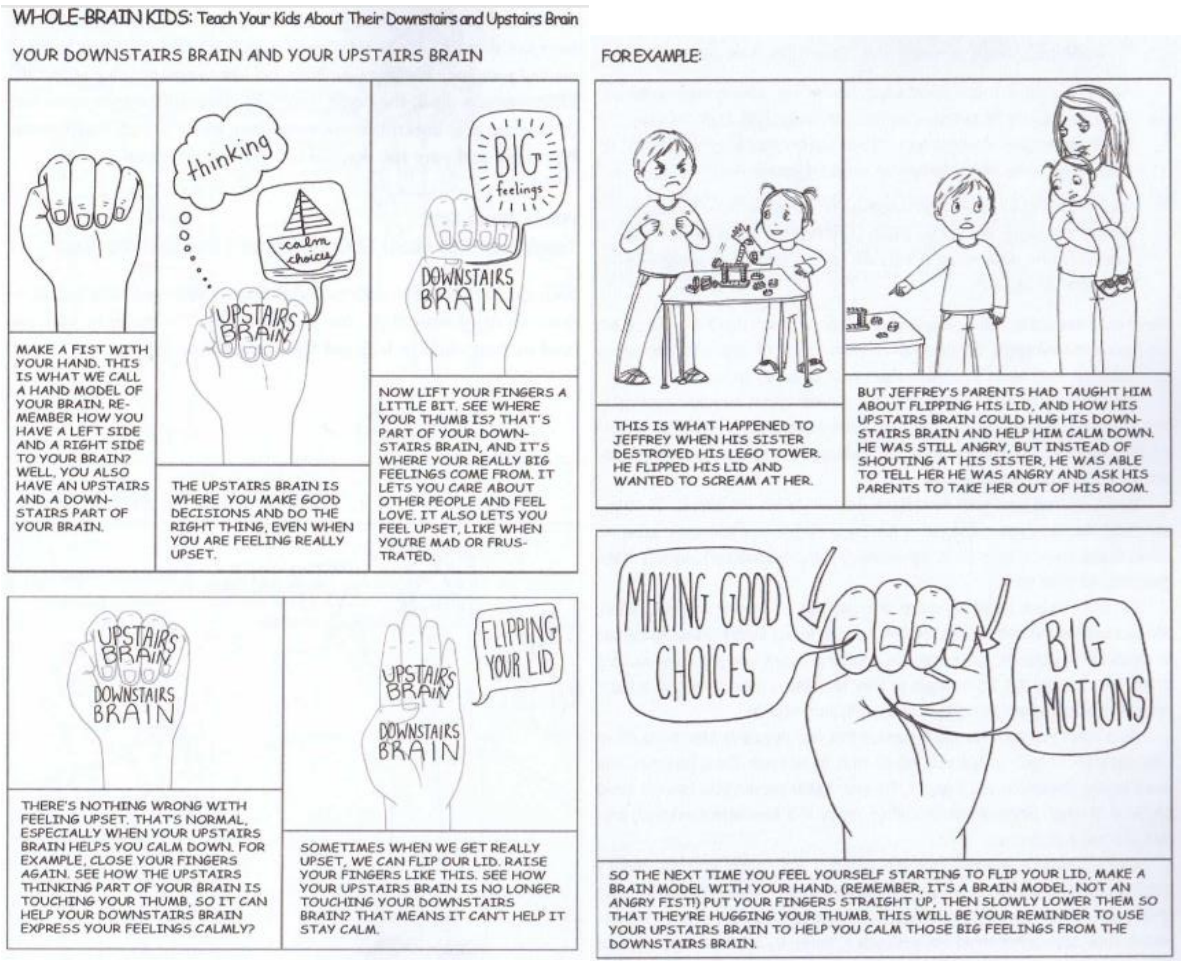


Figure 2.6: Hand Model of the Brain Story. Source: Siegel (2011, p. 84)

The Hand Model of the Brain is a short but impactful visual illustration of how our brain is structured and is also useful for explaining how the integration between different parts of the brain works. At the heart of this model is the student’s metacognition. Dr. Siegel’s key message when sharing his illustration is that when students understand (through the hand-model metaphor) what is going on in their brains, they can change what their brains do or think, thus practising mindfulness and self-regulation. He posits that schools that embrace teaching wisdom by using the hand model to enable students to understand what is going on

in their brains give their students a greater chance of managing their learning and making progress. Furthermore, he points out that teaching such reflection amid already trusting relationships between students and educators could support resilience development. Several researchers have subsequently used the hand model of the brain in studies covering a range of sectors. I discuss these in the next paragraphs.

Codrington (2010) explored family therapists' views into interpersonal neurobiology and the adolescent brain. She became interested in exploring and identifying some of the changes that occur in teenage brains. Her study was to find out how the new understanding of the brain can help interrupt teenagers' negative behaviour cycles and be used to facilitate improving relationships between parents and teenagers. She explicitly used the hand model of the brain in her research, as shown in Figure 2.7.

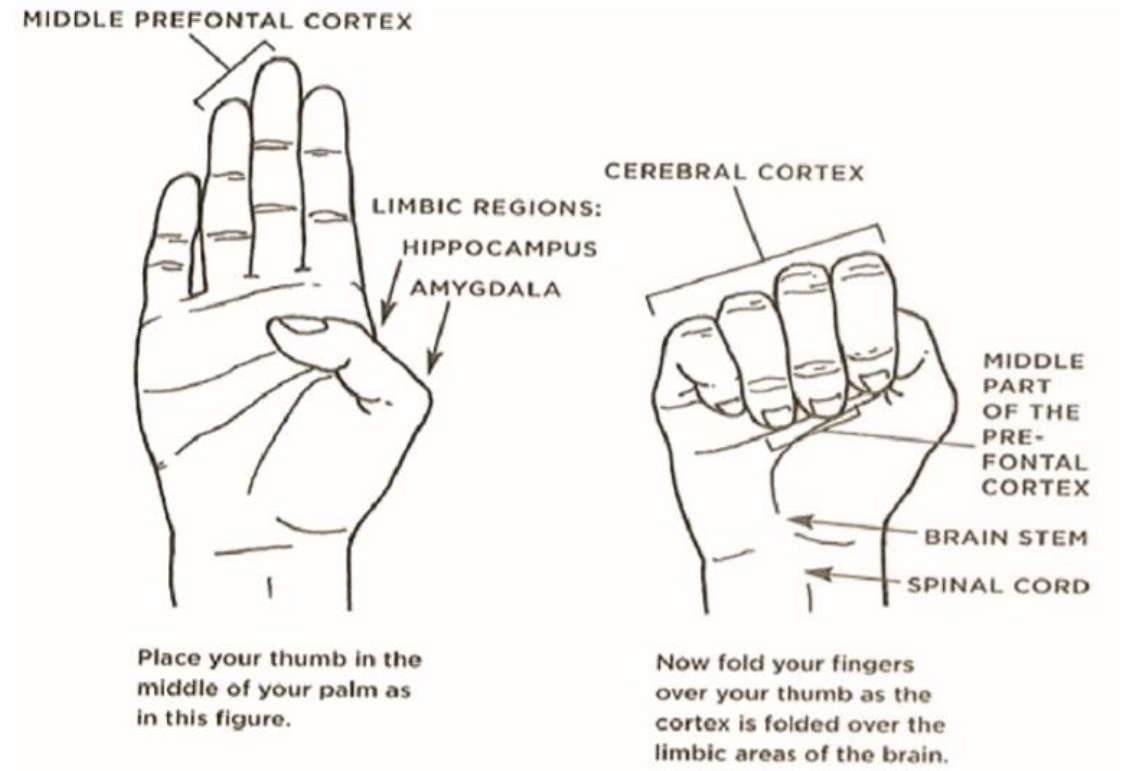


Figure 2.7: Hand Model of the Brain. Source: Codrington (2010, p. 287)

The phrasing in her illustration seems to suggest that she invited the teenagers to model this illustration. She reported that the teenagers responded more from the 'fast track' amygdala than the prefrontal cortex and could have trouble reading other people's faces accurately and reacting accordingly. Furthermore, she reported discovering that all parties involved could benefit from an understanding of the brain. She concluded that "[a] most interesting element is that through the interest families show in these concepts and the focal attention it brings to their interactions with each other, they begin to alter their brain structure and move towards integration through this science of mindfulness." (ibid, p. 299). Codrington seems to concur with the idea that young people would benefit from being introduced to neurology science.

Lorelle and Michel (2017) investigated neuroscience's possible usefulness to professional counsellors. They refer to this as neuro-counselling and define neuro-counselling as integrating neuroscience into counselling to treat behavioural or psychological challenges. They also presented the hand model of the brain as a visual representation which "allows individuals to recognise how parts of the brain are connected and influence human *behaviour* throughout their lifespan." (p. 107). They concluded that professional counsellors should consider brain changes when "designing interventions and providing psychoeducation to clients about their mental health and wellness" (p. 115), a clear suggestion for considering neurology in planning but not as explicit in terms of sharing neurology information with clients.

Schrag (2013) explored the idea of whether there is a future in 'Neuro-Education'. He reported that "no one challenges the notion that the brain is involved in everything we do, including, of course, school learning. Therefore, I don't deny the possibility that neuroscientist will contribute to enhancing academic performance in the future." (p. 28). What he argues is that people can enhance memory or concentration through the development

of drugs. Therefore, Schrag (2013) asserts that "if my argument here is sound, teachers and curriculum makers, though they may be enthralled by the work of neuroscientists, cannot expect that work to inform or guide their own practice." (p. 29). Schrag seems to acknowledge the value in neuroscience but is still to be convinced about its perceived impact on teaching and learning.

Irrespective of whether the knowledge of the brain's functions and structure is shared with young people or clients, the studies presented all seem to agree, to some extent, that neuro-education plays and should play a role in preparing young people to function safely in society. Educators need to become much more aware that neuroscience, finding out how the brain works, could improve learning. This awareness, as shown in the discussion, could have implications for what happens in classrooms. I believe that this focus on understanding the brain, its functions and development can improve the quality of the teaching profession's performance and help young people learn better.

2.1.5.3 Student Voices

The student's voice is an emerging force for change and improvement in many UK schools (Johnston Wilder & Lee, 2013). As indicated in the previous sections, and Figure 2.1, my research aimed to raise the students' awareness of how learning 'mathematics' occurs in their brains and enable them to use their newly formed self-regulating skills to best learn in their mathematics lessons. Crucial to introducing these skills to the students are their current feelings about how they were taught mathematics (Ruffell et al., 1998; Collins, 2004), so these were elicited before the commencement of the interventions as described in greater detail in Chapter 3.

One of my drivers for eliciting students' views in my research was my firm belief that students' stories, the storied pasts they bring with them to the classroom and the storied meaning they make of their learning, are important (Williams & Portman, 2014). Since students' stories, I believe, are one of the most influential shapers of their exertion to both learning and acquiring knowledge, it made sense to attend to ways in which students' voices are actively used in their selection into intervention programmes. In turn, I begin to model how I would shape the possibilities available for the students. Since 1995, research started emerging, which spotlighted the students' voices in the education system. A growing number of researchers have identified student voice as helpful to understand personal and cultural barriers within students learning (e.g. Lincoln, 1995; Graham, 1995; Mitra, 2001; Silva, 2001; Yonezawa & Jones, 2007; Christidou, 2011; Mkimbili & Ødegaard, 2019). Lincoln (1995), for example, in her study 'In Search of Student Voices', concluded that students are, after all, primary stakeholders in their learning processes, and suggesting their voices have to take precedence as they might be different to the adults' views. This view was echoed and extended by Graham (1995), who pointed out that "children's views and adults' views of classroom reality may not necessarily be synonymous" (p. 365). Graham (1995) further argued that the best learning happens when teachers genuinely understand the students they teach. These 'gifted' teachers have 'put themselves in students' shoes' and created and implemented learning experiences that are truly tailored to and beneficial for their students.

Mitra's (2001) and Silva's (2001) research demonstrated how students' voices could be embedded in reform planning and implementation. Yonezawa and Jones (2007) also argued that utilising the student's voice is rare in educational reforms; even though they are the recipients of reformers' good intentions, these students are infrequently asked their opinions to what enhances or detracts from their learning. Christidou (2011) reported that aspects of

students' voices seemed to be interrelated and affected students' achievement in sciences and their relevant study and career aspirations. This view was echoed by Mkimbili and Ødegaard (2019) when they posited that science teaching and learning in the classroom needs to involve learners' voices.

These studies are clear mandates for learning from student voices. Reasons for listening to students can be seen through several different lenses, as is the case for most social research. The studies I sampled in this section provide some of these lenses.

To sum up, there is no doubt that students would immensely benefit from learning and developing character traits and responses to challenges that would enable them to succeed. In this study, I argue that educators can enhance this learning if they help students understand their and others' reactions to learning challenges, the workings of the brain, and being allowed to have a say in their learning journey. As educators, listening to students should take precedence over our assumptions and observations. My study adds another aspect of this 'listening to students' voices', their interpretation of their own learning. Based on the literature sampled and my firm belief in the importance of the students' voices, I believe that excluding students' voices in learning programmes is an absurdity.

The role of gender, which I alluded to in an earlier section, cannot be overlooked in this quest to support the development of coping mechanisms and mathematical resilience. The next section explores that in more details.

2.2 Gender-related resilience

Allana et al. (2014) advanced the idea of gender-related resilience. They reviewed studies on psychological resilience and found that it was "unsurprising that psychological resilience varies by gender, culture, group, context and time." (p. 11). Wasonga, Christman and Kilmer

(2003) found that “female students had a wider variety of protective factors predicting academic achievement than male students.” (p. 70). They concluded that in general female students displayed more resilience than male.

There is a whole host of studies on gender in mathematics learning. The literature review on women and mathematics learning demonstrates that it has been a historically accepted belief that males achieve better in mathematics than females (Neuschmidt, Barth & Hastedt, 2008). In a TIMSS (2003) article entitled ‘Trends in gender differences in mathematics and science’, it was reported that “in all three cycles of TIMSS, more countries display a significant difference in favour of boys over girls.” (p. 57). The report further explained that “using a regression approach to compare the trend data, the findings indicated no major changes for mathematics, but it appears that the gap in science may be closing, especially in the previously male-dominated content areas of chemistry and physics.” (p. 56).

To understand this ability gap in performance, research is needed on factors that could contribute to this disparity. One of the early platforms used to acknowledge the urgent need to explore and understand this gulf in performance was a conference held at Chelsea College in 1975. In her study ‘Girls and Mathematics and Science: An annotated bibliography of British Work (1970-1981)’, Kaminski (1982) cites the Chelsea College conference, perhaps with the help of the 1975 Sex Discrimination Act, as having brought particular attention to the issue of women in science subjects. Future researchers and educators would attribute much of the imbalance between male and female performance in science subjects to the interaction of social, cultural, psychological and educational factors.

In their research that explored, among other things, sex-related differences in affective factors, Fennema and Sherman (1977) measured how strongly male and female students

stereotyped maths as a male domain. The results from this measure, they reported, indicated that in all four high schools involved in their study, while boys did not stereotype mathematics strongly as a male domain on the presented scale, they always stereotyped it more strongly than females. Results from this study seem to suggest that the difference in performance could be explained by stereotype. Fennema and Sherman (1977) further pointed out that, judging from the size of the correlations between mathematics achievement in the affective variables, it may be that stereotyping mathematics as a male subject is a mediating variable affecting other relevant traits, for example, resilience.

Although this research was conducted over 40years ago, it seems to concur with the TIMSS reports of 1995-2003 and resonates with later research (Spencer et al., 1999; Oswald & Harvey, 2003; Keller, 2007). In these studies, they found that where female students are exposed to 'negative' stereotypes, this negative stereotype impacts their engagement and performance. For example, Oswald and Harvey (2003) carried out a study using Q-Methodology to explore women's subjective reactions to and experiences with mathematics. They found three unique groups: the 'Successfully Encouraged, the 'Mathematically Aversive' and the 'Stereotypically Discouraged'. This third group, they explain, consisted of women who were aware of negative stereotypes. They reported that it was possible that this group may have been experiencing stereotype 'threat', which means they may have been facing a psychological barrier about mathematics without even performing any mathematics tasks. The researchers pointed out that being aware of gender stereotypes about mathematics results in psychological pressure on women when performing maths tests, which then creates anxiety that interferes with task performance. Furthermore, they argue that women who experience stereotype threat will eventually dis-identify with maths to protect themselves.

They report that this partly explains the neutral attitudes and self-reported *dis*abilities towards maths.

The 'stereotype affect' finding resonates with Eccles (1994). Eccles (1994) found that using the theoretical model of achievement-related choices (Figure 2.8), she could predict that women exposed to gender role stereotype will be less likely to pursue maths careers because of intense discouraging experiences and awareness of gender stereotype.

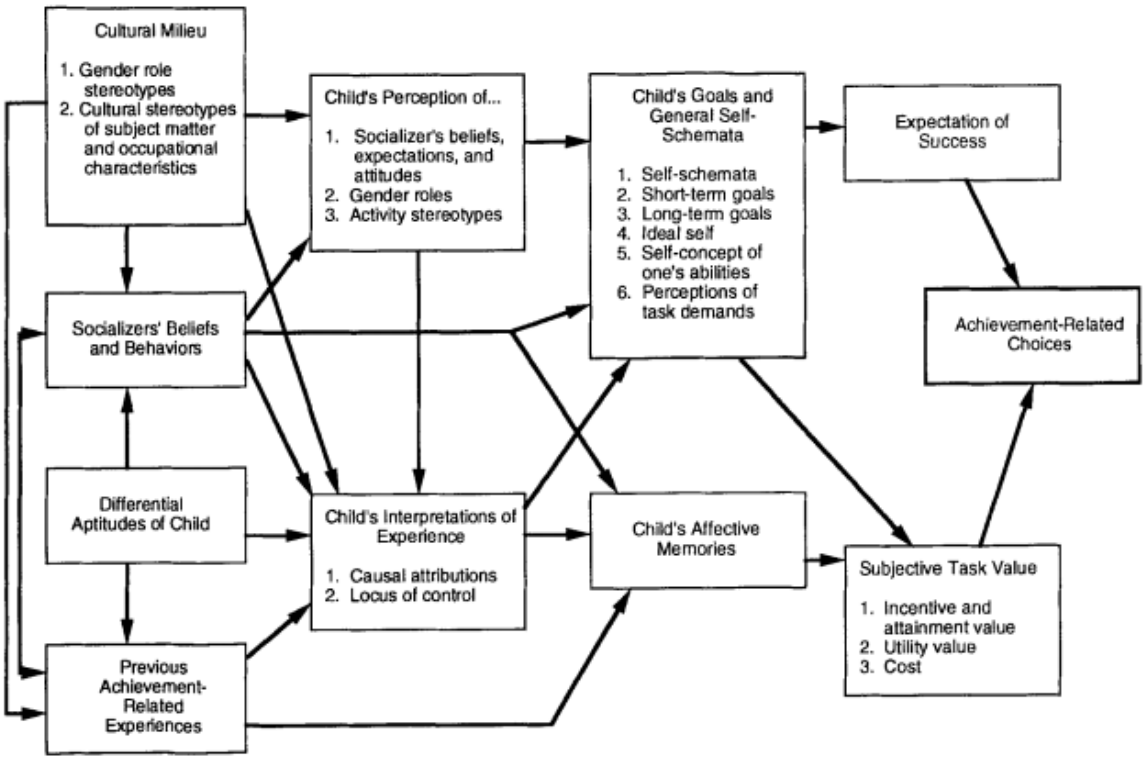


Figure 2.8: Theoretical model of achievement-related choices Source: Eccles et al. (1983, p. 69)

Spencer et al. (1999) further supported that when women perform maths, unlike men, 'they risk being judged by the negative stereotype that women have weaker maths ability'. They called this 'predicament stereotype threat' and concluded that their study indicated that the apprehension caused by this perceived threat might disrupt women's maths performance. Keller (2007) reached a similar conclusion; his study supported the proposition that reducing negative stereotyping's applicability led to increased performance by stigmatised group

members. The sampled studies suggest that stereotyping partly explains the difference in mathematics performance between male and female.

Boaler (1997) reported on a study in which she compared two schools that approached mathematics teaching in two different ways. At one of the schools, Amber Hill, students worked predominantly from textbooks, every lesson which meant that for the vast majority of time students experiences of maths involved short, procedural and closed questions. At the other school, Phoenix Park, they did not use textbooks. Teachers designed the curriculum and is comprised of a series of different open-ended projects. Boaler pointed out that many girls became disaffected by, and disillusioned with, their school mathematics at Amber Hill school. She further explained that these girls achieved less than a similar cohort of girls at Phoenix Park and were considerably more disaffected.

On the other hand, she explained, the boys at Amber Hill adapted well to textbook work and tended to enjoy rushing through questions to achieve speed, if not understanding. Boaler (1997) concluded that even though previous research has reported negligible effect sizes to avoid the danger of forming expectations based on learning styles, it would seem quite dangerous to ignore gender-based preferences in learning styles. In mathematics teaching, schools teaching is biased towards one sex. She points out that mathematics, as it is currently and widely taught, is not equally accessible to two girls and boys, which appears to relate to pedagogy preferences. Her research revealed that females who find that schools' pedagogy favours boys' learning styles will be less likely to engage in and pursue maths-related careers.

The studies I have sampled have reported that stereotype, pedagogy, and culture (among other factors) play a role in young females' navigation of their learning journey. Although these researchers have documented some affective factors peculiar to girls, they have not

explored or reported what the women in their studies say about their own mathematics learning; there is a distinct lack of women's voices and their subjective experiences in mathematics learning.

Oswald and Harvey (2003) used Q-Methodology to elicit women's views on their mathematics learning and considered the impact of these reported views on their mathematics learning. They wrote that women who reported negative attitudes towards mathematics would probably have negative experiences or be aware of negative stereotypes. These women would have experienced a lot of mathematics anxiety, would be perceiving their ability to be low and finding maths personally unimportant, all of which can impact their engagement and resilience. Research on mitigating these types of outcomes has been ongoing and continues. Steps are being made towards narrowing the disparities between boys' and girls' performance in mathematics.

TIMSS (2011-2015) reported that, although mathematics achievement trends by gender showed little change and that in both assessments, boys had higher mathematics achievement in more countries than girls; "11 countries, compared to 2 for girls". (p. 15) at fourth grade, nevertheless, at eighth grade "In 7 countries girls had higher achievement in both assessments compares to 2 countries for boys." (p. 17). Something seems to be shifting and any research towards narrowing the gap, even more, would be desirable because studies have shown that this achievement gap in education relates to other sources of division in society, such as post-school opportunities (Aikman, & Unterhalter, 2005). Boaler (1997) alluded to this shift in her paper 'Reclaiming School Mathematics: the girls fight back', where she reports that in one of her study schools the teachers achieved narrowing the gap by changing the system, i.e. reconstruction of school mathematics, and not the girls.

Before I conclude, I will briefly address the question of single-gender versus co-educational education. Even though my research does not seek to compare the two, I include this section because my research context is a girls' school and I found Doris, O'Neil and Sweetman (2013)'s study an exciting study to be aware of.

While examining the impact of single-sex education on mathematics achievement, Doris, O'Neil and Sweetman (2013), found that, contrary to suggestions in the literature, their research provided no evidence that single-sex schooling helped to narrow the gap. They ascertain that their study revealed that "[i]f anything, the gender differential is larger in children educated in single-sex schools than coeducational schools." (p. 104).

This discussion does not intend to ignore or make light of challenges boys encounter, but there is a consensus that girls surpass the boys on the 'challenges' stakes (TIMSS 2011 - 2015). If girls are not already as resilient as possible, then schools should channel more resources to foster resilience and develop these desirable traits.

In this study, I explore any evidence of stereotype, psychological and pedagogy and their impact on girls' learning journey.

2.3 Addressing the effect of other variables

Research literature related to education, child development, and psychology suggests that several variables significantly impact individuals' academic and social competence. The school environment, the curriculum, the family system, the classroom environment, and peer and community relationships can all impact a child's development of resilience. In this research, I decided to disregard these factors as constant and focus on the students' subjective opinion of their mathematics learning. Most of the other factors are either geographical or extrinsic. However, subjective views of self are intrinsic. They are an integral part of self, so

if this aspect can be managed effectively and changed, any individual would be able to cope better in any geographical or otherwise situation (Machida & Schaubroeck, 2011). Learning strategies and processes to deal with challenges will enable young people to thrive more in any environment. My research aims to equip young people with such skills.

2.4 Towards a resilience-focused systemic paradigm in mathematics classrooms

One of my study aims was to implement strategies that subjective views and literature suggested could help support students' development of mathematical resilience. This study's complete fulfilment would be to translate the study's findings into a practical scheme/programme for initiating truly transformative change in classrooms, moving towards resilience-focused teaching. Nicoll (2014) supports such a resilience-focused approach and asserts that a systemic paradigm would offer a more student-focused perspective that would address mathematical resilience and the interaction effects of all other factors involved in students' mathematics learning.

However, this resilience-focused approach would require educators to recognise that any one of the effective factors can indirectly affect students' mathematical resilience. Drawing on wider research and consistent with what Waber (2010) has termed 'developmental cascade', Nicoll (2014) pointed out that multiple strategies are recognised as combining to contribute to, and maintain, a student's resilience in learning. This idea became one of the influences for my choice of the three intervention strategies I used. I concluded that combining at least three strategies would fulfil the 'developmental cascade' prerequisite and support student resilience, as shown in Table 2.2.

Strategy	Intended for:
Mind-set Matters!	Modifying 'self-talk' from negative to positive to facilitate continued engagement with task at hand.
Split Page	Taking focus away from perceived personal 'inadequacies' to aspects of the problem that presents challenge. Deepening interaction with the challenging work by focusing on at least one aspect at a time.
Mathematical Resilience Pit/6Bs to Mathematical Resilience	Building in more 'structure' into the beginning to find a solution to the challenging work.

Table 2.2: Possible approaches to supporting the development of mathematical resilience

2.5 Chapter Summary

Student voices were at the forefront of my thinking when designing my research, to elicit students' subjective views. While research has moved in the direction of increasing positive stances to learning, I argue that to increase these positive stances to learning effectively, the participant has to voice the process. They must not feel that this is being done to them but rather that they played a part in the process. In the next section. I discuss a methodology that enables me to elicit participants' subjective views and identify negative views that leave individuals susceptible to non-resilience.

Dr. Siegel's Hand Model of the Brain seemed to me to be a good enough entry point into beginning to navigate this idea. The simplicity and clarity with which the most useful parts of the brain are explained seemed to allow both access and confidence to explore this complex neurology concept with students.

In this chapter, I have presented the literature that influenced the direction of my study. I explained the research that influenced some of these initiatives and the journey these studies took, from focussing on decreasing negative affective factors to focussing on increasing positive stances to facing challenges in learning. I also discussed literature on constructs I

deemed could facilitate a transformation of subjective views because I am exploring the hypothesis that transforming subjective views is key to enabling students to manage their reactions and experiences to learning tasks.

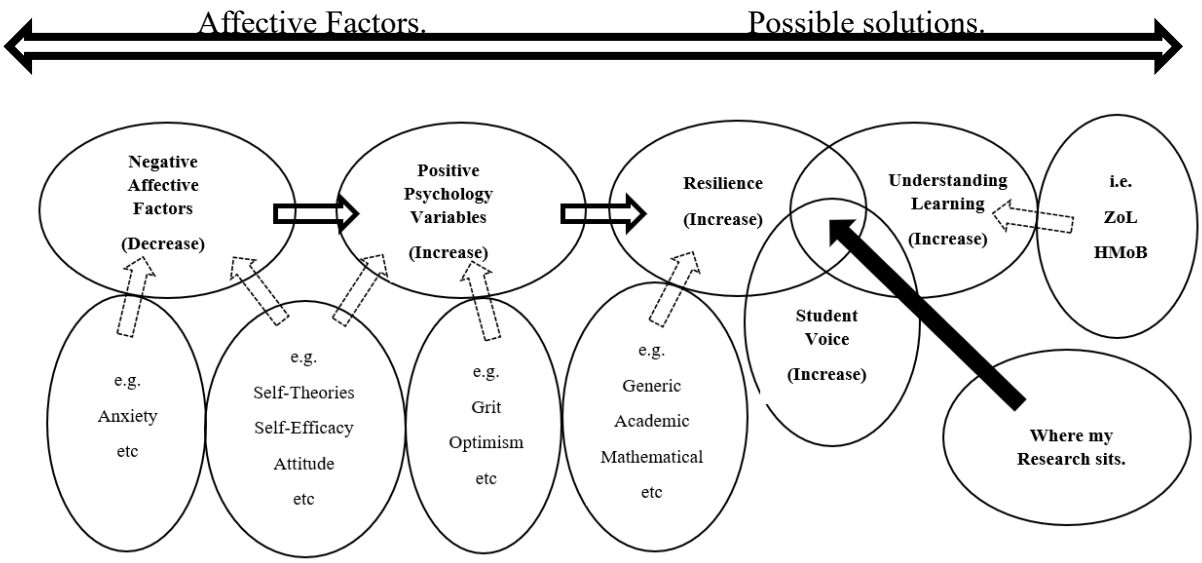


Figure 2.9: Overview of prevailing literature and how I discussed it

In the next chapter, I present the research design that will facilitate this quest.

Chapter 3 – Methodology

Introduction

In this chapter, I discuss the ontological and epistemological stance I took, the methodology and methods I chose to address the research questions, and the data collection and analysis methods I utilised to conclude this study's findings.

One of the critical factors in determining the quality of students' educational experience is the skills that will enable them to navigate learning challenges successfully. This equipping of students is most effective when conducted by and for those taking action simultaneously with doing research (Pithouse et al., 2009; Mertler, 2019). Action research, the "systematic inquiry conducted by those with a direct, vested interest in the teaching and learning process" (Mertler, 2019; p. 54) is one such research framework. As pointed out in Chapter 1, one of the driving forces for my undertaking of this study was my 'off-guard' experience as a secondary school mathematics teacher in the UK. The action research framework provided me with a platform to support the students in my care and equip me with tools that I could use to manage these situations better. As a researcher-practitioner, there are research principles I needed to observe to produce trustworthy findings. I describe these in the succeeding sections.

As described in Chapter 1, my research explores the role of subjectivity in supporting mathematical resilience development, in conjunction with strategies and learning models I carefully chose as the best or most suitable. This chapter of my research project outlines the research framework on which I based my research design. I examine the fundamental elements of action research, namely ontology, epistemology and the different philosophical perspectives in which my research is grounded - which I collectively refer to as my research

paradigm (Corey, 1953; Kuhn, 1962; Johnson, 2008). My chosen research paradigm was useful in providing me with a form of cognitive scaffolding that guided my research.

Guba (1990) forwarded the research paradigm description that guided my study. The paradigm is characterised through the philosophical fields of ontology (What is reality?), epistemology (How do you get to know this reality?), theoretical perspective (What approach can be used to get to the knowledge of this reality) and methodology (How do you go about finding out about this reality?). Figure 3.1 gives an overview of the relationship between the paradigm elements, and I use this diagram to structure the rest of this chapter.

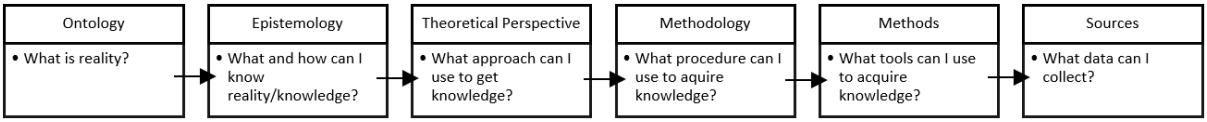


Figure 3.1: The Research Paradigm (Patel, 2015)

3.1 Ontology

Two main aspects of my study, subjectivity and resilience, drove my choice of ontological stance. I begin this account of my ontological stance by drawing from Johnson's (2008) book, 'A Short Guide to Action Research.'. Johnson's (2008) section on ontological perspectives described three views of reality or ontological perspectives. These were materialistic monism (where reality is an objective universe separate from the observer), dualism (where reality is a personal construction based on the objective and subjective reality) and transcendental monism (where reality is just a dream that exists in the metaphysical dimensions).

I decided dualism was most suitable for my research aims; the dualism view of reality is also consistent with constructivism (Watts & Stenner, 2012). The dualist, constructivist approach was particularly appropriate for my research when considering I wanted the students' subjective views of reality to take a key role in my research design. Within my research and in line with the dualist, constructivist approach in which: i) knowledge is constructed by

individuals as they interact with their environment, ii) learning is an inner state that involves constructing and cognitive 'webs' and iii) the primary psychological perspective is cognitive psychology (Johnson, 2008), I sought to gain an understanding of these aspects pertaining to the students in my research group through tailored activities.

Watts and Stenner (2012) further consolidated my constructivist stance. They forwarded that constructivism concerns itself with individual personal viewpoints and knowledge structures as primary research targets. Watts and Stenner (2012) drew attention to the distinction between constructivism and constructionism. They pointed out that, unlike constructivism, constructionism concerns itself with shared viewpoints as it seeks to identify "the current predominant social viewpoint and knowledge structures relative to a chosen subject matter." (p. 42). Although both these approaches appeal to me, I am primarily interested in the individuals' personal viewpoint (personal subjectivity) while at the same time intrigued by the shared subjective perspectives of my chosen groups as a stand-alone entity. Watts and Stenner (2012) helped me justify and clarify how I intended to produce knowledge about, among other things, students' conceptualisation of their mathematics learning. I was able to locate my research aim and research questions more firmly in a constructivist perspective (as described by Watts & Stenner, 2012) with some intriguing constructionism elements (again, Watts & Stenner, 2012).

As shown in the discussion, subjectivity's ontology is located more firmly within a constructive perspective. However, the ontology of resilience is concerned with whether the reality of resilience is a trait (Maltby et al., 2015) or a process (Windle et al., 2011) or a combination. Chandler (2014) reports that "Resilience asserts a[n] … ontology of interactive emergence where knowledge which needs to be acquired can only be gained through self-reflexive approaches" (p. 47). Chandler (2014) asserts that the reality of whether resilience is

a trait or a process could be established through 'self-reflecting'. Self-reflecting is a key component of subjectivity. Therefore, by deduction, it would seem that the ontology of resilience is also located within a constructivist perspective. Consequently, it would also sit, side by side, with the subjectivity part of my research aims.

3.2 Epistemology

The idea that educational professionals should research their own practice and use the findings of their research to improve that practice goes at least as far back as the beginning of the last century (Lunenberg et al., 2007), where the argument put forward was that research aimed at change should be conducted with or by the people who are directly involved in the situation that needs to be changed. This assertion consolidated my decision to conduct this research as an action research study; as a teacher, I was directly involved in a situation that needed changing. I combined the roles of a teacher and a researcher (Hopkins, 1993).

At the core of the epistemological stance, I have chosen as a teacher-researcher to identify a knowledge-generating system that would enable me to discover the required knowledge. At this epistemological level, I recognise an interactive relationship between me as a teacher-researcher and the students. Different perspectives and individual experiences cater to the complexity and particularity of this situation. The reality and knowledge-generating system I utilised was needed to minimise any adverse effect of the teacher-researcher position. These points are discussed in greater detail in the Methods section (3.5) of this chapter.

As explained in section 3.1, I chose to take the constructivist approach as my primary approach with the constructionist approach taking a minor role. The epistemological viewpoint within these approaches is the same (Watts & Stenner, 2012). They seek to answer the question 'how might researchers discover the intended students' viewpoints and

knowledge structures on their mathematics learning, whether individually held or shared. In my study, the end goal was supporting the development of resilience in students while simultaneously improving my practice. Using established 'viewpoint eliciting' methods fits my epistemological aim of exploring students' viewpoints. Such techniques provide a platform for identifying as many views as possible around my chosen subject matter, subjective views on mathematics learning.

3.3 Theoretical Perspective

A philosophical or theoretical perspective describes the philosophical orientation of the researcher that guides his or her actions. It shapes the researcher's choice of methods and affects interpretation, communication and application of results. In gathering and analysing the data in my study, I took a constructivist approach rooted in grounded theory (as described by Charmaz, 2006). The assumptions of the constructivist approach are consistent with the theoretical stance I took in my research: that many different views of reality exist, and that, as the researcher, in attempting to explore understandings from 'inside' the domain, I could potentially become part of and might be affected by, the participants' world; the data collection and interpretation could be affected by shared experiences and relationships. My use of the word 'participant' in this instance indicates the students' contribution to the research with data collection and interpretation. Results are produced through collaboration between me, the researcher, and the target population during the implementation, data collection and interpretation stages. Furthermore, grounded theory entails collecting, reflecting, and interpreting data in an iterative process (Knigge & Cope, 2006); this iterative process fits in well with the cycles of planning, action, observation, and reflection in action research. Therefore, I decided to conduct my research through the action research cycles of the Action Research framework.

The discussed stances primarily addressed research sub-question 1, which reads ‘What are the girls’ subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions’. I discuss Q-Methodology in section 3.5.1. The individual, personal viewpoints and knowledge structures of my students are my primary research targets. The data collected through the Q-Methodology, for example, provided valuable information that enabled me to design further activities that I could use to address any affective dimensions that emerged.

3.4 Methodology

The place of action research methodology in education has been established by numerous studies in the last couple of decades. A search in EBSCOhost using the phrase ‘action research in education’ yielded over twenty thousand results from various sources. Action research is typically associated with hands-on, small-scale research projects. Specifically, action research is concerned with practical issues and problems that arise as a routine part of any activity in the real world (Denscombe, 2010). The thinking behind the action research approach is that researchers should seek and gain a better understanding of the problem at hand and set out to alter things (as part of the research). Therefore, action research presented and still presents opportunities for researchers and teachers to develop and enhance practices. As the latter, a teacher, I conducted this research while being conscious of the inherent effect of being an insider teacher-researcher.

3.4.1 Action Research Models

In this section, I present the action research model I opted to use in my research. Despite all the iterations that the model of action research went through over the years, the core message was not lost: solving problems or, in the context of the classroom, improving learning

(Rapoport, 1970). In terms of the classroom, action research has been defined as studying school classroom situations to understand and improve the quality of learning and teaching (Johnson, 2008; McNiff & Whitehead, 2010; Forster & Eperjesi, 2017).

In deciding which Action Research model to adopt for my research, I initially went to Lewin's action research as a research framework. Lewin (1946) offered the model of an action research cycle, as shown in Figure 3.2.

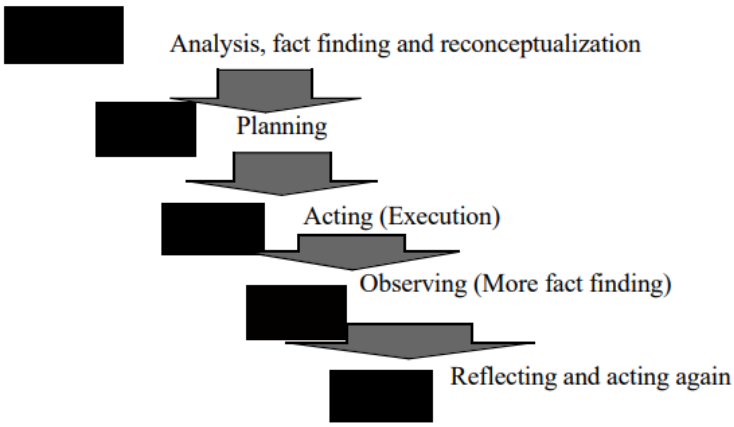


Figure 3.2: Lewin's action research model (Dickens and Watkins, 1999, p. 38)

Based on Lewin (1946)'s original definition and further research I settled on the model of the action research cycle offered by Nelson (2014) as well as the 'series of cycles' as provided by List (2006), as shown in Figure 3.3. At its simplest, Nelson (2014) in Harris and Kaye (2017, p. 7) offers a 4-stage action research cycle.

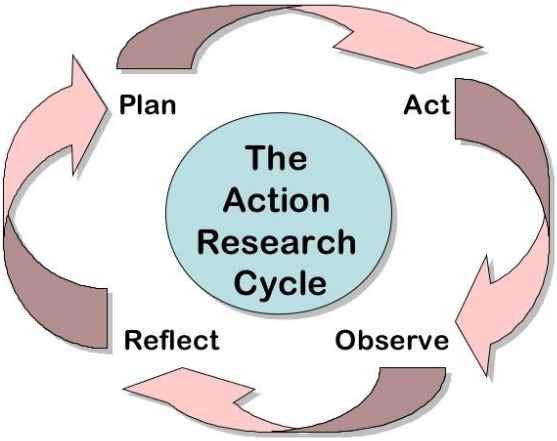


Figure 3.3: The action research cycle (Harris & Kaye, 2017)

which fits into List (2006, p. 677)'s offering (see Figure 3.4).

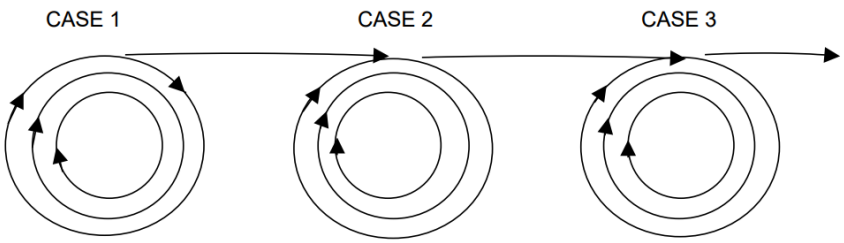


Figure 3.4: List's action research model (List, 2006, p. 677)

The illustrations demonstrate the 'process focus' of action research that involves several steps or parts that are cyclic, characterised by reflective and developmental cycles of activities (Forster & Eperjesi, 2017). It is a combination of these two models that I used in my research: the cyclic model of each ARC and the spiral model of a series of ARCs.

3.4.2 Why Action Research in this study

Unique to the action research paradigm is that it allows research and practice to coexist and co-work simultaneously in solving problems. Therefore, I chose to plan my study around the action research framework because I intended to improve learning and my practice while I studied the construct of mathematical resilience. Furthermore, a significant benefit of Action Research was succinctly forwarded by Denscombe (2010), who pointed out that Action

Research addresses practical problems in any given society to feed the results back into practice. Action Research is, therefore, driven by need and should also bring actual improvement.

Drawing on broader research, Denscombe asserts that Action Research "directly addresses the knotty problems of the persistent failure of research in the social sciences to make a difference in terms of bringing about actual improvements in practice." (p. 131). Action Research finds a very convenient environment within a school setting that could be instrumental in providing an excellent opportunity to redirect research back into the education system. Another advantage of Action Research is that it facilitates the participation of practitioners in the research process. This facilitation democratises the research process and, depending on the nature of the partnership, generally involves a greater appreciation of and respect for practitioner knowledge. In this regard, I believe I have the best of both worlds, in that while Action Research is best suitable for the type of research I am interested in, I am also best placed to conduct such a study. I will need to be careful about being over-involved to the extent that personal biases affect analysing the findings.

It is essential to acknowledge that, like any research framework, Action Research is open to criticism primarily because of some of its key features. These will be addressed in Chapter 6 when I discuss the limitations of the study.

3.5 Methods

In this section, I discuss the methods I utilised to conduct this study. I use my Research sub-Questions to structure this discussion:

1. What are the girls' subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions?

2. As indicated by the subjective views and literature, what educational intervention activities might I devise to address negative subjective views, and how might I implement the developed activities?
3. What is the impact of these activities on students' personal management of reactions to challenges towards developing mathematical resilience?
4. What are the implications of these findings for practice and policy?

I used different data collection tools throughout the various stages of this study. Using other data collection tools and methods enabled triangulation (Denscombe, 2010). It is well established that all data collection methods have their strengths and weaknesses (Denscombe, 2010). Using different tools and methods of data collection, I demonstrated a procedure for increasing my research validity. These methods include testing the consistency of findings obtained through different instruments and increases the chance of controlling or at least assessing, some of the threats to the validity or multiple causes that might be influencing my results.

In the next sub-sections, I describe the methods I chose to address the research questions.

3.5.1 Q-Methodology

The research sub-question I addressed using Q-Methodology was:

'What are the girls' subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions?'

The driver in addressing this research question was the need to elicit students' subjective views of their mathematics learning journey experiences. There are many research techniques available for eliciting personal views or opinions on any given subject or topic of choice.

Interviews and questionnaires are among some of the most commonly used in social research. Any one of these methods could have adequately addressed the decision to elicit students' subjective views of their learning. Still, upon further reading and reflection, I concluded that Q-Sorting, a technique within the Q-Methodology suite of tools, was most suitable for my research aims.

One of the reasons why I chose Q-Methodology's Q-Sorting method is that there is no other method that can capture the essence of what the participants feel about a topic from collective voices, while at the same time identifying subtle differences between some of these voices (McKeown & Thomas, 1988; Van Exel & Graaf, 2005; Coogan & Herrington, 2011; Ernest, 2011). Instead of tick survey questions or answer open-ended interview questions, in Q-Sorting respondents sort statements on a topic into the order of how best the statements describe them, thereby uncovering the pertinence, to them, of one statement over the other and hence the subjective view of each participant. This method fitted well with my intervention candidate selection stage's aim and informed the selection of intervention activities. It was vital for me to use the emerging student 'voices' to select my research candidates.

Also, while generating the Q-Set (statements about a subject under study), Q-Methodology provides the inclusion of statements/opinions constructed by the participants, further strengthening the tool's 'student voice' component. In generating a pure Q-Set, the participants are the primary source of the statements. Hybrids (a combination of literature review, focus groups, participants and other discourse) on the other hand, are another variety of a Q-Set that Q-Methodologists could utilize. This type of Q-Set has been used in other research (e.g. Shinebourne, 2009; Plummer, 2012; Purcel, 2012; Collins et al., 2014; Stollerly, 2015; Crosby, 2015). In my study, I also utilised the hybrid version of the Q-Set;

through the pre-pilot and pilot stages of my research, I requested participants write anything else they would like to say about their learning not addressed within the statements provided. Some of these statements were incorporated in the final Q-Set used in the main study (see Appendix 2). Participant involvement means that the researcher's meaning of the construct is not wholly imposed on the participants.

Another standout advantage of Q-Methodology's Q-Sorting is that it enables collecting qualitative data that can be quantitatively analysed. Because of its mathematical 'quasi-normal distribution' structure, Q-Methodology's PQMethod analysis combines the strengths of qualitative and quantitative research methods. Also, it provides a bridge between the two paradigms of enquiry. Cross (2005) pointed out that no other method or theory matches Q-Methodology's versatility or reach, and it combines well with the principles and concepts of contemporary science.

A drawback of Q-Methodology results is that they cannot be generalised. This stems from any Q sort's peculiarity to each individual (subjectivity). However, patterns and themes can be picked from the Q-Sorts (shared views), and these can be used to guide future thinking and planning for intervention.

3.5.1.1 Administering the Q-Set

As pointed out in the previous section, I used a hybrid version of Q-Set statements. I developed the final Q-Set by reviewing and evaluating statements about mathematics from the literature review, pre-piloting and piloting, and trialling the Q-Set with a focus group during the Mathematical Resilience Conference in 2017, in an AR format as shown in Figure 3.5. The final Q-Set in Appendix 2 consisted of 31% statements from literature and 62% from

students, which fits my emphasis on making the students' voice count. The remaining 7% were statements that originated from the literature review but modified for this study.

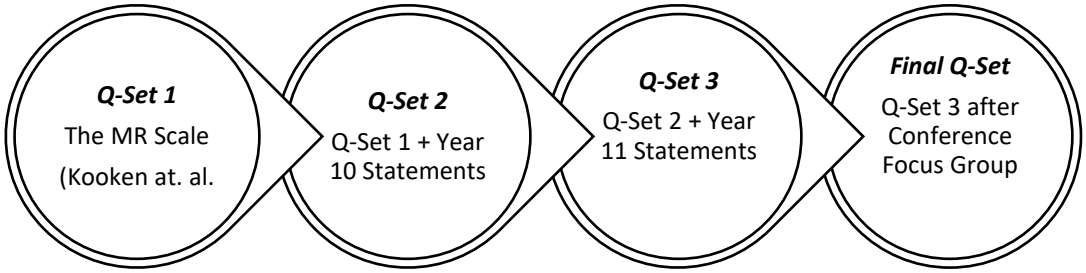


Figure 3.5: Generating the Q-Set

When it came to administering the Q-Set during the Q-Sorting activity, Q Methodologists have not reached a consensus regarding the best format to use. Some studies have utilised a 1-to-1 structure (e.g. Brown, 1980). Others used small group format (e.g. Stollerly, 2012) while others used larger group formats such as class sizes or cohort sizes (e.g. Wheeler & Montgomery, 2009). During the pre-pilot and pilot stages of my research, I trialled all the different formats. Having evaluated and reviewed each structure at the end of each administering phase, I administered my Q-Sorting activity in class size groups for my main study. This structure proved most suitable, predominantly for administrative purposes.

The actual Q-Sorting activity lasted between 20-30 minutes, and participants were given instructions as set out in Appendix A3. I analysed the resultant Q-Sorts using the PQMethod software that is part of the Q-Methodology suite of tools. This analysis process of the Q-Sorts flagged up students whose Q-Sorting arrangements indicated views that aligned with being non-resilient, in that their distinguishing statements, i.e. the most agreed and the most disagreed, were consistent with non-resilient views. It was these flagged-up participants that became my intervention target groups. Participants 'referred' themselves into the intervention

in that the ‘students’ voice’ was the selection criteria unlike other mathematical resilience intervention researchers (Johnston-Wilder & Lee, 2010; Chisholm, 2017; Lugalia et al., 2015; etc.), whose selection criteria or methods seemed insufficient in student voices. Previous studies in mathematical resilience had not yet utilised the ‘student voice’ element of the research process.

The factor extraction process started with the whole cohort of Year 9 being given a 47 statement Q-Set to place in a grid to show their relative opinion of the statements. I gave the Q-Set with both ‘written and verbal’ instructions, which informed the participants how to rank them. The opposite ends of the grid were labelled ‘most disagreeable’ on one end and ‘most agreeable’ on the other.

The participants performed the Q-Sorting procedure within school hours as whole class groups (for Year 9s). I supervised each class during this activity. I initially asked the students to read through all statements and sort them into three roughly equal piles of ‘disagreeable’, ‘neutral’ and ‘agreeable’. I took this approach to ensure participants would get a general ‘feel’ of the whole Q-Set, enabling them to allocate statements to the grid continuum systematically. I explained to the participants that each pile’s number of statements did not necessarily have to be exactly the same, but just roughly the same. The written instructions for this stage of the Q-Sorting task are found in Appendix 3.

After sorting statements into three piles, I instructed the participants to place these statements in the grid, to indicate their opinion of how representative of themselves the statements were. The participants were asked to pick their two most disagreeable from their disagreeable pile and place them in the -5 column. They were then asked to repeat this exercise for the agreeable statements and put two most agreeable in the +5 column. They were asked to repeat

this process, relative to these first two cards, until all the cards from these two, agreeable and disagreeable, piles had been allocated a place on the grid. This process then left them with the middle columns to fill using the neutral statements. There were 47 spaces in the grid (see Figure 3.6), to match the number of statements provided, made up of 11 columns in a shape that roughly followed a symmetrical normal distribution.

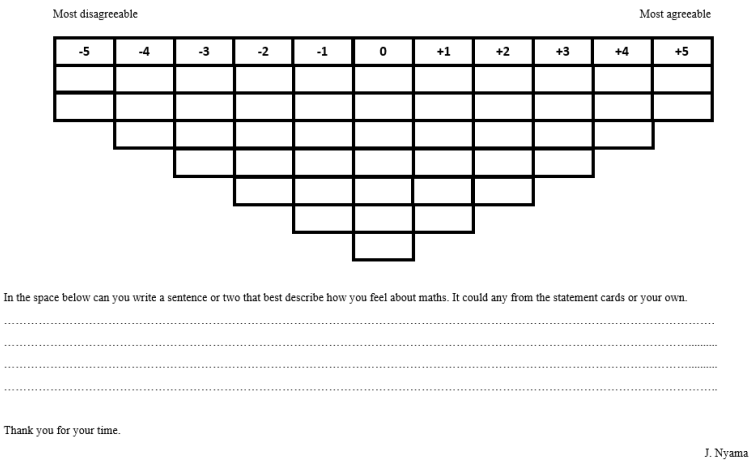


Figure 3.6: 47 Statement Q-Sorting Frame

Watts and Stenner (2012) state that the grid should be roughly the shape of a normal distribution, although the exact shape has little effect on the results. However, care needs to be taken when deciding on the number of columns. The number of columns (11) in my study follows Brown's (1980) advice, who says the number of columns should be carefully considered. This careful consideration is because too many columns can present the participants with too many decisions, while too few can be very restrictive. Therefore how 'deep' or 'shallow' a distribution is should be carefully considered. Brown (1980) further points out that a steeper distribution is the most suitable when exploring a highly emotive 'case'. As indicated by the literature review, mathematics learning is a highly emotive environment, hence the decision to design steep distributions (with a higher middle and only two items at either end).

During the Q-Sorting activity, participants were encouraged to ask any questions about the meaning of statements if they were not sure and were also advised to change the cards' position should they feel like it. After completing the Q-Sorting process, the participants were given the option to express any other thoughts or opinions about maths that might not be represented in the Q-Set. At the end of the Q-Sorting activity, I collected all Q-Sorts while participants remained in their seats.

3.5.1.2 Interpretation: Q-Sorts and Positive/negative loading

I analysed the resultant Q-Sorts using the PQMethod software (http://schmolck.org/qmethod/), which identified individual viewpoints and grouped them into similar arrangements (factors or views) by-person factor analysis. I established emerging factors by examining the factor arrays and deciphering the pattern: the configuration and the ranking of statements within the grid at a qualitative level. As summarised by Watts and Stenner (2012), "[t]he individual items and their inter-relationships within a particular array then serve as the Q methodologist's signs and cues. These must be traced back to a clear understanding of the overall viewpoint which explains or makes sense of the configuration." (p.88). Watts and Stenner (2012) further explain that "We simply need to grasp the 'nature of the beast' that has just passed by, something which can be achieved through close attention to the impression they have left and by means of interpretation." (p.88). After this stage of my research, I had a good grasp of the girls' subjective experiences of their mathematics learning journey to date and better comprehend how Q-Methodology illuminated these affective experiences. Results from the cohort revealed five distinct factors (views) held by the participants in the group. The factors generated are discussed in greater detail in Chapter 4.

For the factors extracted, the analysis software assembled all the Q-Sorts with a similar arrangement (shared views). These Q-Sorts produced by the participants either loaded positively, negatively, non-significantly or confounded on each factor. The ‘factor loadings’ express the extent to which each Q sort is associated with each ‘defining’ factor. A positive loading indicates a ‘most like my view’ statement arrangement with that factor, while a negative flooding implies the ‘opposite of my view’ arrangement. A non-significant factor loading indicates that the association with that factor is very weak, while compounded loading means that the factor loads more than one factor. All defining statements in the same factor were placed in roughly the same column of the sorting grid by each sub-group member.

Once I had identified the ‘intervention students’, I progressed to devising strategies I would utilise to explore developing mathematical resilience in students.

As used to select intervention participants in this study, my Q-Method of collecting subjective data sits aptly within my overall research strategy. R-Methodological approaches are valuable in analysing some orthogonal features of students’ attitudes, but there are grounds (such as reasons for choosing one statement over another) to think that R-Methods will miss some variations in reasons for resilience or non-resilience. Q-Methods allow such extra variations to emerge in the form of orthogonal factors (Ramlo, 2015) and can therefore provide potential supplementary insight into students’ subjectivities, experiences and identities concerning mathematical resilience. I anticipate that the data I present and analyse in section 4.1.3 confirms this assertion by providing supplementary insight into the students’ subjectivities, experiences and identities.

3.5.2 Research Cycle methods

The research cycles addressed the research sub-question:

'What educational intervention activities, as indicated by the subjective views and literature, might I devise to address negative subjective views and how might I implement the devised activities?'

The overriding consideration in devising these activities was to present participants with strategies that would enable them to develop resilience. While mulling over a starting point in light of the literature reviewed in Chapter 2, a good place to start was to provide a framework of reference for the students. Literature research presented in Chapter 2 seemed to suggest that the learning model would be such a place to start. The Zone of Proximal Development, therefore, stood out to me as a suitable framework of reference. Further literature review revealed several iterations of the model (as described in Chapter 2). After careful consideration, I finally settled on the Growth Zone Model proposed by Johnston-Wilder and Lee (2010). I chose to refer to my iteration of this model as the Zones of Learning (ZoL) model (see Figure 3.7) because I envisaged drawing attention to all zones of the model.

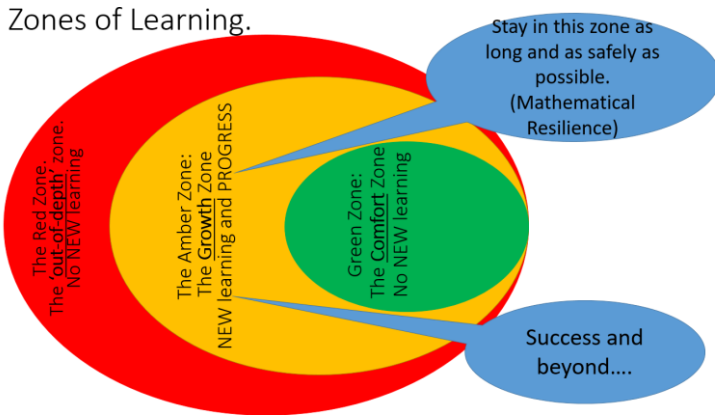


Figure 3.7: Zones of Learning Model

The ZoL model explains the different ‘zones’ of learning used in my research as described in section 2.5.1.1. Upon further reflection on this, I sought to find a model I could use to explain what is happening in the brain during these episodes of encountering new and unfamiliar content. I utilised the Hand Model of the Brain, put forward by Dr. Dan Siegel (2011), as described in section 2.2.5.2. The objective was to enable students to stay in the Growth Zone as long and as safely as possible, hence developing mathematical resilience.

Research has shown that students can safely stay in the Growth Zone with the right support (Johnston-Wilder & Lee, 2010). Apart from accessing the appropriate external support, ‘what can students do to safely stay in the Growth Zone?’. I considered understanding the Zones of Learning and how the brain works to be fundamental cornerstones to maintaining safety in the growth zone. Looking back and further exploring the idea of ‘adjusting’ mental stances and responses to new, unfamiliar and challenging situations, positive psychology stood out to me as a possible solution. Upon further exploration, I decided that Dweck (2006)’s Mindset work was an excellent starting point. I envisaged this would enable students to control better the Fight, Flight, Freeze and Flip responses, ushering in a mental environment where the unhelpful thoughts and feelings are safely managed and a conducive environment for exploring resilience-building activities. This quest naturally led me to studies by Tobias (1976) and Nottingham (2015). These two authors suggested activities I deemed suitable for developing resilient skills and ultimately mathematical resilience. Figure 3.8 illustrates the thinking process behind integrating a series of activities and strategies that I considered would support mathematical resilience development. Mathematical resilience researchers had not utilised approaches involving integrating different strategies in their research as of the time of this study.

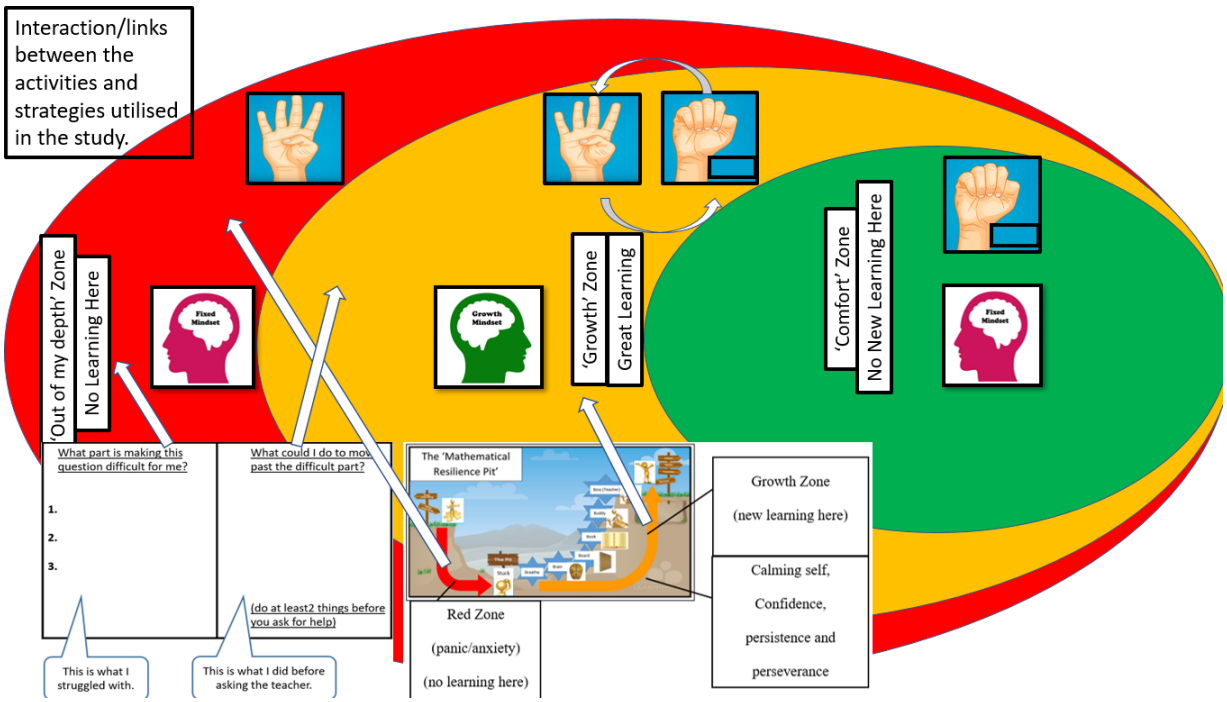


Figure 3.8: Connection between strategies used

Key:

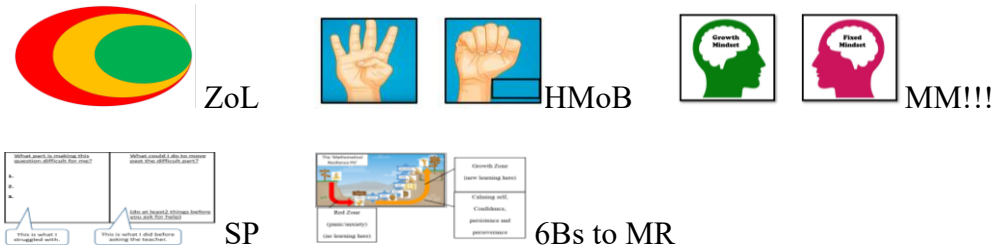


Figure 3.8 illustrates my envisioned interaction between the activities and strategies I utilised in my study. Using the Zones of Learning model as a learning framework, my research proposes that students' awareness of i) what is happening in their brain, ii) their mindset, iii) the idea of splitting up the question (the Split Page) and iv) seeking appropriate support at the right time (the 6Bs to MR) would enable students, to manage their actions and reactions towards challenging schoolwork. I chose each of the activities and strategies for their potential in supporting and potentially developing resilient working. I conjured that this development would, in turn, improve their learning. Each of the proposed strategies evolved

into one of the three action research cycles described in the next sections. Feedback was sought at the end of each cycle to either confirm the strategies suggested from the literature or imply otherwise. For all the cycles, I planned two group sessions, an introduction session and an evaluation session. To collect evaluation information, I designed an evaluative data collection sheet, as shown in Appendix 4.

3.5.2.1: Introductory Workshops

The flagged-up participants were invited to a project-introduction workshop. In this workshop, students were introduced to the Zones of Learning model and the Hand Model of the Brain as the underpinning learning frameworks.

In addition to introducing the students to the project, I convened a session with colleagues to explain and share this study's aims. I explained their anticipated involvement in and contribution to the study. I explained what each stage of the study project entailed and that their input would be to encourage students to utilise the strategies during each cycle. I had these meetings with the teachers of students in the intervention group, and all teachers expressed their willingness to support this project.

3.5.2.2: Action Research Cycle 1 (ARC1)

This action research cycle utilised the mindset strategy because I deemed it pertinent to address the flagged-up students' subjective views by focussing on transforming their mindset.

Planning ARC1 for the main study

Using feedback from pilot studies, I made revisions that took pilot study participants' suggestions (subjective views) and feedback into consideration resulting in a new iteration of

the ‘Mindset Matters!!!’ strategy. Cases in point of such pilot study evaluation feedback were participants who said;

i) ‘I’m not quite sure how to apply it to my learning or how to use it.’;

ii) ‘If there were a practical way of applying this strategy to work, *it would be more useful*.’.

Further probing and ensuing discussions with the pilot participants who gave this feedback revealed that they could have benefitted from some ‘pointers’. As a result of the feedback that more pointers were needed, I made revisions that included providing a ‘thinking/reflection/writing frame’ (Figure 3.9), to support students in reflecting on the mindset influencing their ‘current’ reaction to their learning. I designed this frame to provide some ‘practical way’ of using the strategy in their day-to-day interactions with their education.

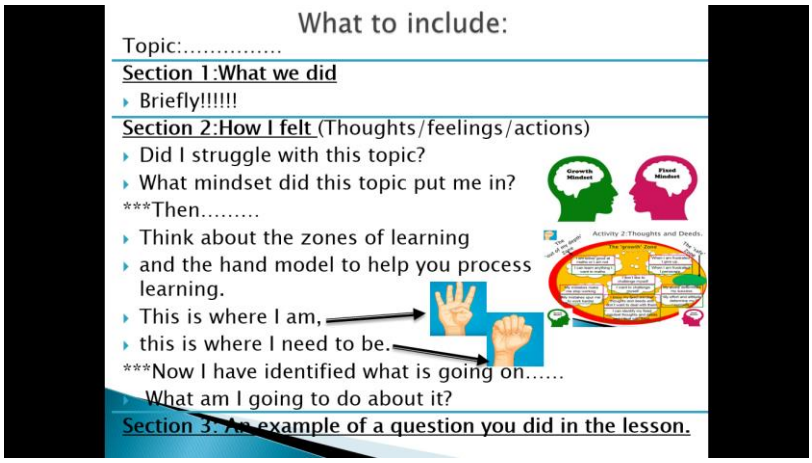


Figure 3.9: MM writing frame

3.5.2.3: Action Research Cycle 2 (ARC2)

The second of my action research cycles, ARC2, utilised the ‘Split Page’ strategy and was undertaken during the first half term of the third school term (over the months of March-April

2018). Like the previous cycle, I used the four main stages of an action research cycle, as shown in Figure 3.3.

Planning ARC2

As reflected throughout my discussions so far, I wanted the students to play a key part in this stage because they are the end-users, and their involvement is crucial. I made sure the participants' views were taken into consideration. I planned ARC2 by taking into consideration evaluation feedback from pilot studies and ARC1:

i) From the pilot study Feedback by 15/16year olds (Year 11) some lessons could be drawn from this feedback that I needed to refer to. In the pilot study, the split page used with Year 11s, the participants were requested to divide their exercise book page into two sections (Figure 3.10):

My work	My thoughts/feelings

Figure 3.10: Split Page Frame

This set-up received a good reception from the participants, but they pointed out a few issues too. The pilot study participants reported that because they did not always get stuck in the lesson, they expressed that they did not like the amount of paper they 'wasted'. They also

pointed out that once they had written their thoughts and feelings, they still did not know how to use these to move forward, i.e. what to do next. In the next iteration that I used for my main study, I designed stickers that students could use if and when they needed them (Figure 4.18). I also planned a brainstorming session on what students could do to move forward.

3.5.2.4: Action Research Cycle 3 (ARC3)

In this third action research cycle, I utilized the '6Bs to Mathematical Resilience Pit' strategy. This intervention followed directly after the 'split-page' intervention and was undertaken during the second half of the third school term (over June – July). I primarily considered and designed the '6Bs to Mathematical Resilience Pit' strategy around the needs of the group of students who strongly disagreed with the statements

'I know how to bounce back when I get discouraged in maths.' and

'When I have done poorly on something related to maths, I know how to adapt.'.

These students were essentially saying they do not know how to bounce back or adapt when they get discouraged in maths. However, all the intervention group participants were involved because I surmised that all the participants would benefit from the proposed tactics within the '6Bs to Mathematical Resilience Pit' strategy. ARC3 aimed to expose students to different coping/learning methods, which they had not been introduced to yet. I planned to introduce the students to the '6Bs to Mathematical Resilience' with the assumption that, if participants, with support, engage with the task at hand for longer, it will enable them to gain enough confidence, which in turn could enable them to navigate their learning as safely as possible.

Planning ARC3

Moving beyond mental blocks is essential, so I designed this third strategy to address these issues. The designing process of this tool was, to a great degree, influenced by ARC2 student feedback because my study, right from the outset, had a focus on students' subjective views. While also using my field notes reflecting on from ARC2, I intended to make sure ARC3 gave students practical steps they could take to stay in 'growth zone' as long and as safely as possible. Based on previous research (Growth Zone Model, Johnston-Wilder & Lee, 2010; optimism, Williams, 2014), I deduced that I needed to provide an opportunity for participants to stay in the growth zone safely, as part of developing mathematical resilience. This deduction is consistent with what Garton and Johnston-Wilder (2013) advanced. They recommended that it was helpful for researchers and educators to think of mathematical resilience as that which is needed to stay, as long as possible and safely, in the 'growth zone'. Coupled with Garton and Johnston-Wilder (2013) recommendation, I planned this strategy to facilitate participants' working with confidence, persistence, and perseverance (Williams 2005's description of optimism/resilience).

When designing the 6Bs to Mathematical Resilience strategy, I drew inspiration from James Nottingham (2005)'s Learning Challenge concept. The tool I created was a modification of this concept.

Figure 3.11a: Before (Nottingham's version)

After (My version)

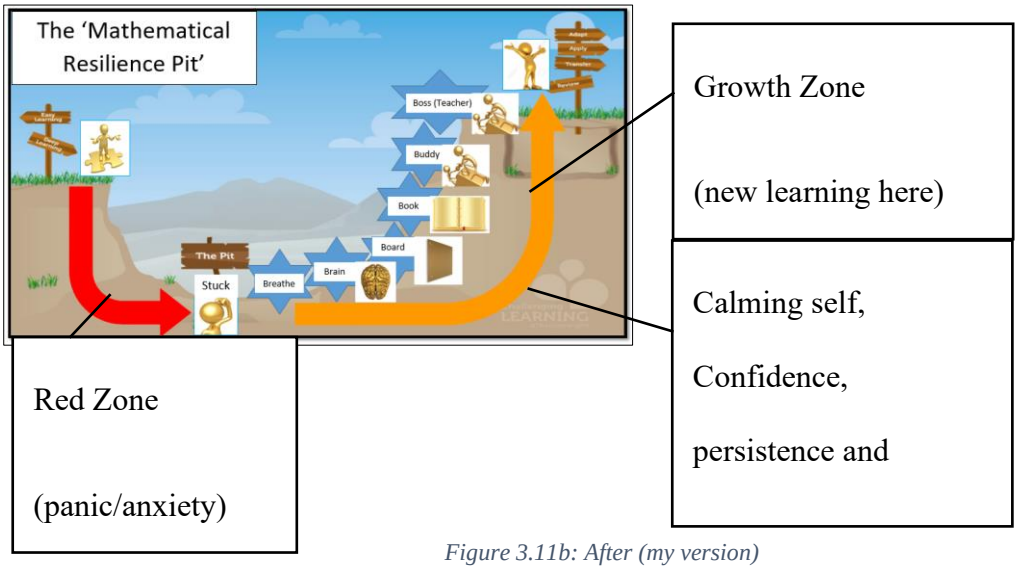


Figure 3.11b: After (my version)

I chose the colours I used in this design deliberately to maintain consistency and a link between the '6Bs to Mathematical Resilience Pit' model and the Zones of Learning Model's colours. The red downward arrow's use depicted the slipping into the 'out-of-depth zone' of the Zones of Learning, where participants would find themselves after encountering challenge they perceived as unmanageable during learning. The bottom of the pit signifies that opportunity to start managing their feelings and reactions and ultimately their learning.

The use of the orange upward arrow characterises working in the 'growth zone' with appropriate support. The left side of the 'pit' illustrated the 'confused' state of encountering an unfamiliar challenging learning task. In contrast, the right side of the 'pit' depicts the results of successfully navigating the learning pit, resulting in students experiencing success. This 'journey' through the 'pit' was supported by the prompt sheet shown in Appendix 5.

I chose to use Nottingham's template because I liked how it seems to symbolise that after successfully 'conquering' the pit, the learner ended up at a higher understanding level. I do not know whether it was a deliberate design plan on Nottingham's part. Still, it perfectly conveyed one of the messages I wanted participants to take away, and they come out at the other end of the 'pit' better off.

Once I was happy with the resulting 'Mathematical Resilience Pit' intervention illustration, I printed them on stickers to be used in conjunction with the prompt sheets. I then went on to plan how I was going to introduce the intervention to my students. The '6Bs to Mathematical Resilience Pit' intervention was entirely new for the participants, so I planned another introduction session.

3.5.3 Impact evaluation methods

This research sub-question was

'What is the impact of these activities on students' personal management of reactions to challenges towards developing mathematical resilience?

To evaluate the impact of the activities and strategies utilised in this study, I collected feedback data through various media. The bulk of the data collected was from student feedback (Floden, 2017). I will discuss these in turn in the subsequent sub-sections.

3.5.3.1 Diaries

Diaries' use is a well-established method of data collection (Badley, 1986; Boud, 2001) because it encourages students to explain themselves in written form (Waywood, 1992; Berman, 1994). It also enables the researcher and the reader to understand the participant's learning experiences in their own words. I requested participants to record in their diaries for this reason. All research participants were invited to use a personal diary I gave them. Each diary was a small, squared exercise book with a guiding frame for Year 9 (see Figure 3.9), giving instructions about using it and what to include when completing the diary. I designed the writing frame to support participants in managing their thinking process while recording their thoughts. Writing frames are widely used to support developing pupils' written expressions of procedural comprehension (Warwick et al., 2003). In my study, I present the participants' diaries as an effective practice for extracting meaning from their recorded events and experiences.

An added vital attribute of diary writing is that the students could reflect on their ongoing experience and learn from it (Baud, 2001). I requested my research participants return diaries either at the end of each cycle or any time after that. Furthermore, during the introductory workshop, the distribution of diaries allowed participants to write their first entry during the workshop, hence reinforcing an understanding of what the expectations were. I considered the timing of the diaries' distribution (during the workshop) crucial because participants were given the opportunity to think more deeply about what they may have to write and what might be discussed later on, before returning to their classes. Furthermore, having the diaries for a time during the workshop allowed essential events to happen. The participants, stimulated by the trial questions, had the opportunity to have a trial run. The students kept the diaries for a period of half a school term.

The use of diaries in my research became a mitigating factor for any reduced reliability in that, according to Denzin (1989), the diaries provided another data triangulation method. Rice and Ezzy (2000) concurred with this. They stated that diaries are another data source. At the same time, Higginbotham et al. (2001) extended this by asserting that diaries improve credibility (internal validity), by examining the students' actual writing samples, and dependability (reliability), by helping not only in understanding the particular situation but also informing similar situations.

3.5.3.2 Field Notes

Field notes are a vital part of my research because they have an ethnographic element to them since I am exploring mathematical resilience from the point of view of the study's subject. Students in my intervention group were spread across five different classes. While each participant was issued a diary to record their experiences and their learning journey, I decided to sit in their lessons and observe as often as possible. Hence, field notes became another data collection tool of choice. Field notes presented several advantages within my study. One of these was that they served a crucial role in connecting me, the researcher, to the students in their familiar environment (Wolfinger, 2002). This 'familiar environment' aspect was a good fit for my study because one of the major decisions I made during the planning and designing stage of my research was that I would endeavour to equip students with strategies they could use in their day-to-day learning environment. I was quite decisive in making sure that I gave the students as much time as possible to operate within their everyday lessons.

Another advantage of field notes in my study was that they added another level of understanding of the whole social setting in which my students function by enabling me more insight into the context in which the students work. Field notes were also valuable in that

they informed me about the influence of the students' physical environment. In terms of the system in which I recorded my field notes, I decided on a structured framework instead of an unstructured one (Mulhall, 2003). The reason for this decision was that I was interested in recording any physical and verbal behaviour pertaining to resilient working. Mulhall (2003) pointed out that in structured observation "observation schedules are predetermined using taxonomy developed from known theory." (p. 306). Table 3.1 shows the template I used as guidance for collecting the field notes, keeping the structure close to the student version for ease of comparison. It was vital for me to record my field notes as close as possible to when the lessons occurred; I mostly recorded in situ while talking to the participants. Other times, I would retire to a discreet location in the classroom to record what I observed. I used the space at the back to record freely any 'unexpected' data.

Name	Agree/Disagree	Comments/Observations/Discussion.
Set 1		Date……
	Agree: Having a solid knowledge of maths helps in my other school work. **Disagree** I know how to bounce back when I get discouraged in maths. When I have done poorly on something related to maths, I know how to adapt.	On a scale of 1-10, how do you feel today's maths will help you in your other school work? On a scale of 1-10, how do you feel you know what to think and do if you get stuck? What would that be? On a scale of 1-10, how do you feel you know how to adapt/find other ways of working at this maths? What would that be?
	Agree: I think maths lesson should be fun to help us remember. **Disagree** I want to study maths at A Level, so I need a good grade at GCSE	On a scale of 1-10, how do you feel this maths lesson has been fun? On a scale of 1-10, how do you feel this maths will encourage you to get a grade good enough for A' Level?
	Agree: I think maths lesson should be fun to help us remember. **Disagree** I want to study maths at A Level, so I need a good grade at GCSE	On a scale of 1-10, how do you feel this maths lesson has been fun? On a scale of 1-10, how do you feel this maths will encourage you to get a grade good enough for A' Level?

Table 3.1: Field Notes Template

3.5.4.3 Semi-structured interviews

Interviews are one way for participants to get involved and talk about their views (Gary, 2004). Also, the interviewees can discuss their perception and interpretation concerning a given situation. It is their expression from their point of view. Interviews were relevant to my

study because I was interested in clarifying any unclear part in my participants' feelings and views on their mathematics learning journey and the intervention activities and strategies utilised in my study. There are several different types of interviews. In my study, I planned for semi-structured interviews for the reasons as outlined by Gary (2004):

- The need to attain highly personalised data.
- Provides opportunities for probing.
- A reasonable return rate was necessary.
- Students had an opportunity to verbally express themselves if they had difficulties with the written language.

Gary (2004) further posits that there are situations in which interviews would be the most logical data collection method and give an example of research that primarily involves examining feelings and attitudes. Semi-structured interviews are unstandardized and often used in qualitative analysis, which fits well with my research paradigm. I had a list of key themes or questions I wished to cover but did not deal with all of them in each interview, and the order of the questions changed depending on what direction the interview took. Furthermore, I could add additional questions if a new issue arose. Semi-structured interviews allowed for probing of views and opinions where I needed students to expand on their answers in the evaluation feedback sheets. This probing was more vital in a study with a phenomenological element and whose main objective is to explore subjective meanings that respondents ascribe to concept or events (Gary, 2004). An interview guide was an essential component for conducting the interview, and the guide I used for my study, is included in appendix A4.

3.5.3.4 Group and Individual feedback

Giving or collecting feedback is a core activity in many types of professional and research settings. The different approaches to gathering feedback from students in school generally determine the depth, accuracy and constructiveness of all students' feedback. Face-to-face feedback typically offers opportunities to make sure that this will occur. Chan et al. (2017) point out that "use of direct dialogue and student interviews is recommended for gathering the personal voices of students." (p. 129).

In my study, I used face-to-face group and individual feedback to elicit and understand students' opinions and preferences on the activities and strategies under evaluation. Youssef (2017) succinctly summarised my main aim for using group and individual feedback by asserting that student feedback provided a "process in which the consequences of educational decisions are systematically evaluated, and practices adjusted to maximise effectiveness" (p. 769). However, it is worth noting that the quality of feedback may be affected because, as Chan et al. (2017) point out, students often feel overwhelmed by extra demand on their time. But when students feel that their feedback is considered in making instructional decisions and see the outcome through modifications made by the teacher, they assign a more positive value to the evaluation process (Youssef, 2017). My study, predominantly based on and around students' feedback, went a considerable way to mitigating this risk of overwhelming students.

3.5.3.5 Online platform

The rapid growth of the internet has increased the frequency with which internet environments are used as data collection sources in social research. Data can be collected from individuals who participate in research through recently-developed, internet-based platforms. The comparison of data collection through online platforms and face-to-face

methods has become a key area of debate in the social science research agenda in recent years (Kilinc & Firat, 2017). Drawing on wider research, in their article, Kilinc and Firat (2017) argue that online platforms provide a more flexible environment for participants to take part and respond.

At the beginning of the 2017/2018 academic year, the school at which I work subscribed to an online platform called Show My Homework (www.showmyhomework.co.uk). This platform facilitated safe online communication between teachers and students. After seeking permissions and guidance from the Senior Leadership Team member in charge, I created a group made up of my study students. Using the online platform, participants could send me their thoughts, feelings and questions about any aspect of this study. Any messages sent to me would be private, and the same applied to any responses I sent back. This online platform was similar to a secure email. Using the 'Show My Homework' platform had the advantage over email in that it was delivered to participants through the school-initiated app.

Another advantage of using this communication platform with my participants was that they seemed to have more confidence in sharing thoughts and feeling they might otherwise have found difficult to express or communicate in person because it offered an adequate level of privacy. Simultaneously, a disadvantage would be the inherent delays in any further probing, should the need arise.

3.5.3.8 Exercise books/Samples of class work

According to Johnson (2008), students' books can be used as data. Johnson further expounds that there is no need to collect every bit of students' work when using this data collection method but rather take only representative samples. This data collection method is supported by Forster and Eperjesi (2017). They point out that children and young people's written

works are a readily available source of evidence that teacher-researchers have easy access to daily. In my study, I utilised students' exercise books to collect data. I took samples of students' work because they provided evidence of the practical use of the activities and strategies. This data collection method became an imperative component for evaluating the chosen models and strategies' impact.

3.5.3.7 Third-party feedback (Colleagues)

According to Cannon and Witherspoon (2005), a third party who does not have strong emotions about the situation can offer a more objective perspective that can be invaluable to those receiving feedback. Third parties can be beneficial if they understand the cognitive and emotional dynamics of the implementer's role and some experience in implementing programmes. The third parties I used in my study, my colleagues, were a good fit for achieving this. In my study, I actively sought feedback from my colleagues, predominantly via email, but I also collected verbal feedback. This choice was because 'third party' feedback via email was a quick, easy, and private communication form. Feedback from my colleagues offered a different perspective on my research strategies on the students' learning.

One of the main complications for third parties is that they may not feel knowledgeable or skilled enough to assist; however, the third parties have potential value even if they may think they lack the know-how. My 'third party' was made up of colleagues in my department who had prior experience in implementing schemes and making critical evaluations of such projects; I considered them to be experienced and knowledgeable enough to give me valuable feedback. This feedback was predominantly used to gain an observer's picture of any resilient behaviour exhibition during the learning process. This feedback, however, did not possess the same weighting as feedback collected from the students.

In addition, teachers can have an impact on students (Kane, 2008). The level of support they provide for students needs to be considered.

3.6 Data Sources: What data did I collect

The primary data of interest in my study was based on my RQs. To address RQ1, I needed data concerning the students' pre-existing viewpoints of their own learning journey. I collected this by using the Q-Sorting activity and the PQMethod analysis software (as described in the Pilot Study section). To address RQ2, I needed to collect and review feedback at the end of each research cycle. I gathered input from pilot studies as well as during evaluation 1 and 2. To address RQ3, I needed data for evaluating the impact of the activities and strategies used in this study. I collected quantitative data in the form of ratings allocated to each strategy and qualitative data in comments and opinions about each strategy.

The data I collected throughout was primarily suitable because each data collection source had a close bearing on the RQs in this study. The data I procured from each source gave me a different perspective on aspects of the data I needed. Also, collecting different types of data, e.g. either qualitative or quantitative, enabled 'triangulation'. What triangulation ensures is that this situation is viewed from different sides. Johnson (2008) also points out that triangulation "provides greater depth and dimension, thereby enhancing …… credibility." (p. 102).

How I analysed and made sense of the impact evaluation data

In terms of analysing the data, I approached this process from literature-suggested analysis methods for qualitative and quantitative data. I used a thematic content analysis approach from two sub-approaches, deductive and inductive approaches for my qualitative data. The deductive approach involves using a structure or predetermined framework to analyse data. I

designed a ‘positive and negative interaction themes’ framework and then used this to analyse the data I collected. Here, I drew on Braun and Clarke (2006)’s framework of qualitative data analysis and applied it systematically to describe and explain the results of my study. According to Braun and Clarke (2006), good thematic analysis lies in devising a systematic method of analysis whose assumptions are congruent with the way one conceptualises the subject matter. This ‘positive and negative interaction themes’ framework approach is useful in my study because I am aware of possible participant responses. The participants would either interact positively with the interventions presented or negatively.

However, while this approach is relatively quick and easy, it has limited flexibility. It can potentially lead to bias in the whole analysis process as the analysis framework has been decided in advance, limiting theme and theory development. To compensate for this possible bias, I also use the inductive approach to analyse the ‘unexpected’ data responses with little or no predetermined theme, structure or framework but use the actual data itself to derive the theme or theory. For my quantitative data, I use Stata/SE 16.1’s statistical techniques, which include: parametric tests, analysis of standard deviation and variance, skewness and kurtosis.

A ‘best case scenario’ measure for definitively concluding RQ3 (and the project) in terms of the impact of these strategies on students would have been to complete an ‘after treatment’ Q-Sorting activity. This Q-Sorting would enable me to compare for any shifts in the students’ self-positioning at this stage. However, because of unexpected timetabling constraints at the school, I could not set up the activity. Instead, I decided to request the students rate their original belief/view defining statement, on a scale of 1 (still feel/think the same) to 10 (my view on this statement has changed to the complete opposite). This task enabled me to identify any increase in ‘resilient working’ traits in students. The data presented in the next

chapter was collected over a year and involved four group evaluation sessions, weekly interviews and lesson visit sessions, and informal discussions.

To address RQ4, I reflected on the implications of the results from data analysis for my practice.

The research data collected is reported in the next chapter as follows:

1. Addressing RQ1: Results from the Q-Sorting Activity
2. Addressing RQ2 and RQ3: i) Results from ARC1, ARC2, and ARC3.
   ii) Results from rating defining views/statements
3. Addressing RQ4: An overview of what these results convey for practice and policy.

3.7 Ethical Considerations

In every study, researchers need to communicate the ethical considerations of their research. Cavan (1977) previously identified ethical consideration as "a matter of principled sensitivity to the rights of others" (p.810) and that it is paramount to protect the wellbeing of participants. This section discusses how this study complied with the University of Warwick's ethical guidelines, protocols, and practices as approved by the university's Centre for Education Studies (Appendix 8). I also discuss how potential ethical issues and concerns were considered throughout each stage of the research process. The following ethical values were integral within this research: informed consent, confidentiality and anonymity, non-maleficence, power and position (Floyd & Arthur, 2012).

3.7.1 Informed consent

Informed consent is defined as when individuals choose whether they wish to participate in the research once they have been told what it is about and what is required (Diener &

Crandall, 1978; MacLagan, 1989). Initial consent to administer the Q-Sorting activity was obtained from the SLT due to the activity being a preliminary activity whose sole purpose was to identify students who held unhelpful mathematical learning views and become research participants. The students were verbally told in their classes what the research project's aims and purpose were and their rights to not participate and withdraw at any point. All students in KS4 who completed the Q-Sorting activity were verbally informed about the purpose of the Q-Sorting activity and how it would inform other programmes (should they end up as one of the flagged-up students). They were informed that their names would not be used in any record resulting from this activity. They were requested to sign the bottom of the data collection sheet to consent to their Q-Sorts to be anonymously used in writing up the study.

Once I had identified the students who could potentially be in the study, I organised a meeting with the group. I explained why they were in the group, informed them of the nature of the research project, the benefits of participating in the research project, what it involved, how the data would be used and stored, and reiterated their rights not to participate and withdraw at any point. All students in this group told me that they were happy to participate in the research before starting the intervention strategies. Informed consent from the students was also seen as an ongoing process. They were asked verbally during each evaluation session of this research whether they wanted to continue to participate, in case they felt that they were obliged to participate due to my position within the school.

3.7.2 Confidentiality and anonymity

To attain the participants' true voices whilst assuring privacy, Frankfort-Nachmias and Nachmias (1992) stated that providing confidentiality and anonymity to all participants is

necessary. All information obtained throughout this study remained confidential as a priority, as the study involved collecting a wide range of data from students; a vulnerable group within the research. Raw data collected during this study were only viewed by myself throughout the research process. For any data that I shared with my supervisor, I ensured it had been stripped of any confidential information, to ensure that participants remained anonymous and could not be identified. Participants and teachers were informed of my commitment to ensuring confidentiality and anonymity throughout the research process, and afterwards. Students who participated in the Q-Sorting stage of the research were assigned an initial and a number to not use their real names. They were referred to using these codes at this stage. The students chosen for the main study were given their factor title initial and a number throughout the data presentation to ensure they remained anonymous. The teachers were referred to as T1, T2 etc., rather than assigning them a name. This use of codes allowed all participants to share their perceptions of managing their reactions to challenges, whilst remaining anonymous and their experiences remaining confidential.

The school in which the research was conducted has not and will not be named, only that it is in the UK. All participants were informed that their data would be published anonymously within my Doctoral thesis. If subsequent researchers quoted this research piece, participant confidentiality would remain secure as the researchers would only have access to the anonymous data published within my research. All data was stored on secure drives throughout the data collection and data analysis periods and will remain securely stored. Hard copies of the data were, and are, stored in a locked cupboard, whilst electronic copies are anonymised and stored in a secure hard drive that is accessible to me.

3.7.3 Non-maleficence

Non-maleficence within ethics refers to how researchers should ensure that no harm is inflicted on participants to reach a beneficial outcome. Hammersley and Traianou (2012) argued that all research involves risks that might not be completely removed, but they can be minimised. Therefore, researchers need to reflect on the immediate harm participants may be in, and the potential knock-on, negative effects (Cohen et al., 2018). Throughout my research, the participants' wellbeing was integral, and I was thoughtful in ensuring that no harm had been inflicted, or would be inflicted in the future.

This research is considered low risk, as there were no expected risks or harm towards me, the participants, or their schooling environment. However, participants were asked that if there was any concern about their safety and well-being, they should contact me to discuss this immediately. The benefits of the study, however, were perceived as worthwhile. These included the possibility of improved management of reactions to challenges, development of mathematical resilience and potentially improved attainment. Whilst there may not have been immediate benefits for all participants, it was hoped that the individualised interventions could lead to the improvements mentioned above.

3.7.4 Power and position

Brooks, te Riele and Maguire (2014) identified that "power relations are immanent in all research settings" (p. 106) and are therefore unavoidable. It is understood that the power and position between myself and the participants was asymmetrical, due to our respective roles within the school (students and teacher) and my role as a researcher, allowing me to determine the research's agenda, timing, and duration project. To overcome this, I ensured that the students participating in the research project felt comfortable and positive about their

role. This quest included making students feel at ease by sharing experiences and demonstrating empathy and understanding during the feedback sessions and the interviews.

Ethical considerations guide the process for how researchers can experience, understand and make value judgements about what is 'worthwhile' or 'truly good', and so to make appropriate choices and to take appropriate action (Taket, 1994; Coghlan, 2013). Once all ethical consideration had been planned for, I proceeded to conduct pilot studies. I discuss these in the next section.

3.8 Pilot Studies

I conducted two pilot studies, phase 1 and phase 2. I conducted my two pilot studies to serve a range of important functions, as indicated by the following discussion. As suggested by Hagen et al. (2011), the overarching research question I was addressing to frame the design of these pilot studies was 'would a larger pivotal study be feasible'. Therefore, the aim for carrying out my pilot studies was to test specific aspects, components and processes of my proposed study (Van Teijlingen & Hundley, 2002). I needed to test some of the procedures and processes in my study more than once (2 phases) as the Q Method was new. So, I needed to familiarise myself with these new procedures and processes to find out what I could or could not do, what would or would not work, and make the necessary adjustments. Pilot studies serve a crucial purpose in the research process. Some of the reasons are:

- They are valuable for testing the research idea's practical undertaking, i.e., this study is possible (Bowen et al., 2009; Friedman, 2013; Drummond, 2017).
- They effectively confirm the need for the research and inform the definitive research (Bowen et al., 2009; Drummond, 2017).

- They lay the foundation for future research to support the main research's evidence base (Drummond, 2017).
- They are beneficial in highlighting ineffective practice that should be stopped or changed (Teijlingen & Hundley, 2002; Drummond, 2017).
- They are efficacious in generating data to inform sample size for a future definitive study (Drummond, 2017).
- The data collected can help determine participant recruitment and retention (Bowen et al., 2009) and testing possible outcome assessments (Friedman, 2013; Drummond, 2017).

The pilot studies were an integral part of my research. In the intervention research process, a pilot study can be a determinant for accepting and advancing only those procedures and interventions worth testing, discarding any that are not worth testing (Bowen et al., 2009; Friedman, 2013; Drummond, 2017). These pilot studies were essentially a smaller scale version of my more extensive definitive study. They enabled a rehearsal of the larger study to test all aspects of the proposed research. However, pilot trials are not adequately powered to allow for statistical conclusions to be drawn, so the analysis I report here is for indicative purposes. There is a danger of either over- or under-estimating an effect (Bowen et al., 2009). Through pilot studies, preparation was crucial to my avoiding conducting a poorly designed or underpowered research study.

According to Friedman (2013), pilot studies should be reported because, even though the researchers who conduct pilot studies know the results and can use them to design their full-scale research, the data they gather might also be useful to others. They point out that it is very rare that a pilot study is researching a condition or type of intervention so unique that its information would not be of benefit to others. Secondly, Friedman (2013) pointed out that

meta-analyses can be adequately applied to the extensive study and data from pilot studies. If the pilot study does not lead to full-scale research, it may be essential for other researchers to understand why it did not work or did not lead to full-scale research. Although my pilot studies did result in full-scale research, reporting their results gives my readers insight into the research process and my decisions.

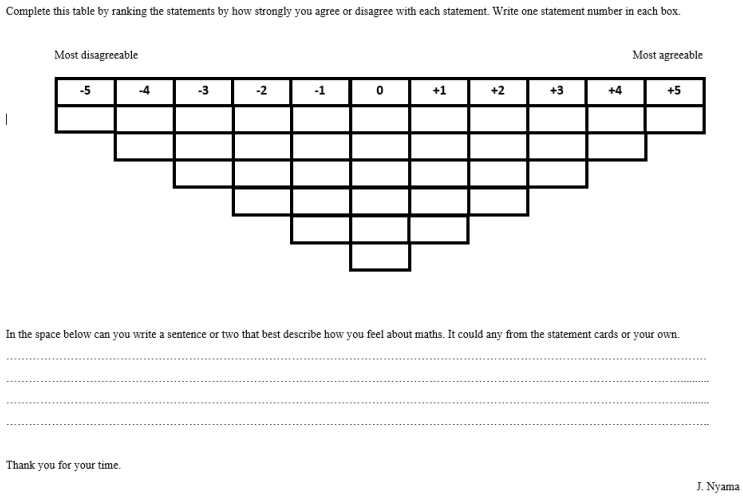
My pilot studies were carried out in my current girls' school. I carried out phase 1 with my Year 10 class (trying out sorting frames instead of questionnaires and also trying out the analysis software) and phase 2 with my Year 11 group (exploring the larger hybrid Q-Set) timings. When I was planning the research, my initial target group for intervention was Year 11. I became interested in this cohort of students for several reasons. One of the main reasons for this was that I investigated mathematics anxiety in KS4 students for my MSc studies. In my MSc investigation, I reported that the KS4 students in my study expressed strong feelings about maths indicative of maths anxiety (Nyama, 2008). At KS4, students (and teachers) are preparing for a critical examination, namely their GCSEs, after 5 years of secondary education. A GCSE examination brings its own anxieties but alleviating the impact of mathematics anxiety on students' day-to-day functioning seemed crucial for this cohort. Secondly, success as a department and school was measured by how many students obtained a pass in the subject. Literature (for example, Dweck, 2006) had indicated that managing challenges and setbacks significantly improved performance, so what better cohort to work with than Year 11, where improved performance was much desired by all parties concerned - students, teachers, parents, school and government. So, Year 11 became my phase 2 pilot target group.

3.8.1 Piloting the Q-Sorting process (leading up to the final Q-Set) and the Q Method analysis

The phase 1 pilot Q sort activity was made up of 100% mathematics-related statements from the mathematical resilience scale (Kooken et al., 2015). The scale had thirty-six statements, and these were administered as a Q-Set to all students in my Year 10 mathematics class at the same time during a normal maths lesson. I just wanted to explore how students interacted with the resources and the structure of the data collection form - the Q-Sorting frame. Previously I had used questionnaires to gather data and had never used a quasi-normal distribution sorting frame. Also, I wanted to understand how long it took, on average, i) to complete a Q Sort and ii) to use the specialist PQMethod software to analyse the data collected.

3.8.1.1 Q-Sorting Process

The Q-Sorting process for this first phase was conducted as a whole class for administrative reasons. The students were supplied with statements cards (Appendix 1) and a sorting frame, as shown in Figure 3.12. At the bottom of phase 1 Q-Sorting frames, students were invited to express any other views they might have about mathematics learning that could have been missed in the Q-Set statements. Students were asked to rank the statements into a thirty-six-box sorting frame according to how they found the statements most agreeable or most disagreeable, by initially splitting them into three piles first (agree, neutral and disagree).



Complete this table by ranking the statements by how strongly you agree or disagree with each statement. Write one statement number in each box.

Most disagreeable | Most agreeable

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

In the space below can you write a sentence or two that best describe how you feel about maths. It could any from the statement cards or your own.

.....

.....

.....

.....

Thank you for your time.

J. Nyama

Figure 3.12: 36 statement frame

According to their own agreement and disagreement, the students ranked the thirty-six statements as a function of the personal value they ascribed to each statement. Drawing on broader research, Watts and Stenner (2012) point out that students rank the statements according to the statements' 'psychological significance' for any given student. This ranking is because "[t]hose items of *great* psychological significance would evidently be ranked or scored highly, whilst those of little relative significance … [would be] ranked or scored lowly." (p. 73). The individual arrangements resulted in single and personal configurations of statements emerging. It is these emerging configurations that classify students of shared viewpoints (or factors), as shown in Figure 3.13.

3.8.1.2 Factors extraction process

The term 'factor extraction' refers to how similar arrangement or configurations emerge from the correlation matrix (the patterns of similarity or difference between each Q sort with every other Q sort). In statistical terms, Q-Sorts' complete matrix represents all viewpoints within the data and, therefore, 100% of the data's meaning and variability (Watts & Stenner, 2012). Figure 3.13 shows the factors extracted from the phase 1 pilot study.

3.8.1.2.1 Factor 1: Defining Sort and Analysis printout

```
Distinguishing Statements for Factor  1

 (P < .05 ;  Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.



 No. Statement                                                  No.

  16 16. People who are good at maths may fail a hard math test.  16
   6 6. People who are good at maths have more opportunities than  6
  25 25. I believe a person's maths ability is determined at birt 25
```

Figure 3.13a: Distinguishing statements for Factor 1

Figure 3.13b: Defining Q Sort for Factor 1

3.8.1.2.2 Factor 2: Defining Sort and Analysis printout

```
Distinguishing Statements for Factor  2

 (P < .05 ;  Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.



 No. Statement                                                    No.

  36 36. When I don't do as well as I hoped on a math task or tes 36
  13 13. Everyone makes mistakes at times when doing maths.       13
```

Figure 3.14a: Distinguishing statements for Factor 2

Figure 3.14b: Defining Q Sort for Factor 2

3.8.1.2.3 Factor 3: Defining Sort and Analysis printout

```
Distinguishing Statements for Factor  3

 (P < .05 ;  Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value (Q-SV) and the Z-Score (Z-SCR) are Shown.



 No. Statement                                                    No.

  21 21. Maths can be learned by anyone.                          21
   3 3. Maths courses are very helpful no matter what I decide to  3
```

Figure 3.15a: Distinguishing statements for Factor 3

Figure 3.15b: Defining Q Sort for Factor 3

3.8.1.3 Tentative 'interpretation' of the pilot study results

These pilot exercises afforded me good experience of the 'workings' of the Q method and its analysis software. After a few attempts and restarts, I was able to produce useful results. The analysis also gave me helpful insight into what I should expect when carrying out my actual study. The factor analysis produced groups of distinct 'shared views' that are called 'factors'. The same analysis results produced 'factors' with distinct differences between the factors identified. These similarities within a factor and differences from factor to factor signify the students' viewpoints of their mathematical learning journey in general and their mathematical resilience in particular. For example, zooming in on the distinguishing statements, factor one seems to identify the student who believes that a person's mathematics ability is not determined at birth. If they are good at maths, they do not expect to fail a maths test, even if it is hard. They strongly disagree with the statement that read 'I believe a person's mathematics ability is determined at birth' and disagree, to a lesser extent, with the statement that says, 'people who are good at maths may fail at a hard maths test'. This view is in line with Dweck (2008)'s fixed mindset student, who attributes success to ability rather than effort.

Similarly, distinguishing statements for factor two seem to identify that student who firmly believes that there is value in keeping on trying but does not think everyone necessarily makes a mistake. This view is in line with Bandura (1997)'s enactive mastery experience as a source of self-efficacy. Distinguishing statements for factor three seem to identify students who do not value mathematics (they strongly disagree with the statement 'maths courses are very helpful no matter what I decide to study'). They do not think that everyone can learn mathematics, another example of Dweck (2006)'s fixed, mindset student.

From these results, it became apparent that students who loaded on factor one and factor three would be good candidates for intervention because their beliefs are synonymous with individuals susceptible to being non-resilient; they might avoid challenges. This becomes more apparent when the distinguishing statements are viewed within the context of each factor's defining sorts. By considering the additional knowledge of the actual placement of distinguishing statements, this simultaneous examination of the defining sorts and distinguishing statements unravelled a new, more in-depth understanding of where the participants positioned themselves.

Worth noting, also, is the seemingly shared belief between factor one and factor three student. These 'students' do not recognise the value of mathematics. The factor one student takes a neutral stance and does not think that being good at maths has any advantages or disadvantages for future career options. The factor three student expresses a strong opinion and does not think mathematics is essential for further study. This lack of value in mathematics is prevalent in mathematical classrooms across the UK (Nardi & Steward, 2003; Johnston-Wilder & Lee, 2010). The neutrality of factor one and the strong sentiment of factor three identify potentially not mathematically resilient students. The defining sort for factor two identifies a potentially mathematically resilient student, who strongly agrees with the

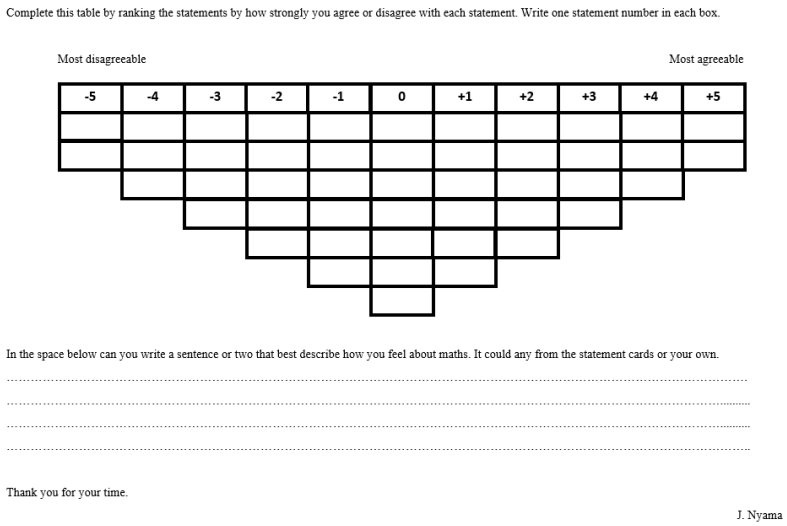
notion that if they fail at a task they will keep on trying until they are successful. This trying could either mean they are either persistent or perseverant - both aspects of resilience according to Williams, 2014).

The Q-Sorts from my main research were subjected to similar interpretation treatment. This pilot study enabled me to more confidently identify students whose Q-Sorts indicated they would benefit from intervention.

The second phase of my pilot helped develop the Q-Sorting process further and pilot using a 'hybrid' version of the Q-Set. The timeline for developing the Q-Set is outlined in Appendix 4. In developing the Q-Set for this second pilot phase, I considered my literature review of articles and books relating to good Q-Set characteristics. Watts and Stenner (2012) call the type of Q-Set that wholly originates from literature a 'ready-made' set. I used 36 statements in phase 1, drawing from an existing questionnaire (Kooken et al., 2015) which presented a good 'ready-made' set of existing opinions and arguments on my research interest area. They were adequate to present participants with 'dilemma' situations - where they needed to decide to choose one statement over another. I also deemed the material would adequately serve the purpose at this stage of my research - to try out the Q-Sorting procedure, the timings as well as the analysis.

However, Watts and Stenner (2012) suggested that an 'adequate' Q-Set would have between 40 to 60 statements. It would be primarily made of statements collected from the intended population or a mixture of both. Based on this suggestion, I decided to revise my phase 1 Q-Set for several reasons; i) to include some of the student statements I collected from phase 1, ii) increase the number of statements in line with existing literature and iii) to use this Q-Set as a template for my main study. The statements from phase 1 were incorporated to form the

phase 2 Q-Set. Students in phase 2, Year 11s, were supplied with 60 statements and a 60-card sorting frame (Figure 3.16).


Complete this table by ranking the statements by how strongly you agree or disagree with each statement. Write one statement number in each box.

Most disagreeable — Most agreeable

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5

In the space below can you write a sentence or two that best describe how you feel about maths. It could any from the statement cards or your own.

.....

.....

.....

.....

Thank you for your time.

J. Nyama

Figure 3.16: 60 statement frame

Following this pilot, I presented the statements to a focus group consisting of mathematics education researchers at a Mathematical Resilience Conference. They trialled the 60 statement Q-Set. Taking their feedback and that of the Year 11s into consideration, I reviewed the statements and reached a final Q-Set that consisted of 47 statements. 62% were from students and 31% from literature.

3.9 What I learnt from the pilot studies

3.9.1 Administration

I learned that the most suitable format for my research would be to use the whole class lesson time format. The use of lesson time had its advantages and disadvantages. For one, using lesson time meant that there was no unnecessary disruption to other lessons. It also meant there was no need to make any special arrangements, e.g. finding a ‘substitute’ teacher to supervise the class while I supervised the Q sort activity. However, a disadvantage to the

whole-class lesson-time format was that it did not allow time variations in task completion. Some students completed the ranking task much more quickly than others. These different completion rates seemed to indicate that I needed to either do it in small groups, plan for another activity they could do silently or plan for somewhere they could go once they had completed the task. I decided to try a small group format in phase two because I deemed it would be easier. The small group format meant that I needed to liaise with teachers who were timetabled to teach this group when I had non-contact time on my timetable. Time variation was mitigated because, after seeking and being granted permission to withdraw students from their lessons for this activity, any students who completed early could go back to their lessons. However, it also meant that data collection took longer. When it came to the format I used for my main research; I had to consider these observations to inform the format I used carefully.

The Year 11 pilot group identified 18% of the students as holding non-resilient views.

3.9.2 Data collection

Data collection in both phase one and phase two was done under exam conditions, which allowed students to be as 'true' to themselves as possible with no discussions or comparing Q sort arrangements. However, this 'exam conditions' arrangement meant that any student's queries were bound to be overheard by others, despite whispering. Using smaller groups, I only managed to minimise this disturbance but not get rid of it completely.

3.9.3 Analysis and interpretation of the results

There were distinct factors extracted from the data, with clearly stated distinguishing statements for each factor. Through further literature review (for example, Ramlo, 2015), I discovered that it was worthwhile to examine both the defining sort for each factor and

corresponding outputs for a richer interpretation of analysis outputs. The simultaneous examination of the defining sorts and their corresponding output reveals the positionality of their distinguishing statement. It gives the added advantage of revealing where the students placed any other statements 'of interest', resulting in a deeper and broader understanding of these individuals' perspectives.

3.9.4 From using the Q-Sorting technique

One significant and crucial advantage of the Q technique that I realised was that some students who would not have been comfortable talking openly about their views and feelings reported that the cards helped them say what they felt without feeling anxious.

3.10 Limitations

The viewpoints gleaned from this pilot study are a product of prevailing conditions at that moment in time. They may or may not emerge in subsequent studies. The Q method of collecting viewpoints provides for the study of an individual's subjectivity. Results produced from such a study may or may not be generalised. Generalisability is not a goal of any study that utilises the Q method factor analyses. It can only inform similar situations.

3.10.1 Addressing issues raised about the Q-Set

As communicated at the beginning of this chapter, the final Q-Set underwent iterations. These culminated in a set made up of statements of views received at various points during this study's pilot phases.

In March 2017, I attended the Second International Conference on Mathematical Resilience (The Mathematical Resilience Website, 2017). I introduced and presented the Q sort

technique to conference attendees. I used this opportunity as a focus group session. The feedback from this exercise was that:

i. Some of the participants reported that some statements seemed to be repetitive.
ii. Others relayed that the statements appear to be unbalanced, in terms of being negative or positive statements.
iii. Some communicated that the statements were too many.

The next paragraphs will address these issues and explain how this feedback was used to revise my Q-Set.

3.10.2 Addressing the issue of repetitiveness

Stephenson (1953) says "It is essential…….to achieve a certain homogeneity in the (*Q-Set*) sample, so that no item in it is picked out for particular regard on any extraneous or incidental grounds. This picking out may happen, for example, if a statement is too difficult for anyone to understand." (p.76). He also says a structured sample obviates any peculiarities, such as language, repetition and any necessity to be exhaustive. This view aligned closely with what was pointed out by the 'focus group' and was supported by Watts and Stenner (2015) who postulated that a Q-Set design aims to "generate a set of items that provide good coverage in relation to the question", making sure "each individual item makes its own original contribution to the Q-Set and that in their totality all sitting side by side without creating unsightly gaps or redundant overlaps." (p. 58). Taking the feedback and further research into consideration, I revised my Q-Set.

3.10.3 Addressing the issue of imbalance

According to Stephenson (1968), other considerations that should govern the selection of a sample include the fact that "[t]he sample should be balanced with respect to at least one effect." (p. 78). This condition is usually a simple method to achieve in that "for every statement with a *positive* assertion on meaning; there can always be chosen another with *negative* – for 'good' the word 'bad' is an example. But mere negations are not recommended, e.g., 'honest' and 'dishonest' would never appear in the same sample because of the possibility that a contingency may be involved in operations by a person on this sample containing the antonyms." (p. 79). This seems to imply that care needs to be taken when considering balance in terms of negative and positive statements, as mere negation does not always mean 'balance'. Watts and Stenner (2015) support this by saying "[t]his kind of representation and seamless coverage is what people generally mean when they referred to a *balanced* Q-Set. A suitably balanced Q-Set will come very close to capturing the full gamut of possible opinions and representative in relation to [the] research question. This [need not] imply, as often seems to be concluded, that half the items in the Q-Set have to be positive (or pro) responses to the research question and half negative (or anti). It might mean that in some contexts and in relation to some research questions, but balance always has a wider connotation than mere positives and negatives." (p. 58). From this feedback and further literature review, the key message was that balance is desirable, but not clear cut.

On this aspect, it would appear that there is a slight difference in what constitutes 'balance' within a Q-Set. Although Stephenson states that there 'can' always be negative assertion for a positive one, he does not say that there 'must' be one, which does not necessarily contradict Watts and Stenner's posit. Care just needs to be taken not to be overly preoccupied with how many negative statements versus how many positive statements there are. I considered this

during the revision of my Q-Set. Also, I was not aware of any research that showed that the absence of 'balance' between negative and positive statements affects Q-Set results.

3.10.4 Addressing the issue of too many cards

In terms of statement numbers, Stephenson (1968) says one is always bound to wonder how far any set of items could be a representative sample. He says in principle, all statements in existence could be listed. The same procedures employed to select a people sample in R methodology can be followed in drawing representative statement samples. Even though Stephenson does not give an absolute number of statements, he goes on to say, that "one of our early studies made use of sixty coloured photographs of vases *(60 items)* and what was essential, from a statistical point of view, the Q-Set lends itself to satisfactory operations leading to statistical universes." (p. 765). Watts and Stenner (2015) posit that "the exact size of the final Q-Set will, to a greater extent, be detected by the subject matter itself. A Q-Set anywhere between 40 and 80 items has become the house standard." (p. 61). They say the lower limit occurs because small numbers tend to threaten claims of adequate/comprehensive coverage.

The upper limit is even more pragmatic. Too many items can make the sorting process very demanding and unwieldy. Kerlinger (1969) suggests "the number should probably be no less than 60" and that "a good range is from 60 to 90." (p. 583). It is fair to say, however, there is little evidence presented to justify these conclusions. Indeed, some authors have suggested that they have gained good results with as few as 40 items. Watts and Stenner (2015) extend the discussion by saying "it is pretty clear that limits are only rules of thumb. In some circumstances, it can be sensible to employ a more limited number of items. These circumstances usually involve some pressing need to make the task least taxing. Using fewer

statements might be necessary if your participants are children, for example, or adults with learning difficulties, or if a participant needs to complete two or more Q-Sorts in a single data collection." (p. 61). If reducing numbers is essential, care must be taken to broaden the Q-Set's semantic content and coverage. Watts and Stenner (2015) summarise this fittingly by saying whatever the final number ends up as it is crucial to start with an overly large number of items that can be refined and revised through piloting. Getting other people to look at the items in some fashion is very important. This piloting can help clarify individual items' wording, reduce duplication, generate new items and ensure that the Q-Set provides adequate coverage of relevant ground.

3.10.5 Summary

As shown in the discussion, three critical elements to an effective Q-Set stand out:

i. Each item must make its own original contribution (no repetition).
ii. The best possible coverage should take precedence over the 'negative-positive' balance.
iii. There is no set rule on how many items can be in a Q-Set; the consensus is that the Q-Set must be large enough to cover the pertinent subject area.

During the piloting process, I revised my Q-Set based on the findings. However, I added another element - that of age. I considered the participants' age group, especially when it came to the number of items. For example, I adjudged that Year 11 participants would cope well with 60 statements. In contrast, Year 9 participants might be overwhelmed by 60 items, so I revised the Q-Set to only consist of 47 statements. I was conscious that while I reduced the number of statements, I needed not to lose coverage. The paramount desired outcome

from using these statements was to extract subjective and self-reporting views from the participants. In that regard, the desired outcome I wanted was sufficiently achieved.

3.11 Chapter Summary

This chapter set out to outline the framework on which I based my research design. I examined the fundamental elements of my action research; namely my ontological stance, my epistemological stance and the different philosophical perspectives in which my research is grounded. I explained the research framework, data collection methods and what data I collected. I also introduced the subjectivity element, utilised my research and briefly reported on my pilot studies.

Researchers have increasingly begun to assess the consequences of self-reported attributes for students' academic outcomes. Over the past years, different models have been developed to address self-reported issues. A majority of them suggest that core beliefs about self can set up different patterns of response to challenges and setbacks (Dweck, 1999). My research seeks to extend that body of literature by reporting on a study to support the transformation of beliefs about the self (subjectivity) so that there is more prevalence of positive responses to challenges and setbacks. I use Q-Methodology to assess where students position themselves (belief about self) in their mathematical resilience tendencies. After determining where students positioned themselves in a self-reporting frame, I selected and adapted educational intervention tools to help transform these subjective views with the expectation of supporting the development of these students' mathematical resilience. This study's desired outcome is to have participants report the benefits of and skills gained from the models and strategies used in this study, thereby supporting the development of the participants' mathematical

resilience. I believe it will subsequently help them navigate the mathematics learning journey and consequently improve their achievement.

I expect that the assessment of participants' beliefs will generate individual as well as shared beliefs. It is important to acknowledge that, in undertaking this study, I do not assume that shared beliefs about mathematical resilience coupled with subjection to the same intervention strategies will imply that everyone will have exactly the same outcome, or everyone will learn everything with equal ease; subjectivity defies that. Instead, the assumption is that mathematical resilience can always be further developed for any given individual, to varying degrees.

In the next chapter, Chapter 4, I report on the subjective views held by my research participants, the data I collected on the impact of the chosen activities and strategies, and the analysis of results from this data.

Chapter 4 – Action Research Cycles and Results

Introduction

In this chapter, I report on and offer an interpretation of the action research cycles. This chapter is structured in line with the research questions, as set out in Chapter 3: the data collected and the relevant interpretations towards addressing RQ2 and RQ3 primarily but first; I describe the subjective views of the participants involved in this study, addressing RQ1. I show links between each cycle and how one informed the next. While Section 1 describes participants' subjective views in this study (RQ1), Section 2 describes the action research cycles, the data collected, and analysis results (RQ2 and RQ3). Section 3 addresses students' initial subjective views, and Section 4 summarises the ARCs. Section 5 looks at gender-related findings, while Section 6 concludes the chapter. Chapter 5 goes on to address RQ4, in greater detail.

In the next section, I give an account of the data I collected on the participants' subjective views in the study and how I interpreted this data to provide an insight into the views students held about their mathematics learning journey so far. The data presented in this chapter assumed all other affective factors are controlled and held constant.

4.1 Subjective Views of Participants (RQ1)

Research sub-question 1 is 'What are the girls' subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions?'

The Year 9 cohort undertook the Q-Sorting activity, as described in section 3.5. I analysed the Q-Sorts that the students produced using the PQMethod software. Five distinct factors

(unhelpful viewpoints) emerged from 36 participants out of a cohort of 98; that is, 37% of the students were identified as potentially holding non-resilient views, comprising students from set 1 (high achievers) to set 5 (low achievers). This result meant that the remaining 63% appeared to hold views that may not make them susceptible to being non-resilient. The Year 11 pilot group's Q-Sort revealed that 18% of the students as holding non-resilient views.

4.1.1 Factors extracted: a brief description

Five factors were extracted from the Q-Sorts. Factor 1, which I called 'Maths as Application', describes students who think success in maths is directly proportional to the effort they put in; the more effort they exert in their learning, the more successful they are. Factor 2, which I called 'Maths as Enjoyable and Explained', describes students who think maths should be fun (Moyer, 2001) and, if they are explained clearly, the students will remember the principles.

Factor 3, which I called 'Maths as Enjoyable and Relevant', describes students who believe maths should be fun and have yet to established clear links between mathematics and future careers or further study. Factor 4, which I called 'Maths as Thinking Skills', describes students who think that childhood mathematical experiences are fundamental and that logical thinking skills learnt in mathematics are transferable to other related areas of life. Factor 5, which I called 'Maths as Utility', describes students who think that mathematics is essential for most careers, and if you are good at mathematics, you have more opportunities for a successful career.

4.1.2 Students/Factor Distribution

Of the students in this cohort who completed the Q-Sort ($N = 98$), 33% loaded significantly onto Factor 1, 9% loaded significantly on to Factor 2 and 11% loaded significantly onto Factor 3. 6% loaded significantly on to Factor 4 and 7% loaded significantly onto Factor 5.

Unlike the pilot study outputs (see Section 3.5.1.2), the Q-Sort of 13% of the main study participants loaded non-significantly. 20% loaded on three factors that I eliminated from this research because I determined, after thorough consideration using established literature, that they did not present views that made them vulnerable to being non-resilient. Also, none of the Q-Sorts was a confounding sort (see Section 3.5.1.2)

4.1.3 Detailed Descriptions

In the subsections following, I describe the factors extracted from the main study Q-Sorting in greater detail. I discuss the defining statements, their implications in terms of students' subjective views, and justification for their inclusion in the study.

4.1.3.1: Factor 1 *- Maths as Application*

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
If someone is not good at maths, there is nothing that can be done to change that.	Personally, I struggle a lot in maths.	It feels like there is a limitation on my ability to understand it.	Maths can be used as a tool for empowering communities.	Having a solid knowledge of maths helps in my other school work.	I think maths is important for most *careers* but I don't believe it's essential for a successful or happy life.	When I fail or do poorly on a maths test, I know I have to work harder.	Maths keeps me thinking each time I do any maths related work.	More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths.	Good mathematicians experience difficulties when solving problems.	Everyone can get better at maths if they try.
I believe a person's maths ability is determined at birth.	It's really hard to remember how to incorporate the rules we learn in class into exam and test questions.	I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.	When I have done poorly on something related to maths, I know how to adapt	Maths gets easier when you get a lot of help	I think maths lesson should be fun to help us remember.	I believe I can grow in my knowledge of maths.	I am aware that I can improve in maths	Maths is a wonderful world of numbers.	It would be difficult to succeed in life without maths.	Maths is all about the effort you put in from the start. What you put in is what you get out.
	People are either good at maths or they aren't.	Maths is the reason why I come to school.	When I struggle with maths, I return to it until I get it.	Ability to do well in maths is based highly on confidence.	Maths helps my brain to develop.	I sometimes get discouraged by difficulties in mathematics.	Making mistakes is necessary to get good at maths.	I think that the kind of teacher you have will be an influence in how well you'll do in maths.	Struggle is a normal part of working on maths.	
		I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra	People who are good at maths have more opportunities than those who aren't good at maths.	I think if I enjoyed maths I would work hard to succeed.	Maths develops good thinking skills.	Maths is essential for my future and very helpful no matter what I decide to study	Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.	Maths can be learned by anyone.		
			I have strategies to use when I get stuck on a maths question.	Knowing maths contributes greatly to achieving my goals.	I think some maths topics shouldn't be taught as they make maths harder such as algebra.	Maths can be a very difficult subject and many people get discouraged by it.	When I experience a setback in something related to maths, I seek encouragement from others.			
				I know how to bounce back when I get discouraged in maths.	I want to study maths at A Level, so I need a good grade at GCSE.	I think how people are taught maths when they are young makes a big impact later on				
					Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.					

Figure 4.1: Defining Sort for Factor 1

These students think success (or lack of) in maths is directly propositional to how much a person applies themselves to their learning; they are of the view that effort is important and the more effort a person exerts in their learning, the more successful they are. This view is

consistent with Dweck's incremental theory. Even though they express strong associations with struggle, these students believe that struggle is not something they would experience in their maths learning. This factor exhibits characteristics of published understanding of 'self-efficacy' (Bandura, 1997).

Delving deeper into this factor's landscape, it is closely aligned to one of Dweck (2006)'s self-theories. Her 'incremental view' theory describes students who believe their intelligence is malleable and can be increased through effort, which is the view this factor identifies with. Students in this factor would benefit from teachers praising them for their effort rather than their intelligence. Interestingly, another highly ranked statement in this factor indicates that students whose Q-Sorts load on it also believe they can learn anything (Bandura (1997)'s self-efficacy) and will be willing to do so.

In terms of being a 'maths person', this factor seems to describe students who agree they are 'a maths person' and will say 'I will work as hard as I can, I can learn anything I put my mind to, and I will give it my best shot and there is a good chance I will be successful'.

Also, in terms of mathematical resilience, it is interesting to note that this factor identifies a kind of personal assertion about learning that might enable students to overcome hurdles and challenges; they are willing to put in the effort necessary to succeed.

Intervention Target Group: students who loaded negatively on this factor were invited to participate in the intervention group.

*4.1.3.2: **Factor 2 -** Maths as Enjoyable and Explained*

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
When I struggle with maths, I return to it until I get it.	More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths	I want to study maths at A Level, so I need a good grade at GCSE.	Maths can be a very difficult subject and many people get discouraged by it.	Maths is all about the effort you put in from the start. What you put in is what you get out	Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.	I think maths is important for most careers but I don't believe it's essential for a successful or happy life.	It would be difficult to succeed in life without maths.	I think if I enjoyed maths I would work hard to succeed	Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.	I think maths lesson should be fun to help us remember.
Maths is a wonderful world of numbers	Everyone can get better at maths if they try.	I believe a person's maths ability is determined at birth.	Good mathematicians experience difficulties when solving problems.	When I have done poorly on something related to maths, I know how to adapt.	People are either good at maths or they aren't.	Ability to do well in maths is based highly on confidence.	I think how people are taught maths when they are young makes a big impact later on.	I think that the kind of teacher you have will be an influence in how well you'll do in maths.	Personally, I struggle a lot in maths.	I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra
	Maths is the reason why I come to school.	I have strategies to use when I get stuck on a maths question.	Maths develops good thinking skills	Maths can be learned by anyone.	I think some maths topics shouldn't be taught as they make maths harder such as algebra.	I sometimes get discouraged by difficulties in mathematics.	When I fail or do poorly on a maths test, I know I have to work harder.	Maths gets easier when you get a lot of help	It's really hard to remember how to incorporate the rules we learn in class into exam and test questions	
		I know how to bounce back when I get discouraged in maths.	Maths can be used as a tool for empowering communities.	It feels like there is a limitation on my ability to understand it.	Maths keeps me thinking each time I do any maths related work.	Maths is essential for my future and very helpful no matter what I decide to study.	If someone is not good at maths, there is nothing that can be done to change that.	Struggle is a normal part of working on maths.		
			I believe I can grow in my knowledge of maths.	Maths helps my brain to develop.	People who are good at maths have more opportunities than those who aren't good at maths.	Making mistakes is necessary to get good at maths.	When I experience a setback in something related to maths, I seek encouragement from others.			
				I am aware that I can improve in maths.	Having a solid knowledge of maths helps in my other school work.	Knowing maths contributes greatly to achieving my goals.				
					I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.					

Figure 4.2: Defining Sort for Factor 2

These students think maths should be fun and if explained clearly principles will be remembered. They see confidence as important and this priority is consistent with published understandings of 'resilience' (Williams, 2014). Though procedural maths is not at issue, these students are yet to identify and establish clear reasons and motivations for engaging with mathematics to A level and beyond. There is no clear evidence to read this factor as an expression of discontent or failure in and of themselves, but if they do not find learning enjoyable, they will disengage and subsequently lack the motivation to continue beyond GCSE.

This factor resonates with what Nardi and Steward (2003), in their publication 'Is Mathematics T.I.R.E.D?', called 'tedium'. The students loading on this factor want to enjoy maths but may find that the learning framework does not address and cater to their learning style and interests. It is also interesting to note that, in this factor, it is not the mathematics itself that students who load on this factor are opposed to, but the excluding and

unimaginative way it is explained. This perception seems to have had a profound impact on their motivation to pursue mathematics beyond compulsory age.

In terms of mathematical resilience, some aspects of this factor seem to identify a kind of personal perception that might not enable students to want to overcome hurdles and challenges - for example; they have not established enough confidence to believe they can successfully apply classroom knowledge into examination situations.

Intervention Target Group: students who loaded positively on this factor were invited to participate in the intervention group.

*4.1.3.3: **Factor 3 -** Maths as Enjoyable and Relevant*

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Maths is the reason why I come to school.	Maths is a wonderful world of numbers.	If someone is not good at maths, there is nothing that can be done to change that.	Maths can be used as a tool for empowering communities.	When I struggle with maths, I return to it until I get it.	People who are good at maths have more opportunities than those who aren't good at maths.	When I fail or do poorly on a maths test, I know I have to work harder.	It feels like there is a limitation on my ability to understand it.	Struggle is a normal part of working on maths.	I think maths is important for most careers but I don't believe it's essential for a successful or happy life.	I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra
I believe a person's maths ability is determined at birth.	Ability to do well in maths is based highly on confidence.	I think how people are taught maths when they are young makes a big impact later on.	When I have done poorly on something related to maths, I know how to adapt.	Maths gets easier when you get a lot of help	Knowing maths contributes greatly to achieving my goals.	Maths is all about the effort you put in from the start. What you put in is what you get out.	I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.	More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths.	I am aware that I can improve in maths.	I think that the kind of teacher you have will be an influence in how well you'll do in maths.
	People are either good at maths or they aren't.	I think some maths topics shouldn't be taught as they make maths harder such as algebra. .	When I experience a setback in something related to maths, I seek encouragement from others.	Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.	I think if I enjoyed maths I would work hard to succeed.	It's really hard to remember how to incorporate the rules we learn in class into exam and test questions.	Maths develops good thinking skills.	Maths helps my brain to develop.	I think maths lesson should be fun to help us remember.	
		I want to study maths at A Level, so I need a good grade at GCSE.	Maths is essential for my future and very helpful no matter what I decide to study.	Maths can be learned by anyone.	I have strategies to use when I get stuck on a maths question.	Making mistakes is necessary to get good at maths.	I believe I can grow in my knowledge of maths.	Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.		
			Having a solid knowledge of maths helps in my other school work.	It would be difficult to succeed in life without maths.	I know how to bounce back when I get discouraged in maths.	Good mathematicians experience difficulties when solving problems.	Everyone can get better at maths if they try.			
				I sometimes get discouraged by difficulties in mathematics.	Personally, I struggle a lot in maths.	Maths can be a very difficult subject and many people get discouraged by it.				
					Maths can be learned by anyone.					

Figure 4.3: Defining Sort for Factor 3

Students holding this view, like Factor 2, believe maths should be fun. They believe that, if maths is explained excitingly and enjoyably, they would be more successful at working at it. However, unlike Factor 2, they have not established clear links between mathematics and future careers or further study. They cannot see the future benefits of what they are doing now.

Mathematics plays a central role in the scientific picture of the world. How the connection between mathematics and the world is to be accounted for remains one of the most challenging problems for students. Delving deeper into the landscape of Factor 3, and similar to Factor 2, this factor closely ties to 'tedium' (Nardi & Steward, 2003) implying a level of banality surrounding the learning of mathematics. Students who load on this factor will engage mostly out of a sense of obligation and under school or parental pressure. They seem to have minimal appreciation and gain little joy out of this engagement.

Also, unlike factor 2, this factor identifies students who have not established a connection between any aspects of mathematics to their perceived future career. Students who load on this factor would have internalised widely held views that most mathematics concepts have no relevance in life due to the societal perception of mathematics.

Relevance, excitement and variety (Nardi & Steward, 2003) would be cited by students loading on this factor as characteristics of mathematical activities they want to be asked to participate more in.

In terms of mathematical resilience, this factor identifies a commitment to learning that would not enable students to manage their learning, especially when faced with hurdles and challenges. They believe that mathematics has no value or utility in their future and that if someone does not enjoy this engagement, there will be no long-term memory internalisation of the content.

Intervention Target Group: students who loaded positively on this factor were invited to participate in the intervention group.

*4.1.3.4 **Factor 4** - Maths as Thinking Skills*

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Maths can be a very difficult subject and many people get discouraged by it.	Maths is the reason why I come to school.	Maths gets easier when you get a lot of help	I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra	I know how to bounce back when I get discouraged in maths.	It's really hard to remember how to incorporate the rules we learn in class into exam and test questions.	I sometimes get discouraged by difficulties in mathematics.	Struggle is a normal part of working on maths.	Maths can be learned by anyone.	Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.	More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths.
I believe a person's maths ability is determined at birth.	It feels like there is a limitation on my ability to understand it.	If someone is not good at maths, there is nothing that can be done to change that.	I think maths is important for most careers but I don't believe it's essential for a successful or happy life.	People are either good at maths or they aren't.	I think that the kind of teacher you have will be an influence in how well you'll do in maths.	When I have done poorly on something related to maths, I know how to adapt.	I think if I enjoyed maths I would work hard to succeed.	Everyone can get better at maths if they try.	Maths develops good thinking skills.	I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.
	When I struggle with maths, I return to it until I get it.	People who are good at maths have more opportunities than those who aren't good at maths.	Good mathematicians experience difficulties when solving problems.	Knowing maths contributes greatly to achieving my goals.	Maths can be used as a tool for empowering communities.	Having a solid knowledge of maths helps in my other school work.	Maths is essential for my future and very helpful no matter what I decide to study.	Maths keeps me thinking each time I do any maths related work.	I think how people are taught maths when they are young makes a big impact later on.	
		It would be difficult to succeed in life without maths.	Making mistakes is necessary to get good at maths.	When I fail or do poorly on a maths test, I know I have to work harder.	I believe I can grow in my knowledge of maths.	Maths is all about the effort you put in from the start. What you put in is what you get out.	Maths helps my brain to develop.	I have strategies to use when I get stuck on a maths question.		
			When I experience a setback in something related to maths, I seek encouragement from others.	I want to study maths at A Level, so I need a good grade at GCSE.	Personally, I struggle a lot in maths.	Ability to do well in maths is based highly on confidence.	Maths is a wonderful world of numbers.			
				I think some maths topics shouldn't be taught as they make maths harder such as algebra.	Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.	I think maths lesson should be fun to help us remember.				
					I am aware that I can improve in maths.					

Figure 4.4: Defining Sort for Factor 4

These students think that childhood mathematical learning experiences are fundamental and impact future success and that the logical thinking skills learnt in mathematics are transferable to other related areas of life. While acknowledging that maths is hard, they disagree that it gets easier with help and do not believe that making mistakes is sometimes necessary to get good at working at maths.

Consistent with earlier research (Boaler, 2000), this factor identifies students who believe that the kind of teacher one had in childhood has a significant impact on their current and future success. They believe that how educators deliver content is very important. While attribution theory suggests that students, especially females, tend to attribute their lack of success to themselves, this factor indicates the contrary. This factor is closely tied to Boaler (2000)'s finding that female students "at Amber Hill were clear about the reasons for their lack of success in mathematics and these had nothing to do with their own inadequacies." (p. 123). This factor frames the content delivery issues largely in terms of pedagogical traditions in childhood learning spaces.

In terms of support, students who load on this factor see help as a futile exercise that does not yield any intended results. These students would sit in a contemporary classroom and think 'I will try this. If I get it great, I did not get it even in primary school if not that's life.' They think mistakes are who they are, not a part of learning.

Also, in terms of mathematical resilience, the students who load on this factor present a perspective that would not enable them to manage their learning in the face of challenges and hurdles. Intervention Target Group: students who loaded positively on this factor were invited to participate in the intervention group.

4.1.3.5: Factor 5 - *Maths as Utility*

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
I believe a person's maths ability is determined at birth.	Maths is the reason why I come to school.	When I have done poorly on something related to maths, I know how to adapt.	Maths keeps me thinking each time I do any maths related work.	Good mathematicians experience difficulties when solving problems.	Maths can be learned by anyone.	Maths can be a very difficult subject and many people get discouraged by it.	Knowing maths contributes greatly to achieving my goals.	When I fail or do poorly on a maths test, I know I have to work harder.	People who are good at maths have more opportunities than those who aren't good at maths.	I think maths is important for most careers but I don't believe it's essential for a successful or happy life.
I think maths lesson should be fun to help us remember.	Maths develops good thinking skills.	I know how to bounce back when I get discouraged in maths.	Maths helps my brain to develop.	I think some maths topics shouldn't be taught as they make maths harder such as algebra.	I have strategies to use when I get stuck on a maths question.	I think how people are taught maths when they are young makes a big impact later on.	Maths is essential for my future and very helpful no matter what I decide to study.	Personally, I struggle a lot in maths.	People are either good at maths or they aren't.	Having a solid knowledge of maths helps in my other school work.
	Maths is a wonderful world of numbers.	When I experience a setback in something related to maths, I seek encouragement from others.	Maths gets easier when you get a lot of help	Maths is all about the effort you put in from the start. What you put in is what you get out.	It would be difficult to succeed in life without maths. .	Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.	I think that the kind of teacher you have will be an influence in how well you'll do in maths.	I think if I enjoyed maths I would work hard to succeed.	I sometimes get discouraged by difficulties in mathematics.	
		I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra	Maths can be used as a tool for empowering communities.	Ability to do well in maths is based highly on confidence.	When I struggle with maths, I return to it until I get it.	Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.	It feels like there is a limitation on my ability to understand it.	It's really hard to remember how to incorporate the rules we learn in class into exam and test questions.		
			Making mistakes is necessary to get good at maths.	If someone is not good at maths, there is nothing that can be done to change that.	I want to study maths at A Level, so I need a good grade at GCSE.	Everyone can get better at maths if they try.	I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.			
				Struggle is a normal part of working on maths.	More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths.	I believe I can grow in my knowledge of maths.				
					I am aware that I can improve in maths.					

Figure 4.5: Defining Sort for Factor 5

Students who hold this view think that mathematics is important for most careers and, if a person is good at mathematics, they have more opportunities for a successful career. Despite the knowledge that they need to work 'harder' when they perform poorly in maths, they have not been able to identify strategies for working better at mathematics. They think recovering from a setback is important but have not developed skills to enable them to do so.

Delving deeper into the landscape of Factor 5, if these students believe that they are not good at maths, they are most likely to be discouraged not only to be successful at maths but from pursuing maths-related courses and careers. These students need to become aware of strategies they could try to overcome challenges and thrive.

Intervention Target Group: students who loaded positively on this factor were invited to participate in the intervention group.

4.1.4 Subjective views summary

At the beginning of section 4.1, I outlined the data collected and analysis results using the PQMethod and gave a systematic description of the interpretation of the results from this reconnaissance phase within my study. I also reported how the interpretation was used to identify and select the participants in the intervention groups. Table 4.1 provides an overview of the resultant analysis and interpretation of data collected.

Maths as Application	Students think success in maths is directly proportional to the effort they put in.
Maths as Enjoyable and Explained	Students think maths should be fun and if explained clearly principles will stick.
Maths as Enjoyable and Relevant	Students believe maths should be fun but have not established clear links between maths and future career or further study.
Maths as Thinking Skills	Students think that childhood mathematical experiences are fundamental and logical thinking skills in maths are transferable to other related areas of life.
Maths as Utility	Students think that maths is important for most careers and if you have good maths skills you have more opportunities for a successful career.

Table 4.1: Summary of subjective views as indicated by student's self-referencing

In the following section, I focus on the steps taken to address these potentially 'non-resilient' views, by describing how I introduced the programme to the intervention groups and

discussing the implications of what I introduced concerning the students' day-to-day mathematics learning. I also expound on the interventions that I selected and redesigned to support positive learning stances to enable students to thrive in mathematics despite challenges.

4.1.5 The intervention groups for the main study

The identified Year 9 main study participants (37%) attended a workshop before embarking on the main intervention programme. The workshop started with a brief introduction of me as a researcher, my research interest area, and what this project was. I gave the students a brief outline of their involvement in this project, starting from completing the Q-Sorting activity. I shared the results of the Q-Sort analysis - including how and why the analysis results indicated they would benefit from being in this group and explaining what they could potentially gain from participating in the project.

I made it clear that, even though the Q-Sorting activity results picked up some of their 'thinking and opinions' that could hinder them from reaching their full potential, participation in this project was completely voluntary. They could withdraw at any time during the project, including during the workshop. Having established that the students were willing to participate and continue with the project, I proceeded with the rest of the workshop. All ethical approval guidelines were observed during this part of the workshop, as described in section 3.7. It is noteworthy that none withdrew and additional students elected to join in (see page 188).

The Year 9 main study involved the reconnaissance Q-Sorting activity, the introductory workshop and three research cycles, ARC1, ARC2 and ARC3 (Figure 4.6), using strategies to

support the students in developing mathematical resilience. I report the results and findings in the next section, and I evaluate the impact of the strategies in Chapter 5.

Figure 4.6 represents the flow of planning/evaluation/reflection information. ARC1 was the first cycle to be implemented. Feedback from ARC1 informed planning for ARC2 as described in the subsequent sections. Feedback from ARC2 informed ARC3, and at the end of the study, I requested students to offer an overall evaluation.

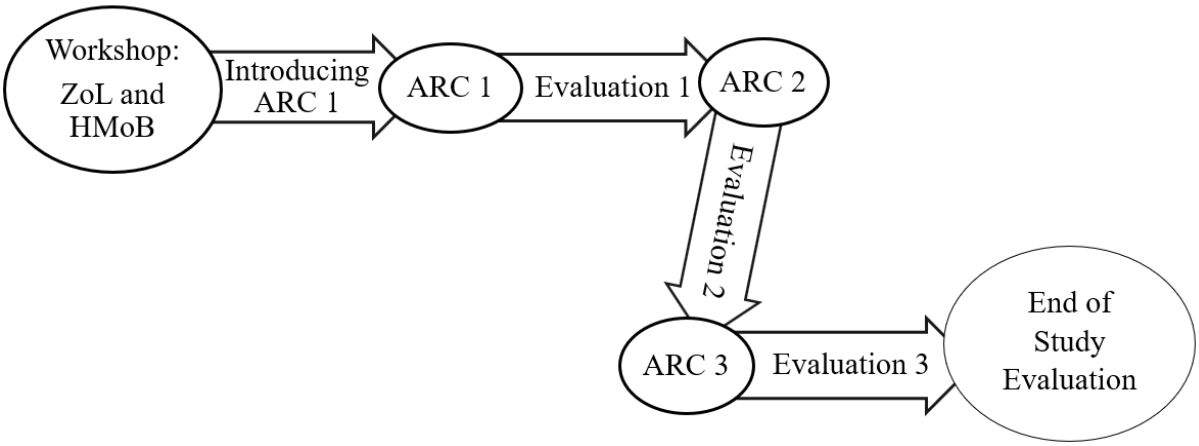


Figure 4.6: Order of ARCs

4.2: Results and interpretation from addressing RQ2 and RQ3

RQ2 was 'What educational intervention activities, as indicated by the subjective views and literature, might I devise to address negative subjective views and how might I implement the devised activities?'

4.2.1: Action research Cycles (Addressing RQ2 and RQ3)

I chose what I called 'Mindset Matters!!!' as my first strategy. There was a strong association between the students' views and the 'Fixed Mindset' described by Dweck (2006). Next, I looked at the defining statements for each factor. When participants strongly disagreed with statements like 'I know how to bounce back when I get discouraged in maths' or 'I have strategies to use when I get stuck on a maths question', I explored literature helping students

‘bounce back’ or get ‘unstuck’. After a lengthy literature review, I settled on two potential further strategies, the ‘Split Page’ (inspired by Tobias, 1987) and the ‘6Bs to Mathematical Resilience’ (inspired by Nottingham, 2014), which were confirmed as appropriate after analysis of ARC1 feedback. For another example, participants who expressed that the teacher and how they are taught held the key to their success I deemed would benefit from these strategies in that they would be made aware that they can succeed equally through their own endeavour. Furthermore, another example is of some participants in this group who reported that ‘Personally, I struggle with maths’ I deemed would benefit from looking at the problem from a different viewpoint where instead of focusing on the ‘person’, they could focus on the ‘problem’; I chose the Split Page to help achieve that.

These strategies seemed a good fit for addressing the participants’ views flagged up from the Q-Sorting activity. However, the nature of action research is predominantly reactive in that the next cycle is informed by the feedback from the previous cycle. In planning for the three cycles based on the students’ subjective views, I was ensuring that these views are patently addressed. During implementing these cycles, I made adjustments to the selected strategies in response to the feedback given from each cycle. These are discussed in greater detail in the subsequent sections.

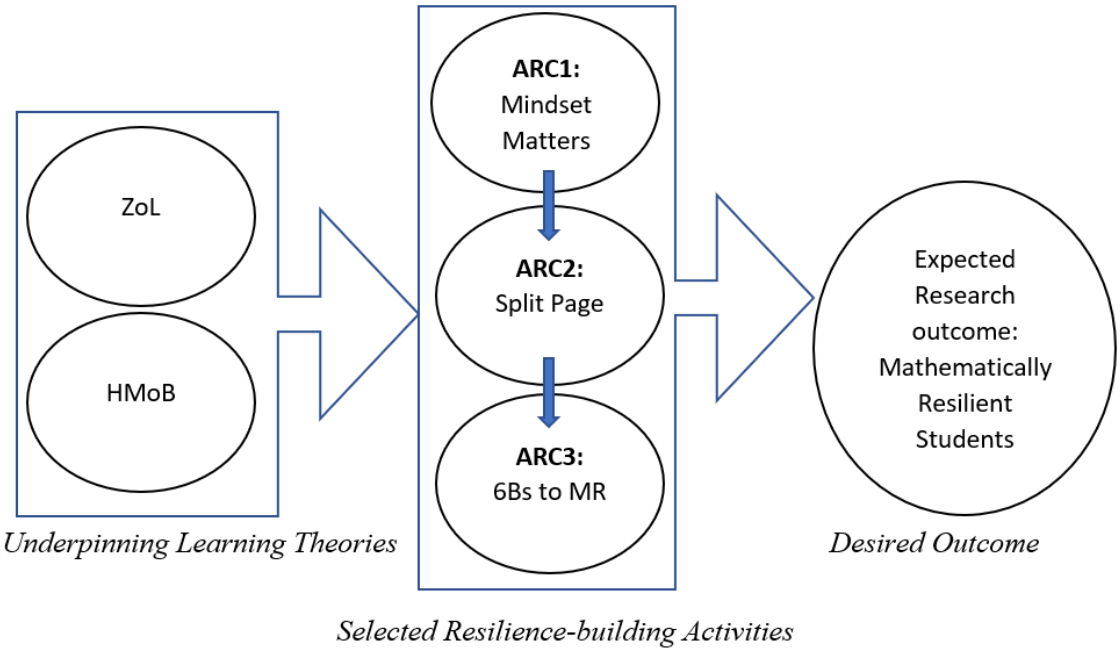


Figure 4.7: Addressing unhelpful views

As pointed out in Chapter 3, at the end of each cycle, students were asked to rate each intervention activity's usefulness and give suggestions for improvement. I expound on these action research cycles in the next sections, including observations from the underpinning learning theories.

4.2.1.1: Students' interactions and reactions to the learning models

4.2.1.1.1 Zones of Learning model.

Some of the students' qualitative feedback I collected on ZoL included statements like 'The majority is understandable, but I still don't get it', 'You can talk about how you can be in the different zones', 'I can improve my learning in the right zone', 'Doesn't really work for me', 'I understand, but it doesn't help me get better at Maths', 'I wasn't really thinking about the zones, I was just trying to understand the lesson', 'I'm not sure, sometimes I don't understand the learning zones', 'It was more captivating and memorable', 'Giving us examples to show us how to use this to help us', 'I don't understand the use of this concept', 'It's ok', 'I found this easier to understand, but I didn't see how this could be used for my learning', 'If I'm in

the red zone I know to try and work harder to get out of there', 'Have it explained more'. These statements are both indications of positive and negative interaction with the model. These mixed results seem to suggest that students either understood the idea of zones of learning and their impact on their learning or misunderstood the concept and therefore deemed it to be of little use to them. This assertion is supported by the rating they gave for the model's usefulness (mean rating of 5.8 and 5.6 ranging from 1 to 10).

4.2.1.1.2 Hand Model of the Brain.

For the Hand Model of the Brain students' qualitative feedback included reports like 'I could use it to manage and improve my learning', helped in 'managing the ways of how to do that piece of work', I could 'go back to hand model', 'I understand, but it doesn't help me work out Maths questions', I can 'try harder and work my way to the amber zone', 'I'd be better if I understand what was going on', 'maybe making it more memorable for the student so that they can remember to think about it when you do work', 'because I don't think it's got to do with the brain', 'unsure about it', 'I didn't understand this I found it hard to understand', 'I understand, but I don't see how it will help me with my classwork', 'Showing ideas and examples to manage your learning better'. Another set of mixed opinions seems to reflect that while some students found the strategy useful, others had not yet established any links between the model and managing learning.

4.2.1.2 Students' interactions and reactions to the Intervention Strategies MM, SP and 6Bs.

The qualitative data discussed here was inductively and deductively analysed (see Appendix 6 for the table of statements). I categorised the data into positive comments, negative comments and statements that were more general (classed as 'unexpected').

Over the three strategies, 16 out of 34 (just under 50%) of the positive comments expressed approval of the 6Bs to Mathematical Resilience. Fourteen were about the Split Page and four about the Mindset Matters. Some of the positive comments were, for example, 'I can understand my mindset and I can improve when learning' (MM); it helped me in 'Understanding what maths is needed….'(SP) and 'Helped me understand what can be done to get me out of the pit' (6Bs to MR)

Of the 29 negative statements made across the three strategies, five were regarding the 6Bs, fourteen about the SP and ten about the MM. Most of the negative statements centred around not understanding how to apply the strategy to learning. For example, when commenting on the MM, one student said, 'I don't understand the use of the concept', while another said 'maybe giving more ways to resolve the confusion' (SP) would help. One student reported that the 6Bs strategy made her feel slightly more stuck, which is understandable, especially as they were a claustrophobic individual where the mental picture of being in a pit would elicit such feelings.

In terms of the 'unexpected' statements, a few referred to some aspects of the strategies and the programme. One student pointed out that 'I don't see how *knowing* how my brain works will help in maths', while another seemed to find joy in the programme's setup. She expressed her happiness at mixing with other sets in this research programme and commented that it would 'make maths more fun *if* the whole year group joined for challenges to support each other and *better* teamwork is gained with different sets'.

So, in terms of students' qualitative feedback on the proposed strategies, there were slightly more positive comments than negative which seemed to indicate that more students found the strategies suitable for the purpose. Furthermore, the 6Bs to MR was better received by more

students (most positive comments and least negative comments). This is further consolidated by the quantitative data shared in the next sections.

4.2.2 Action Research Cycles: Impact on managing learning (Addressing RQ3)

Research sub-question three was:

> 'What is the impact of these activities on students' personal management of reactions to challenges towards developing mathematical resilience?'

This section discusses each strategy's reported usefulness, as indicated by the data I collected. I present it through two approaches - quantitative and qualitative analysis. The quantitative analysis focuses on the ratings allocated to each strategy; the qualitative analysis focuses on comments forwarded about each strategy. As described in Chapter 3, the qualitative data analysis was undertaken through two approaches, the deductive approach for 'expected' responses and the inductive approach for 'unexpected' responses; some of these responses I have briefly mentioned in the previous section.

The study was underpinned by the Zones of Learning and the Hand Model of the Brain. During the initial planning stages of this research, these underpinning constructs were 'controlled' and held constant because my research's original focus was on what I classified as 'intervention strategies' I deemed addressed the unhelpful views students had (as opposed to learning frameworks/theories). However, during implementing the cycles and reviewing my 'intervention input' with these students and introducing them to 'new knowledge/strategies', I deemed it appropriate to determine the impact that awareness of the HMoB and ZoL might have had on their learning and the managing of their learning. It can be argued that awareness could be a resilience-building activity in itself. Therefore, as action researchers should do (be reactive to developing state of affairs), I applied RQ3 to these

learning frameworks. Consequently, this research question is addressed through a two-pronged approach, assessing the impact of the learning theories and the impact of the utilised resilient building activities. In deducing the impact of Zones of Learning and the Hand Model of Brain frameworks, I report on the observations I made during the workshop and the judgement students made of the underpinning constructs at the end of the study.

4.2.2.1 Workshop observations and interpretations

In this section, I report on the observations I made during the introductory workshop. This workshop was a whole group session that involved the use of PowerPoint and worksheets. 36 Year 9 participants were involved during the first half term of the spring term. I encouraged students to ask questions as and when they wished and made it as interactive as possible through individual reflections, paired discussions and whole group summaries.

One of the workshop activities was that students were asked to think about a time when they had struggled with something, absolutely anything. They were then asked to write down their thoughts and the emotions they felt at that time, including their actions as a result of these emotions and thoughts. I linked their notes back to the 'Zones of Learning' model and the 'Hand Model of the Brain'. I pointed out that if they eventually succeeded, they would have triumphantly navigated the 'growth zone' and managed to get their brains from 'flipped' state to 'learning' state while learning new 'skills'. If they had not succeeded, they probably would have either retreated to the 'safe zone', which would also have the same 'flipped' state to 'learning' state in the brain, but with no new 'skills' acquired, or slid into the 'out-of-my-depth' zone, where panic could ensure, resulting in no new learning.

During the ensuing discussions, I overheard one participant remarking that 'finally, I know I am not dumb, when I cannot do the work in class it means I am in the red zone or my brain

has just flipped, why did someone not tell me this before.'. This remark was a significant insight and indicative of non-existent previous awareness with regards to this participant.

In terms of identifying and addressing unhelpful thoughts, feelings and actions, I observed that some students completed the task without any apparent hesitation. Perhaps, unsurprisingly, these are the students who are comfortable identifying how they feel when actively present in an activity. This active engagement displayed a clear capability to 'name it and tame it', a first step to addressing unhelpful feelings, thoughts and subsequently actions described by Siegel (2011). Others, with some prompting, were able to complete the activity. While students demonstrated willingness (for some) and an association with thoughts and emotions that come with a challenge or an overwhelming situation, their knowledge of (and ability to identify) potential strategies for successful navigation, and indeed sustaining safe presence in the 'growth zone', were noticeably limited, as exemplified by the need for prompting. This limited knowledge of strategies is where this research project comes in; a programme instituting strategies for sustaining a safe and active presence in the 'growth zone' was beneficial to these students. Figures 4.8a and b are the results collected at Evaluation 1 and Evaluation 3 when I requested the students rate how helpful they felt about learning theories in managing their learning.

The report I present here, and the rest of the chapter, is based on the premise that any student who rated each aspect a two or more is reporting 'some' impact. The degree of impact varies according to the rating they allocate to each strategy to learning. Each strategy is rated from 1 (unhelpful or not useful at all) to 10 (very helpful or useful).

a) Zones of Learning Model

Tables 4.2a and b report on how helpful it is to manage their learning the students found to be aware of this model.

Variable	Obs	Mean	Std. Dev.	Min	Max
zolb	22	5.613636	2.935545	2	10

Table 4.2a: Mean and SD of ZoL quantitative data

Variable	Obs	Mean	Std. Dev.	Min	Max
zola	25	5.08	2.596793	1	10

Table 4.2b: Mean and SD of ZoL quantitative data

The 'ZoLb' (Zones of Learning **b**efore) data was collected during Evaluation 1 (see Figure 4.6) at the end of ARC1, after the participants had been exposed to the model for half a term (duration of ARC1), while the 'ZoLa' data was collected at the end of the research project, in Evaluation 3 (see Figure 4.6)

The mean scores indicate students' finding of value in the knowledge/awareness of the Zones of Learning model's knowledge/awareness slightly regressed, from a mean of 5.61 to a mean of 5.08. This could be partially explained by the fall in the minimum value allocated to this model or the difference in the number of students who gave feedback. I conducted a histogram distribution analysis to explore this further, as shown in Figures 4.8a and b.

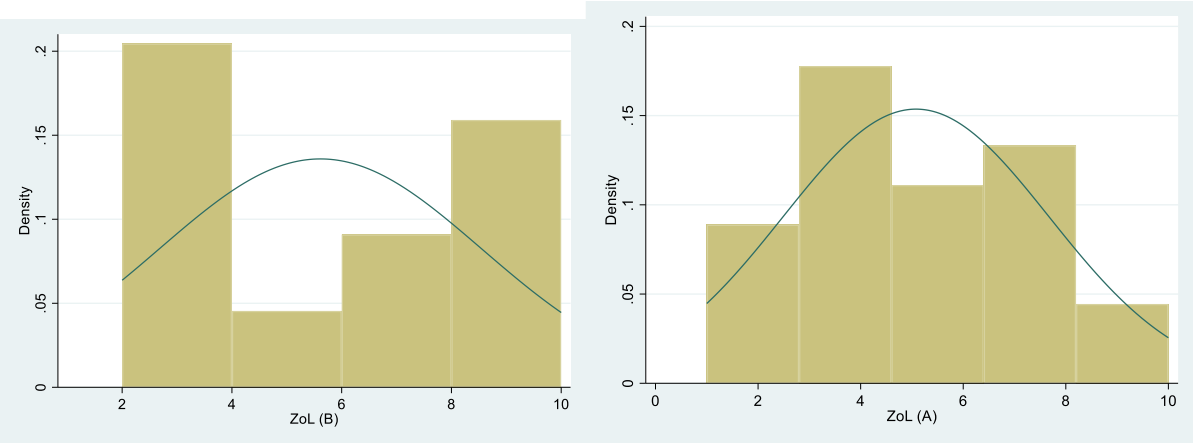


Figure 4.8a and b: Graphic distribution of ZoL quantitative data

By presenting the evaluation data in a histogram mapped over a normal distribution, it becomes clear to see that the difference cannot be explained by just a fall in the minimum value, at the beginning of the project. It is also because a large proportion of the students did find awareness of the Zones of Learning useful (the 8-10 bar) compared to after, which could explain the higher mean score. Although there is a noticeable shift from both ends of the distribution towards the middle values, the lower to higher shift was not strong enough to offset the higher to lower shift. Having said all this, the difference in the two means is quite marginal (0.53).

ZoL (B)	Freq.	Percent	Cum.
2	4	18.18	18.18
3	4	18.18	36.36
3.5	1	4.55	40.91
4	1	4.55	45.45
5	1	4.55	50.00
7	4	18.18	68.18
8	3	13.64	81.82
9	1	4.55	86.36
10	3	13.64	100.00
Total	22	100.00	

ZoL (A)	Freq.	Percent	Cum.
1	3	12.00	12.00
2	1	4.00	16.00
3	3	12.00	28.00
4	5	20.00	48.00
5	2	8.00	56.00
6	3	12.00	68.00
7	2	8.00	76.00
8	4	16.00	92.00
9	1	4.00	96.00
10	1	4.00	100.00
Total	25	100.00	

Table 4.2c and Table 4.2d: Numerical distribution of ZoL quantitative data

Further exploration using a box-and-whisker analysis (Figure 4.9) seems to confirm that although there was a shift from the extreme ends of the distribution, the lower rating of the

middle 50% of the students remained the same (first two graphs), implying that 75% of the group found the model useful at both data capture times.

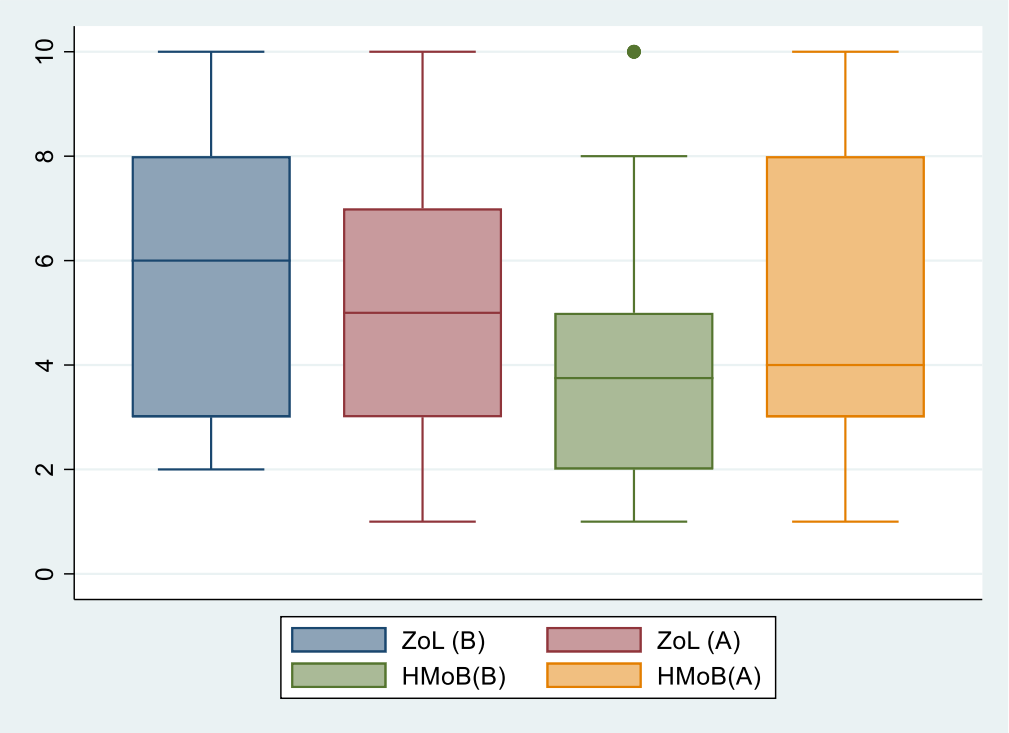


Figure 4.9: Box Plot over the two underpinning theories

So, in terms of the reported usefulness of this framework, I would deem it to have positively impacted most students to some degree during the study. Only three students gave a response of 1.

b) Hand Model of the Brain

The HMoB was subjected to a similar analysis treatment. Similarly, the HMoBb data was collected at evaluation one, and the HMoBa data was collected at evaluation 3. Tables 4.3a and b report on how helpful, in terms of managing their learning, the students found being aware of this model afforded them.

Variable	Obs	Mean	Std. Dev.	Min	Max
hmobb	22	3.977273	2.76232	1	10

Table 4.3a: Mean and SD of HMoB quantitative data

Variable	Obs	Mean	Std. Dev.	Min	Max
hmoba	24	4.916667	3.020462	1	10

Table 4.3b: Mean and SD of HMoB quantitative data

These mean scores indicate that as a group, students' valuing of the model progressed, from a mean score of 3.98 to a mean of 4.92. Although the minimum and maximum value allocated to this model's usefulness remained the same, the difference in the mean score could be explained by further exploration.

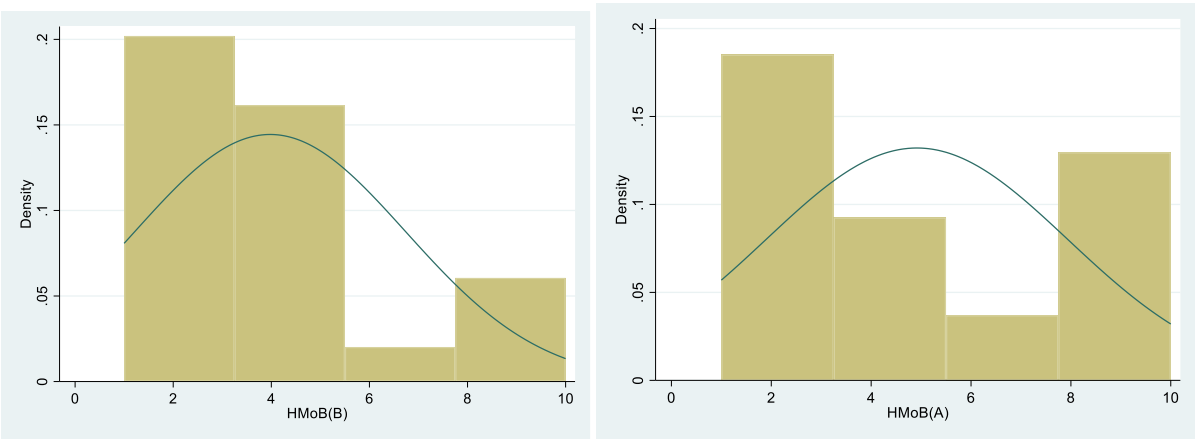


Figure 4.10a and b: Graphic distribution of HMoB quantitative data

By presenting the evaluation data in a histogram mapped over a normal distribution, it is clear to see that the difference can be explained by a marked shift in the number of students who initially did not find great value at the beginning of the study but then grew to appreciate the awareness more as the study continued (indicated by falls in the first 2 bars and increases in the last two bars). A box-and-whisker analysis also confirms this notion (the last two graphs

in Figure 4.11). There is a marked shift in the middle 50% of the students, and the similar range in the data is explained by the 'outlier' in the 'before' data.

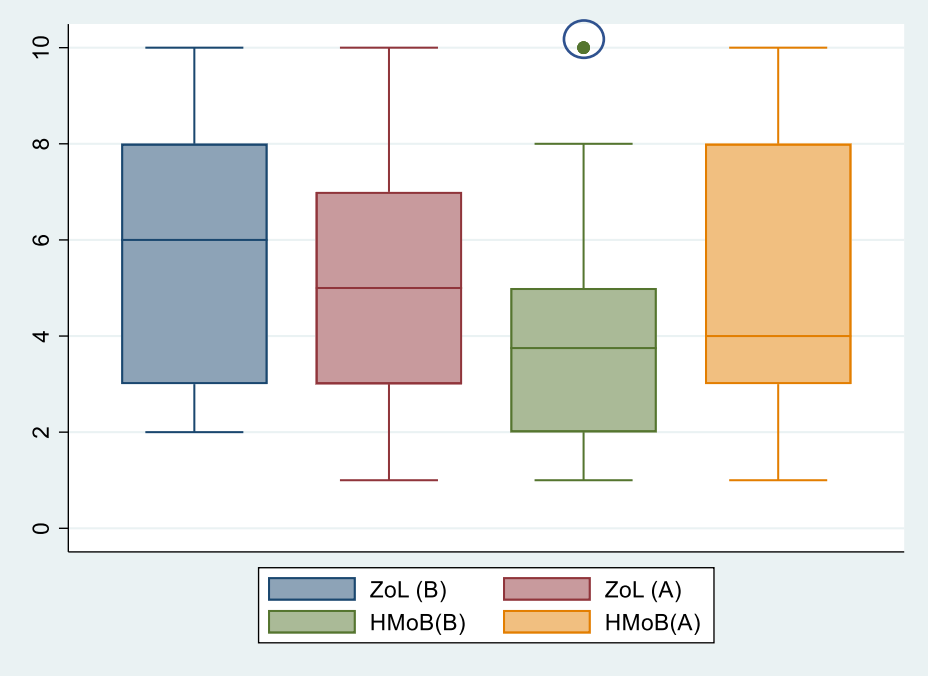


Figure 4.11: Box Plot over the two underpinning theories

Because there were reports of ones (not useful or helpful at all) in both data sets, I performed a further exploration of the data to see what percentage of the students did not find the model useful. Tables 4.4 elucidate that. At Evaluation 1, 22.73% of the students did not find awareness of the model useful. In contrast, by Evaluation 3, only 16.67% of the students reported that they did not find the model useful-a positive result in terms of the number of students reporting not finding any use in the model.

HMoB(B)	Freq.	Percent	Cum.
1	5	22.73	22.73
2	3	13.64	36.36
3	2	9.09	45.45
3.5	1	4.55	50.00
4	3	13.64	63.64
5	4	18.18	81.82
7	1	4.55	86.36
8	1	4.55	90.91
10	2	9.09	100.00
Total	22	100.00	

HMoB(A)	Freq.	Percent	Cum.
1	4	16.67	16.67
2	1	4.17	20.83
3	5	20.83	41.67
4	3	12.50	54.17
5	2	8.33	62.50
6	1	4.17	66.67
7	1	4.17	70.83
8	3	12.50	83.33
9	2	8.33	91.67
10	2	8.33	100.00
Total	24	100.00	

Table 4.4a and Table 4.4b: Numerical distribution of HMoB quantitative data

What would shed even more light is to see if the same students reported a one. Upon inspecting the raw data, only one participant recorded one on both occasions. Based on this set of results, I conclude that the HMoB was useful to all but one student at some point during the research. Therefore, it is worth serious consideration moving forward. 13 participants found it very useful by rating it more than five on at least one occasion.

In sections 4.2.2.2, 4.2.2.3 and 4.2.2.4, I report the results from the three resilience-building strategies I utilised in this study. While reporting the results from the action research cycles undertaken in this study, I also highlight how the feedback from each research cycle confirmed the suitability (or not) of the pre-selected resilience-building strategies and the adjustments made (where necessary) in light of the feedback from each of Evaluation 1 and Evaluation 2. I present the data I collected on the impact of the three resilience-building strategies from two approaches, quantitative analysis and qualitative analysis. The qualitative analysis will take the deductive approach for ‘expected’ responses and the inductive approach for ‘unexpected’ responses. All Action Research Cycles followed the four main stages of an action research cycle, as shown in Figure 3.3. Then in section 4.5, I offer the chapter summary. The next sections present the data gathered from each of the sources described in Chapter 3, and I offer an interpretation of this data.

4.2.2.2 Observation: Data collected and interpretations ARC1: Mindset Matters!!! (MM)

4.2.2.2.1: Implementing/Acting ARC1

The introduction session involved a PowerPoint presentation (see Appendix 7) that I used to explain how mindsets impact learning and how to use the thinking/writing/reflection frame shown in Figure 3.9. I also used examples of questions and scenarios to practice with. In introducing Dweck's mindset theory, I emphasise how established research had shown that mindsets had a huge impact on how students react to and manage their learning, ultimately impacting their achievement. I shared some key facts about how what students say to themselves when working on tasks could improve their GSCE outcomes by a whole grade. Discussion during this introduction session centred around the idea that 'self-talk' influences action taken (Seligman, 2006) and action taken ultimately impacts performance. I used several examples to illustrate this, both positive self-talk and negative self-talk. This activity was interactive, where participants were given scenarios and decided what impact that scenario would have on learning. Participants were supplied with a practice frame and trialled using it. This trial was to make sure that they were able to use the frame in their lessons effectively. I used a crossover question (a question found in both the GCSE higher and foundation paper).

At the end of this session, participants were invited to ask any questions, whether they related to further clarification or any other concerns. Once these were addressed, I provided participants with a small exercise book, and the 'thinking/reflection/writing frame' and participants were urged to record their 'use' of this strategy in their lessons. I also reminded them that they could use the Show My Homework (SMHW) online platform to communicate

with me or send an email through the school email platform. They then went back to their classes, urged to use the 'thinking/reflection/writing' frame during their lessons. Also, during the implementation period of this strategy, I planned to pay 'observation/support' visits to their lessons. A feedback session, at the end of the half term, concluded this cycle.

To illustrate the link between the learning theories and the mindset, students were presented with a graphic (Figure 4.12) showing how the Mindset Matters!!! strategy fits into a sustainable and safe presence in the 'growth zone' (Figure 4.13).

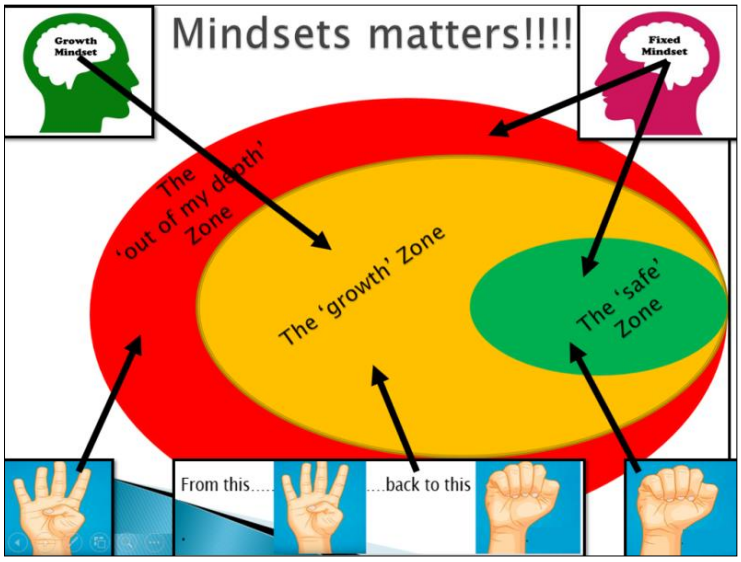


Figure 4.12: MM and learning models (Nyama, 2016)

This was used in conjunction with activity cards as shown in Figure 4.13, where, during the introduction session, students were requested to sort out and match an exemplar thought to the labels 'Fixed Mindset' or 'Growth Mindset' while simultaneously matching opposing thoughts. Figure 4.13 is a group result of this introductory activity. The colour coding between each statement's border and the two mindsets' images were designed to make that connection even clearer.

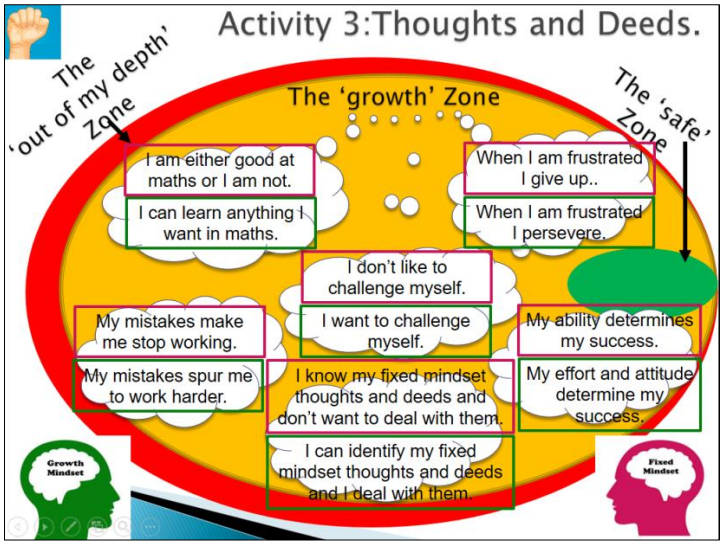


Figure 4.13: MM Thoughts and Deeds (Nyama, 2016)

The next section reports on the data collected at evaluation 1.

4.2.2.2.2 Data Collected at Evaluation 1 and Interpretation

Table 4.5 indicates that many in the group benefitted from utilising this strategy. They rated its usefulness or helpfulness at a mean score of 5.86. The minimum value of 1 indicates that some students did not find it useful or helpful. To determine the proportion of participants who did not find this strategy useful, further analysis is needed.

Variable	Obs	Mean	Std. Dev.	Min	Max
mm	22	5.863636	3.299285	1	10

Table 4.5: Mean and SD of MM quantitative data

By presenting the evaluation data in a histogram (Figure 4.14), mapped over a normal distribution, it becomes clear that the majority of the students reported significant usefulness of the strategy. Although there seems to be a substantial number of students reporting at the lower end, further exploration will reveal the extent of participants who did not find it useful.

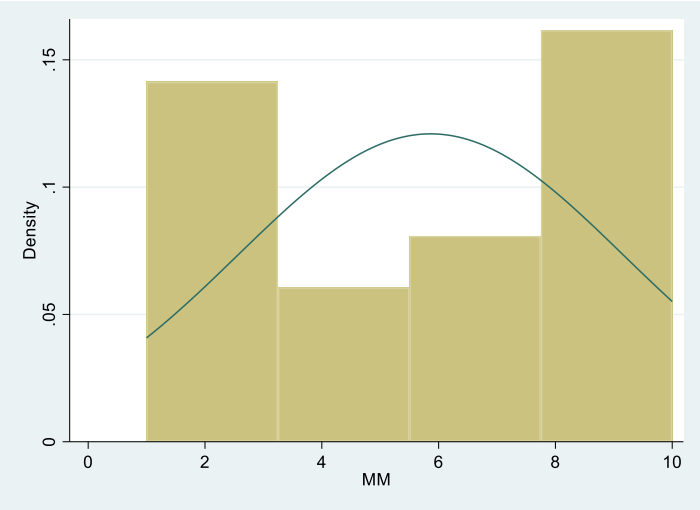


Figure 4.14: Graphic distribution of MM quantitative data

Table 4.6 provides further insight. Only 13.64% of the students in the group did not find value in the mindset strategy. Statistically, this means 86.36% of the students found this strategy useful by rating it a two or more, with some finding it very useful.

MM	Freq.	Percent	Cum.
1	3	13.64	13.64
2	1	4.55	18.18
3	3	13.64	31.82
4	1	4.55	36.36
5	2	9.09	45.45
6	3	13.64	59.09
7	1	4.55	63.64
8	2	9.09	72.73
10	6	27.27	100.00
Total	22	100.00	

Table 4.6: Numerical distribution of MM quantitative data

Further exploration reveals a small negative skewness in the data, which indicates that the tail of the left side of the distribution is slightly longer or fatter than the tail on the right side. The mean (5.86) and median (6.00 on the first box and whisker diagram in Figure 4.15) are less than the mode (10.00, as shown in Table 4.6). This data further confirms that more students

rated the strategy quite high. The kurtosis (the *measure of outliers* present in the distribution) is low (less than 3) in this data set. Therefore, it is an indicator that data has light tails and does not have outliers, so the mean value is a fair representation of the students' progression.

```
                              MM
-------------------------------------------------------------
      Percentiles      Smallest
 1%            1              1
 5%            1              1
10%            1              1       Obs                  22
25%            3              2       Sum of Wgt.          22

50%            6                      Mean           5.863636
                        Largest       Std. Dev.      3.299285
75%           10             10
90%           10             10       Variance       10.88528
95%           10             10       Skewness      -.0480829
99%           10             10       Kurtosis       1.648791
```

Table 4.7: Skewness and Kurtosis of MM quantitative data

**Kurtosis less than 3 = the extreme values are less than that of the normal distribution

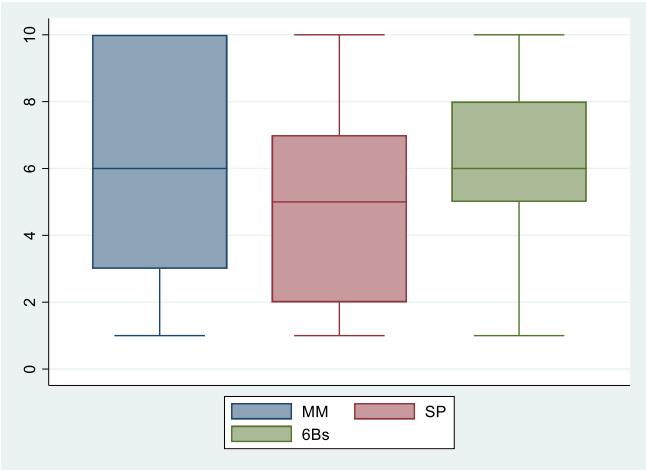


Figure. 4.15: Box Plots of the three strategies

From this data alone, it would be reasonable to conclude that about 86% of the students, by inference, benefitted from this strategy. They are, to varying degrees, better able to manage

their reactions to challenges. That leaves the remaining 14% in the same predicament as they were before participating in this study, that is, still holding non-resilient views and tendencies and possibly still struggling with managing their learning.

In the next section, I delve into this data by scrutinizing the data by the subjective views, not just to explore which group benefitted the most or benefitted the least, but also which student/s did not benefit from this strategy. I would be interested in tracking these students to determine if they benefit from the other strategies utilised within this study. Table 4.8 presents the mean scores by sub-group. The first subgroup I discuss is the Maths as Utility subgroup.

Understanding mind-sets and how you can use them to improve your learning	Scale 1 – found it most unhelpful [not useful at all] 10 – found it most helpful [very useful] **(Mean Score and range of scores)**
MaU	Mean Score: **6.3** (6.3333) Range: **1 – 10**
MaA	No data
MaEE	Mean Score: **5.9** (5.875) Range: **3 – 10**
MaTS	Mean Score: **3.8** (3.75) Range: **1 – 10**
MaER	Mean Score: **5.2** (5.20) Range: **1 – 10**

Table 4.8: Sub-group Mean Score and Range

i) Maths as Utility (MaU)

At a sub-group level, and understanding how having a growth mindset could boost their learning, some of the participants who loaded on this factor seemed to communicate that they found this strategy beneficial. The mean rating for this sub-group was 6.3 out of 10 (see Table 8). This rating was higher than that of the intervention group as a whole. 17% of the group (1 out of 6 girls) reported that they did not find it useful at all by giving it a rating of 1, the rest

either rated it rated highly (33%) or did not offer a rating (50%). The participants who reported the most benefit rated it between 8 and 10, promising results at this early stage of the project.

At an individual participant level, I next explore the feedback from participants who reported that they did not benefit from the strategy. One of those participants (MaU1) commented that she rated it a one because she did not understand the 'use' of the Mindset Matters!!! strategy in class. Upon further probing, it became evident that it was more a failure in recognising the connection between the strategy and the learning situation rather than not understanding the 'use' of the strategies. MaU1 could explain the mindset concept and its connection to learning clearly without a lot of prompting from me. It appeared that MaU1 separated what she had practised in the introduction session from what she could do in class; she appears to have struggled to carry on using the strategy after she went back to her class. Another participant (MaU5) in this group commented that she could have benefitted more if she had been reminded regularly in the classroom. MaU5 and MaU1 happened to be in the same teaching group, so perhaps regular reminders could have benefitted MaU1.

Based on the quantitative data, I can reasonably conclude that most students in this sub-group benefitted from the MM strategy. The participants who reported non-benefit referred to the non-application of the strategy.

ii) Maths as Application (MaA)

Feedback not given from this group because the participant in this subgroup did not attend this session.

iii) Maths as Enjoyable and Explained (MaEE)

This subgroup's rating of the Mindset Matters!!! strategy indicated that most of the participants in this sub-group (89%) found this strategy helpful. They mean-rated it 5.9 out of 10 with a spread of between 3 and 10. None of the participants reported that they found this strategy not useful at all; they all found it impactful to some degree and only 11% (1 student) did not offer any rating.

At an individual level, I next explore some of the opinions offered to explain why they found the Mindset Matters!!! useful or not. One participant (MaEE1) reported that she found it '[v]ery effective'. Upon further probing she pointed out that she used to find herself often giving up when things get too hard but now tries to maintain a growth mindset although she finds with certain things she has a fixed mindset. However, most of the participants commented that they could have benefitted more with further explanation and examples. For example, MaEE6 said she rated it a three because she needed to be 'Show[n]... ways [she] can improve and stick to [her] learning'. This rating indicates two things, i) she could do with more 'support' and ii) the comment seems to stem from a fear that this strategy will distract her from her learning. When asked to elaborate further on why she felt that she might not stick to her learning and what could be done to make it more useful to her, she declined to offer any explanation. Because of the 'voluntary' nature of the research project, I did not probe any further.

Another participant (MaEE8) commented that she needed '[m]ore explanation and help', suggesting that a more 'detailed' support structure would benefit her more. In their Q-Sorting activity, these three participants were found to be students who had not yet identified clear reasons and motivations for engaging with mathematics to A' Level and beyond. This

strategy's reported impact seemed to demonstrate that these participants could, with what they consider 'more explanation and help', potentially encourage themselves to consider engaging with their learning beyond GCSE. None rated it 1 (completely useless), and the qualitative data seems to indicate that given the right support, they could be encouraged to work resiliently. On the other hand, another participant (MaEE5) remarked that even though she did understand the construct, she did not see how it would help her with her classwork. This remark seemed to suggest that this might not be something specific to this strategy but could be symptomatic of a broader issue - perceived lack of a direct link to the task at hand. She explained that she preferred to be given facts or hints about how to answer the question. The lack of 'practical way' to find a solution to the tasks at hand seemed, to this participant, to be what constituted 'uselessness'.

Based on the quantitative and qualitative data reported above, most students appear to have benefitted from this strategy. The opinions offered seem to indicate a desire to establish a direct link between the strategy and the task at hand.

iv) Maths as Thinking Skills (MaTS)

This sub-group of participants' mean rating suggests that they had benefitted the least from understanding mindsets and how they can use adjusting their mindset to manage their learning better. A mean rating of 3.8 out of 10 seems to indicate a marginal impact. Also, 33% of the participants reported that they did not find this strategy useful by rating it a 1. In comparison, 34% reported varying degrees of impact ranging from 3 to 10 and 33% not offering any rating. Based on these figures, the strategy seemed to have had the desired effect on some of the group participants but not a substantial proportion of the group.

At an individual level, the opinion offered by one of the participants who rated it a 1 (MaTS3) commented that 'I think personally if I understood more of mindsets, it would help me out.' This comment seemed to indicate that this participant was open to new ways of learning but felt that further explanation would be beneficial. Another participant (MaTS4) who also rated this strategy a 1 commented that the rating was because she did not refer to it in class. She reported that '[i]t doesn't help in classes because I don't refer to it.', which could be symptomatic of, for example, resistance to change. This participant was attributing the mindset construct's ineffectiveness to their lack of utilizing it. MaTS1 and MaTS2 concurred that the teacher did not remind them, so they did not use it. Through discussing with these participants, they appeared to confirm their initial belief (as revealed by their Q-Sort) that their success is dependent on other people. They pointed out that the teacher did not call attention to it, that is they needed constant reminding, shifting responsibility to the teacher.

In terms of benefitting from the strategy, there was minimal impact overall in this subgroup. More clarity and regular reminders seem to emerge as possible solutions to increasing effectiveness for this subgroup.

v) Maths as Enjoyable and Relevant (MaER)

Overall, this subgroup's mean rating seemed to indicate that the participants had also benefitted from this strategy. A mean rating of 5.2 indicated a significant reported impact. Only 9% of the group reported that they did not benefit from the strategy at all by rating it a 1, while 37% reported different levels of impact ranging from 2 to 10 and just over half did not offer a rating. At the Q-Sorting stage, this is the group that agreed with the belief that if maths was explained excitingly and enjoyably, they would be more successful at it. In

selecting the mindset strategy, I anticipated this group might realise that the 'maths must be fun' mindset is not always helpful to their progress. The hope was that regular scrutinizing of their mindsets during lessons would bring this to light.

In terms of usefulness in their day-to-day learning, it appears some of the students in this subgroup had established the connection between mindsets and their application to learning. For example, some participants (for example, MaER2 and MaER6) agreed with the comment that 'I can understand my mindset and I can *use this to* improve by learning things that are difficult.' These participants seem to be reporting that they understood and recognised that their mindset could hinder or enable them to try challenging tasks to improve their learning. Another participant reported that they could understand their mindset and could use that awareness to improve their learning ''…makes me think I can do it if I try hard', while another reported it helped them 'stay on track'.

However, one of the participants who reported to have benefitted the least by rating it a 1 (MaER5) commented that she 'did not learn' about it. I found out that she had missed the introduction session on further probing, so this rating was based on 'lack of awareness' instead of perceived uselessness. I organised a one-to-one meeting to catch her up on the strategy and how she could use it in class. Another participant (MaER2) rated it a 3.5 and her reason was that she understood the concept, but it did not help her 'work out the maths' and she did not understand why she needed to look at mindsets. This reasoning seemed to be indicative of a lack in connecting mindset to performance and possibly failure of my explanation on her part. Saying 'it does not help me work out the maths' is a mindset that could stop the girls from exploring other ways of achieving success. However, some of the comments point to some shift from the 'maths must be fun' mindset to 'I can improve my learning'.

Based on the students that did rate the strategy, I deem it to have been overall beneficial to this group. I am mindful that this conclusion cannot be definitive due to a large number of students in this group who did not offer any rating. The opinions expressed were a mixture of positive and negative ones.

4.2.2.2.3 Data from diaries and Interpretation

The turnover of data from the diaries was very poor. The majority of participants did not submit their diaries for analysis. Table 4.9 shows the data that was collected was from one diary.

What we did	How I felt	Examples of questions I did in lesson
We were learning how to factorise equations as well as recapping on expanding equations	I already knew a bit of this so I didn't find it hard bad is it got harder I continued to expand my knowledge.	$9p^2 + 6pt$ $8ab - 4bc$ $3y^2 + 2y$ $mn + 3m$
We continued what we did yesterday just a bit more challenging questions.	I gained a lot of more confidence because the questions were kind of easy but they were still challenging	$4y^2 + 12y^3 + xy$ $6xy + 9x - 12y^2$ $2(x + y) - (x + y)^2$ $wx + wy - 3x - 3y$
We learned how to simplify algebraic fractions we started with easy questions by bendy two challenging ones	I felt confident with the easy questions they had the questions was a bit tricky I actually got one of them right.	$\frac{5a}{a}$ $\frac{12bd}{3d}$ $\frac{17x^3y^2z^2}{16x^2y^3z^2}$
We continued learning algebraic fractions just more challenging ones	I felt the same as yesterday they were challenging but I got majority of them right	$\frac{6x^2y + 15xy - 33y}{9xy}$
We learnt a new way of simplifying fractions	I felt confused it first but after some help I go to more confident on how to do them	$\frac{6y^2}{y^3 - y^2}$
Miss introduced us to some easy addition and subtraction questions	Because the questions were easy I found the lesson is in the field very confident	$\frac{7}{x} - \frac{2}{y}$
Indie lesson we continued on what we did yesterday is we didn't get to do much	I felt the same as yesterday is the questions went really challenging	$\frac{2}{x+3} + \frac{5}{x-5}$
Miss gave us tricky problems to do with algebraic fractions	I was really confused and didn't know how to do it	$\frac{6}{x+1}$ $10x$ $\frac{4x}{x+1}$
We learnt how to add subtract and divide algebraic fractions	I felt a bit challenge to buy it was kind of easy	$\frac{a}{b} + \frac{c}{d}$
We did a review of everything we did involving fractions	I felt challenged but some of the work I found easy	$5(2a + 3)$
We learnt about the different angles in parallel lines	I felt confident because I already knew about this	
We started to learn about interior and exterior angles	I felt like I was being challenged in a good way because I had forgotten how to do this	We didn't do any questions
We were given questions on working out angles	I thought it was easy is I learnt a lot in class to help me	
We just learnt the understandings of bearings in the rules we must follow	I felt confused it first but then with a bit of help I understood how to do it	

Table 4.9: A Diary Entry

I cannot say whether this participant explicitly used the mindset strategy. There is no explicit reference to the mindset strategy. However, the reflections recorded in this diary show evidence of an awareness of the normalcy of challenge in learning and positive outcomes. Viewing challenges as part of learning and achieving positive outcomes are a good indication of some resilience being present and possibly developing further. I reached this conclusion because the participant recorded moments of struggle, which she overcame in some way. This experience means that she can draw on this experience of encountering challenges and successfully working through them when she encounters a challenge.

4.2.2.2.4 Data from online platform and Interpretation

As mentioned in Chapter 3, one of the feedback options students were given was to use the online platform. The print-screen shots (Figures 4.17a and b) comprise two examples of feedback from the online platform SMHW.

Example One -

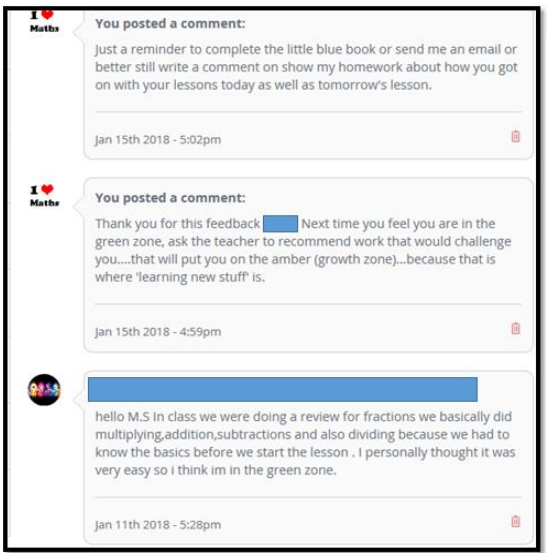


Figure 4.16a: Online feedback

Example Two -

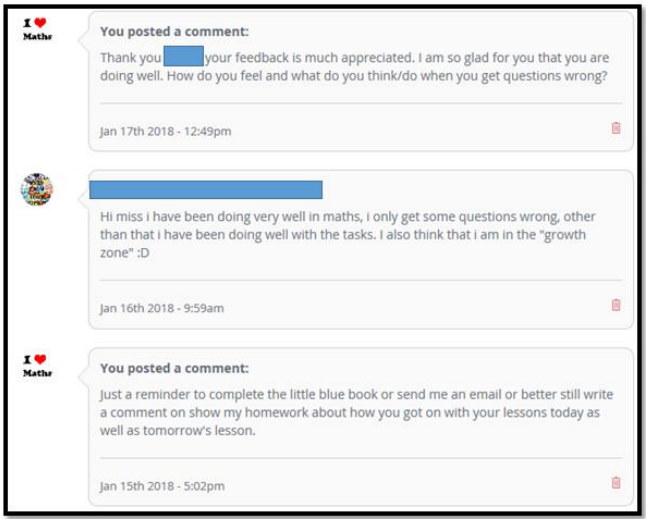


Figure 4.16b: Online feedback

These two participants appear to understand the different Zones of Learning and their links to learning. Participant MaA1 (Figure 4.16a) reported that during a lesson on fractions, she

found the work really easy and was, therefore, able to identify that she was in the green zone. By recognising that the work is easy, what they are reporting is ‘I am not encountering any challenges/there is no threat being presented by this work’. The comfort zone is typically characterised by finding work easy, not encountering any hurdles and therefore, by argument, not presenting the student with opportunities to develop their desired resilience. Participant MaU3 (Figure 4.16b) was able to identify that she was in the growth zone. She reported that although she found succeeding in the work achievable, she found some parts of this work challenging (I got some questions wrong). This description is synonymous with characteristics of the growth zone, where students are typically expected to find some work challenging but not to the point of causing panic, which could indicate the ‘out-of-depth’ zone. The appropriate support would normally enable participants to function safely within the growth zone.

Furthermore, on the online platform, MaU3 reported ‘I was in the growth zone’ during my lesson. When we explored this comment further during the feedback sessions, this sentiment was echoed by about 75% of the group, a clear indication of the established link between learning and the ZoL model.

In terms of developing mathematical resilience, I can deduce, with some degree of conviction, that MaU3’s report suggests that she might be able to work resiliently in future. In contrast, MaU1’s report shows that she might be able to work persistently (she is comfortable with the topic they worked on) but might struggle when she encounters challenging work.

4.2.2.2.5 Data from field notes and Interpretation

Table 4.10 presents samples of the field notes I collected. I collected the field notes during class visits, where lessons coincided with my non-contact times. The feedback consisted of a

mixture of subjective ratings and subjective comments, consistent with the Evaluation 1 feedback structure. Some participants gave both a rating and a comment, and others preferred only giving a rating while others preferred only commenting. Contributions from all participants were valuable.

In the first instance, I report on the mean scores and range given by students. Table 4.10 shows the spread and mean ratings by sub-groups, and the last row shows the combined spread and mean rating for the whole group.

Sub-group	Mind-set Strategy **Spread and Mean**
MaU	(range: 4 -5) **4.5**
MaA	(range: 3.5 -5) **4.3**
MaEE	(range: 8 -8) **8**
MaTS	(range: 6 -10) **8**
MaER	(range: 4 -6) **4.8**
Whole Group	(range: 4 -10) **6.3**

Table 4.10: MM ratings from field notes

Regarding how useful the participants found the mindset strategy, the data I collected during class visits seemed to indicate that the participants as a whole group found the strategy useful. At the whole group level (Table 4.10), the strategy ratings are all over 4; no one reported that they did not find it useful at all. From this 'whole group' vantage point, the participants reported that they found the strategy useful, with a mean rating of 6.3 out of 10.

Exploring this data by subgroup and in conjunction with some individual opinions will shed more light on the students' subjective views.

i) Maths as Utility

Regarding how useful they found the mindset strategy, all participants reported that some benefit was gained from using this strategy.

At an individual level, some participants described positive interactions with the mindset strategy in lessons. For example, one participant commented that "I feel I was able to tap into what 'mindset' was needed for this lesson." (MaTS6) This comment seemed to indicate that this participant could regulate their reaction to the challenging situations presented by their learning. Upon further probing into what could have happened if she had not tapped into the mindset needed for this lesson, the participant reported that she probably would 'have given up'. Instead, she reminded herself that she needed to 'keep trying' because she would not learn anything, indicative of the emergent of resilient learning tendencies if she gave up.

ii) Maths as Application

Participants from this sub-group also reported that they benefitted from the MM strategy. They gave it a mean score of 4.3, with a range of 3.5 to 4. No participant gave a rating of 1 (not useful at all). They opted out of sharing their subjective feelings on this strategy.

iii) Maths as Enjoyable and Explained

This sub-group reported the most impact from the MM strategy. A mean rating of 8 out of 10 indicated quite a significant impact. No participant reported that they did not find it useful at all.

iv) Maths as Thinking Skills

This sub-group reported significant impact of the strategy. A mean rating of 8 indicates quite a considerable impact with a range of between 6 and 10.

In terms of comments on how they feel about the mindset, one participant reported that they rated the strategy an 8 'because it has helped [them] improve', while another reported that 'I kind of understood it'. These reports suggest that participants are starting to establish coping mechanisms that could allow them to better deal with challenges.

v) Maths as Enjoyable and Relevant

Based on statistical measures in Table 10, this sub-group appears to have been one of the least impacted by the MM strategy. They gave it a mean rating of 4.8 out of 10 with a range of between 4 and 6. Like the other groups, no participants reported that they did not find it useful.

The field notes are not extensive observations of every lesson but are snapshots of participants' subjective views on the lessons I could visit. The substantial disparity in the mean rating by, for example, sub-group MaTS (3.8 and 8) could be explained by some assumptions I can make. For one, the fieldnotes resulting in this data were heavily influenced by the participants' topic on the day. Some maths topics are historically associated with evoking strong feelings. Secondly, my proximity might have influenced some students into rating higher than they would have otherwise (to please me). This assumption is corroborated by Evaluation1 data where some students rated the strategy a 1. However, this disparity does not take away from the reported benefit of this strategy by most students.

4.2.2.2.6 Reflection on feedback

This strategy appears to have had the desired impact on most participants. This result is acceptable in terms of making inroads into developing coping mechanisms. Participants seem to be more aware of what they can do to stay longer and safely in the growth zone: 'I can understand my mindset - I can improve by learning things that are difficult.' This comment demonstrates that they understand that difficult things need not be 'scary'; their perception and mindset need to adjust. The feedback suggests that some participants have realised that 'struggling when faced with challenges doesn't mean *they* are dumb', but they can improve their learning chances by recognising the zone of learning they are in, the mindset they are entertaining and that this is adjustable. Any challenges they encounter and succeed in may improve their resilience. For example, I observed participant MaEE1 displaying an 'I am frustrated' dejected body language (she was sitting slumped over, sighing) which is usually a reflection of the state of mind that could potentially result in negative outcomes for this participant. After a brief recap of the ZoL, HMoB and mindsets, her body language changed and indicated that she could persist with her learning.

4.2.2.2.7 Evaluation: Mindset Matters!!!

In any endeavour or undertaking, satisfaction is an important component of impact evaluation. Research has shown that satisfaction can influence whether an individual continues to engage with the services or tools they are pursuing (Dansky & Colbert, 1996) or not. The results from this research cycle generated a lot of positive outcomes compared to negative ones. Therefore, I deemed I had promoted some growth in resiliency to some extent among the participants. Overall, the results seem to indicate that the majority of this group (19 out of the 22 who gave feedback, i.e., 86%) reported some benefit from this strategy.

Of the participants who reported that they had not benefitted from this strategy (14%), I examine, in sections 4.2.2.3 and 4.2.2.4, what impact they report from ARC2 and ARC3. I anticipate that these participants will benefit from the strategies utilized in ARC2 or ARC3. It is also worth pointing out that some of the reported 'lack of impact' was due to the strategy not being used in lessons with regular teachers. However, the overarching aim of supporting participants in developing their mathematical resilience takes precedence, hence observing how impactful they find the other strategies.

In terms of the next cycle, although primarily this next strategy was selected to address the students' Q-Sorting declarations such as 'I do not know how to bounce back' or 'Maths gets easier with a lot of help', it was the comments students made during Evaluation 1 that gave credence to the suitability of this next strategy in this study.

During the Evaluation 1 session, the student who voiced 'show us ways we can improve and still do our learning' summed up what the students found lacking in the mindset strategy. This remark seemed to indicate that these participants needed more support, more 'scaffolding' in terms of the next steps after 'identifying and adjusting mindset'. I deemed the students would benefit from the 'split page' strategy, as it offers some 'next step' thinking, as shown in Figure 4.17.

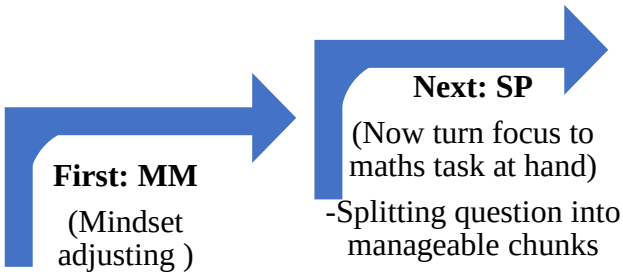


Figure 4.17: Order of ARCs

Students who reported not to have benefitted from the MM strategy at all:

MaER5
MaU1
MaTS4

4.2.2.3: Observation: Data collected and interpretations ARC2: Split Page

This second strategy aimed to provide students with guidance on how to progress from 'mindset adjustment' stage to 'tackling the maths problem at hand' stage. At the end of the cycle (Evaluation 2), students were asked to rate the split page strategy in terms of how useful or helpful they found it to better manage their learning. Like the previous cycle, both quantitative and qualitative data were collected during Evaluation 2, and this data is discussed in the next sections. But first, when planning for ARC2, feedback from ARC1 was taken into consideration as follows:

i) From ARC1 Feedback: during the ARC1 feedback session, one of the participants reported that 'it doesn't help with school/homework'. At further probing this participant said that, even though they could 'see' what mindset they were in, they did not understand how they could use this to work out the maths. Another participant reported that 'I just don't see how this helps with classwork.' While another's request was to 'show us ways we can improve and still do our learning'. These three remarks seem to suggest that these participants needed more support, more 'scaffolding' in terms of what the next steps should be after 'identifying

mindset'. I decided that these participants would benefit from the 'split page' strategy, as it offers some ideas of the 'next step'.

While considering this feedback and the pilot study feedback and thinking about how to improve further the way participants use this strategy, I decided I would also split the right side of the page into 'What is it' and 'What can I do', to end up with Figure 4.18. For practice questions, I used the examiner's report to decide what questions to use for the introduction/trial exercise. The examiner's report is released every year, and it gives, among other things, a breakdown of questions exam candidates struggled on the most. By referring to this guidance, I ensured that I chose questions that would introduce some struggle in at least some participants. The presence of struggle in the learner's mind is crucial because it would encourage them to restructure their ideas and consider solution models that encompass various aspects of understanding mathematics (Tall, 1977; Allsoop et al., 2007). Some of the areas of struggle pointed out by the report were multi-stage problem-solving and geometry on the foundation paper. The report details that 'candidates need to be encouraged to organise their work better, particularly in those questions requiring several stages to the solution. The guidance could perhaps be given as to how to set out their work in the space available. But space should not be a constraint: additional paper can be requested if needed.'. The report highlighted that 'Reasoning skills in geometrical contexts remain weak; this includes formal proof.' (Examiners' Report, 2017, n.p.)

Based on this report and established research that identified this area of mathematics as the most problematic, I chose geometry questions. Ali et al. (2014) assert that "the poor performance of students in mathematics and geometry, in particular, has been a thing of concern to mathematics educators, parents and government." (p. 74). This assertion is supported by other researchers (for example Adolphus, 2011; De Villiers, 1996), who found

that geometry is the core difficult area where students' performance has always been low. Teaching and learning problems occur most in mathematics student's performance at the secondary level, and geometry is far worse than algebra. These studies consolidated my choice of practice questions as an appropriate choice.

I planned ARC2 in three phases. The first phase involved planning how I was going to deliver the introductory session. I made sure that the participants had an opportunity to familiarise themselves with the split page strategy. I utilised a PowerPoint presentation that allowed, as much as possible, a clear explanation of the strategy and an opportunity for participants to 'trial the split-page strategy' (Appendix 11). I also planned an opportunity for participants to ask for further explanation/demonstration to make sure they were as confident as possible to apply this strategy in their day-to-day learning.

The second phase of this planning involved choosing the actual 'trial' questions the participants would use in the workshop. My participants constituted a mixed-ability group. I had students from all the sets, 1 to 5. When choosing tasks, the participants could use to try this strategy; I had to consider that participants from sets 1 and 2 are taking higher GCSE maths, while the rest follow the foundation GCSE maths course. I decided to use a higher GCSE question for participants from sets 1 and 2 and a foundation GCSE question for the rest of the group. Even though a crossover question would have been ideal, some higher set students found the question too easy in the previous cycle where I used a crossover question. In contrast, some foundation students found the question too challenging, so each group was given a typical GCSE question at their level.

I also wanted to arouse participants' curiosity and inventiveness, to provide an opportunity for participants to learn how to manage challenge and sustain resilience in times of difficulty

and to promote deeper and organised thinking and decision-making. It was crucial that I provided clear information from the outset about what 'success' looked like to manage reactions to challenge. I explained to the participants they would have 'achieved success' if they have moved from being in an 'I am stuck mode' which might involve panic, to 'I am ok, I can identify aspects of the question I can attempt'. They did not have to have worked out the answer; they just needed to recognise how to come out of the 'I am stuck mode'.

The third phase involved deciding how the participants were going to record their experiences with this strategy. Based on feedback from previous participants, I revised the 'split-page' setup to this set up:

What part is making this question difficult for me?	What could I do to move past this difficult part?
	(do at least two things before you ask for help.)

Figure 4.18: Split Page sticker

This strategy is akin to the '3 before me' approach to teaching students to be independent learners (Phillips & Chen, 2015). I also decided to produce sticker versions of this setup that participants could use as and when they needed, without 'wasting' a lot of paper. As well as the revised 'sticker version' of the split page, I decided to add another layer to this strategy. I designed motivational stickers (Figure 4.19) to complement the use of the 'split-page' sticker. One of the reasons I decided to add the motivational stickers was that I recognised that

participants could benefit from being encouraged to work resiliently by acknowledging when they ‘worked resiliently’ (see Figure 4.19). Initially, I designed the stickers to be used by teachers (Figure 4.19a) later during the cycle; I designed student-speak stickers that students could also use (Figure 4.19b). The student version was designed in response to a suggestion by one of my colleagues whose teaching group had students in the intervention group. He observed that he had missed the opportunity to ‘encourage’ participants a few times and believed that the participants in his group were capable of discerning if they had demonstrated some resilient working and would benefit from ‘student-speak’ stickers. Examples of the respective stickers are as shown:

Teacher Version Student Version.

Figure 4.19a and 4.19b: Motivational stickers

Once I was content with the planning of the introduction and implementing resources, my next course of action was to find a time slot in my timetable to hold the introduction session.

4.2.2.3.1: Implementing ARC2

The first stage was to introduce the strategy to the participants. With permissions from the school’s Senior Leadership Team, participants were invited to the introduction session. All

the participants that were present in school on the day attended. Six girls from the group were out of school. However, at the ARC2 introduction session, three new 'voluntary' participants requested to join the group. They reported that they had seen and heard the other girls talk about the programme and they wanted to join. I allowed these participants to join the group. I utilised a PowerPoint presentation during this session (see Appendix 7).

The presentation included an overview of what we had done so far and where we were aiming. This overview aimed to recap on purpose, enhance the clarity and re-focus on this project's direction. After the introductory part, the next activity involved discussing results from the evaluation of ARC1, the 'Mindset Matters!!!' strategy, particularly how their feedback informed the strategy. I then moved onto introducing the new strategy, the 'Split Page' strategy.

I introduced how the participants were going to use this strategy. I used two analogies to explain the Split Page concept. The first analogy I used was baking. I explained how baking is about taking basic ingredients and putting them together to make something delicious, and that maths was like that too. I explained how maths were about taking some basic maths 'ingredients' and putting them together to make an examination or test 'question'. I recommended to the participants that to increase chances of working successfully at maths, identifying these basic maths 'ingredients' was an essential first step. The second analogy I used encouraged participants to think about the 'split page' as a 'divide and conquer' situation. I used an analogy of predators (e.g. lions) in the wild who come across a herd of buffaloes, where at first instance it might seem like an impossible task to the lions (they are probably outnumbered and definitely outsized). Instead of giving up, the lions identify and focus on one aspect of this enormous problem and work on that (i.e. pinpoint one weak animal that they can do something about and act on it). Participants were then given an

opportunity to use this strategy on the geometry questions chosen from previous GCSE examination questions (Figure 4.20).

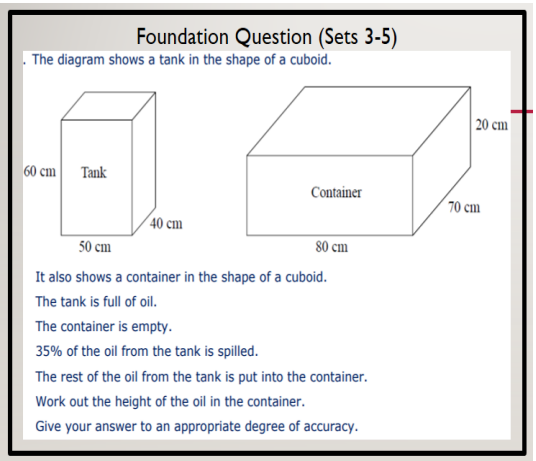


Figure 4.20a: GCSE Foundation Question

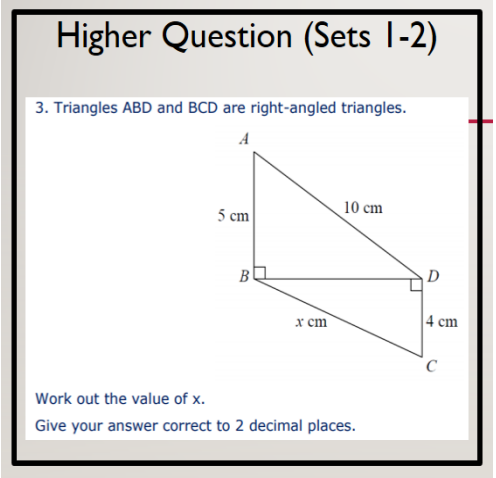


Figure 4.20b: GCSE Higher Question

Students were shown the strategy pack contents, then informed that the strategy stickers would be given to their teachers. All they needed to do was go about their lesson as usual, but each time any one of them found that they felt 'stuck' on a question the teachers would give them a 'split-page' sticker to help them think that little bit deeper about the question, similar to how they practised in the session. I also informed the participants that I would visit their lessons often to see how they were getting on and help them if they needed help. I concluded the session by inviting participants to ask any questions, whether they related to further clarity or anything else. Once these were addressed, participants went back to their classes. At the end of the session, participants left with a general expression of a good sense of reception, eagerness and commitment to undertake this strategy. The concluding discussion and informal chats on the way out gave this indication.

A week or two into the cycle, I had an informal feedback discussion with one of my colleagues. He suggested that a 'student speak' version of the motivational stickers would ensure no opportunity for encouragement would be missed. This suggestion made sense to

me and resulted in me designing the student-speak stickers described above and during one of my class visits, I distributed these to the participants. These stickers were designed to acknowledge students' demonstration of resilient working.

4.2.2.3.2 Data Collected at Evaluation 2 and Interpretation

In terms of the quantitative data, the group as a whole rated the split page strategy at a mean rating of 4.8 (Table 4.11). These results seem to indicate that the group as a whole found the strategy moderately beneficial, with some students reporting that they did not find it useful or helpful at all.

Variable	Obs	Mean	Std. Dev.	Min	Max
sp	25	4.8	2.886751	1	10

Table 4.11: Mean and SD of SP quantitative data

By presenting the data in a histogram over a normal distribution, it is clear to see that the largest area (first bar in Figure 4.21) is between the 1-3 rating, which would explain the low mean score. Further analysis (Table 4.12) shows that 20% of the students did not find the strategy useful.

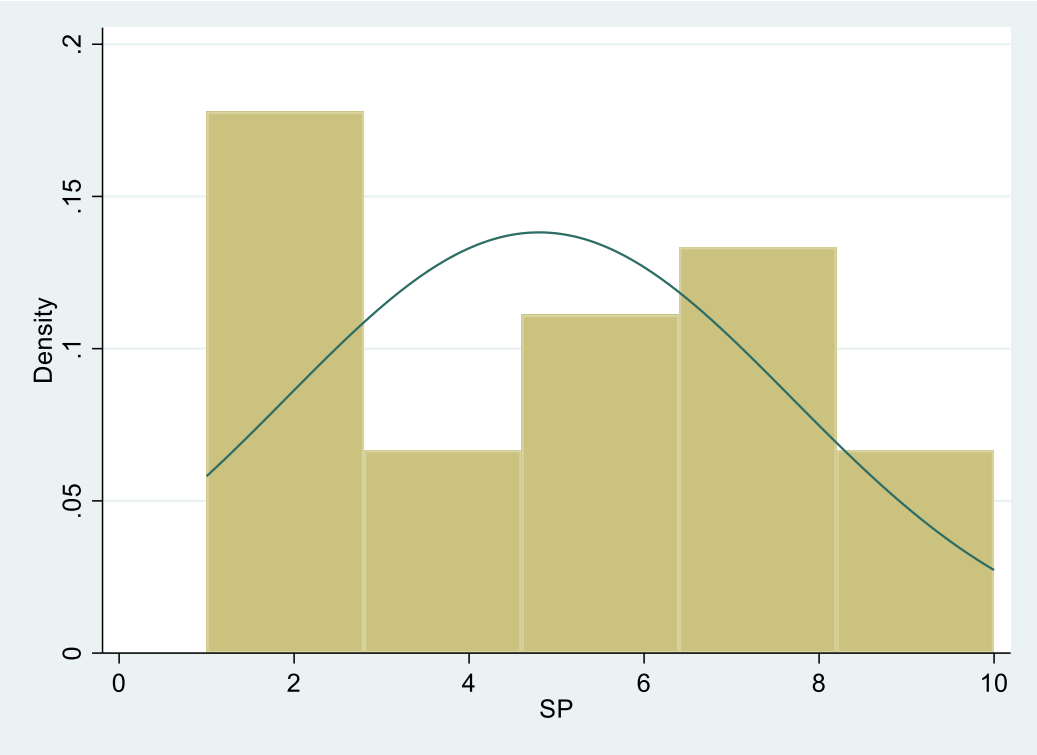


Figure 4.21: Graphic distribution of SP quantitative data

SP	Freq.	Percent	Cum.
1	5	20.00	20.00
2	3	12.00	32.00
3	1	4.00	36.00
4	2	8.00	44.00
5	3	12.00	56.00
6	2	8.00	64.00
7	5	20.00	84.00
8	1	4.00	88.00
9	2	8.00	96.00
10	1	4.00	100.00
Total	25	100.00	

Table 4.12: Numerical distribution of SP quantitative data

This data presents a significantly small positive skew (Table 4.13), which confirms the closeness of the data to a normal distribution and hence expectation that the mean is a good strong representation of the groups' feelings.

SP

	Percentiles	Smallest		
1%	1	1		
5%	1	1		
10%	1	1	Obs	25
25%	2	1	Sum of Wgt.	25
50%	5		Mean	4.8
		Largest	Std. Dev.	2.886751
75%	7	8		
90%	9	9	Variance	8.333333
95%	9	9	Skewness	.0551543
99%	10	10	Kurtosis	1.7612

Table 4.13: Skewness and Kurtosis of SP quantitative data

It is clear to see that a substantial number of students from the group benefitted from this strategy. The next subsections will delve deeper into these two aspects. I present, interpret and evaluate this strategy's impact on the students' mathematics learning, as evidenced by the data from evaluation sheets.

In this first sub-section, I share the data collected from the student evaluation forms at Evaluation 2 stage. The participants were invited to consider how the split page helped them pinpoint the exact aspect of the question that was making their working challenging and suggestions about what they could do to get past the 'sticky' part of the question. Table 4.14 shows the results of this evaluation exercise.

Understanding the split page and how you can use them to improve your learning	Scale 1 – found it most unhelpful [not useful at all] 10 – found it most helpful [very useful] **(Mean Score and range of scores)**
MaU	Mean Score: **3.4** (3.40) Range: **1 – 7**
MaA	Mean Score: **5** Range: **2 - 7**
MaEE	Mean Score: **5.25** Range: **2 - 9**
MaTS	Mean Score: **5** Range: **1 - 9**
MaER	Mean Score: **4** Range: **1 - 6**
Vol	Mean Score: **8** Range: **7 - 10**

Table 4.14: Rating the Split Page

At a whole group level, the mean score of 4.8 out of 10 seemed to indicate that the students found the split page reasonably useful. However, in most subgroups, some students reported that they did not find the strategy helpful. Subgroup analysis is discussed next.

i) Maths as Utility

Based on the ratings, the position this group of participants' reports would seem to be that they did not find the 'split page' as beneficial as anticipated. A mean rating of 3.4 with a range of 1 to 7 seems to indicate limited impact. While 50% of the participants in this group reported varying degrees of usefulness, 33% reported that they did not find this strategy useful by giving it a rating of 1 (not useful at all). The rest of the group did not offer any rating.

On an individual basis, one of the participants who gave feedback reported that for her, it was not part of the question that they struggled with but the whole question. It seems to indicate that this participant is not yet able to mentally visualise that some maths questions are made up of basic maths concepts that are put together to make 'the question', similar to the baking

analogy used during the workshop – this participant seems to see the 'cake' but not aware that the cake is made from 'flour, eggs, sugar' etc. The ability to 'see' these basic components, I argue, underpins the development of some resilience because of the increased opportunity to experience small-scale successes. It was this idea I was trying to put across by using this strategy that there is often a component of the question that a student can be successful at solving. A participant who said 'I know what I am stuck on most of the time and use a buddy or think better' demonstrates an ability to recognise these basic components.

It can be argued that, to some extent, resilience can be developed from being able to identify those basic concepts that the participant can solve. Another point raised by another participant was that even though they have used the strategy, they still needed help from the teacher after all. This sentiment was an expected possible outcome because one of the underpinning premises of this strategy is that participants' first port of call when stuck should be themselves. This strategy was about giving participants opportunities to experience some success in solving parts of the problem even though they may not necessarily be able to fully answer the question. I argue, based on Bandura, that the small successes that the participants experience will increase their self-efficacy and ultimately their resilience.

ii) Maths as Application

Similar to the previous section, participants in this group were asked to consider the split page from three aspects: i) whether they were able to identify specific parts of the questions that were causing them difficulty, ii) whether they could identify things they could do to help themselves before asking the teacher for help and iii) to reflect on different ways of working resiliently.

There would seem to be some understanding, and subsequently, benefits, experienced by this group of participants. A mean score of 5 and a range of between 2 and 7 indicates all participants found this strategy useful to some degree. No one reported that they did not find this strategy useful at all.

At an individual level, responses to the first two statements indicated that participants had understood the main purpose of this strategy: to enable them to anatomise the questions and think of things they could do to help themselves find solutions to questions hand before asking the teacher. However, the participant in this group seems to have been left in doubt as to what 'aspect' of resilience they displayed in successfully working at the mathematics tasks at hand. For example, one of the participants reported that she was 'trying to help [herself] to understand.' When probed further, she explained she was confused by what 'aspect' of resilience meant. When I used the stickers to clarify this to her, she seemed to be content and able to identify different ways of working resiliently.

iii) Maths as Enjoyable and Explained

Participants in this group reported slightly higher levels of benefit, from this strategy, compared with the previous group. The mean rating this group gave was 5.25 with a range of 2 to 9. No one in this group reported that they did not find this strategy useful at all. All participants reported some degree of usefulness.

On a participant level, positive and negative comments were reported. One participant (MaEE1) reported that they felt '[h]appiness when *they* understand', indicating that this participant experienced some success while using this strategy. However, another participant (MaEE6) reported that '[u]nderstanding what maths is needed and how to do the maths' was problematic for her. This comment indicates that she could identify the 'sticky' aspect of the

maths question but struggled to identify what information she needed to solve the questions. Participant (MaEE1) reported that even though she found this strategy useful, teachers never commented/encouraged her to use the strategy. She reported that there was a lack of reinforcement from her teacher.

iv) Maths as Thinking Skills

As alluded to earlier, one of the aims of this strategy was to enable participants to fragment any maths questions into easier-to-deal-with parts. It was affording participants that extra footing towards developing resilience (Nadge, 2005). I wanted them to give them an opportunity to succeed in some aspects of mathematics. I also wanted them to start recognising the elements of resilience traits that they were exhibiting to tap into that skill more comprehensibly. Based on the mean rating of 5 (with a range of 2 to 9) given to this group's split page strategy, the participants in this group seemed to show that they found the strategy useful. While 50% reported varying degrees of impact, 33% reported that they did not find this strategy useful, and the rest did not offer any rating. Although the proportion of participants in this group who found the strategy useful is similar to the MaU group, they rated the strategy higher, meaning they perceived to have benefitted more.

At an individual level, this group's positive comments suggest that this strategy seems to have promoted some resiliency among some of these participants. For example, one participant reported that 'I learned to take time and think through what I know and don't know and overcome it'. In contrast, another reported that 'I don't get stuck in class anymore, the sticker helped me a lot', and another commented 'Very helpful.' Another participant also shared that 'you can still succeed because you can try multiple things/strategies.'. However, another participant reported that 'It is confusing, for me I don't think it is helpful.' This

comment is another expected result because not every individual is impacted by the same strategy in exactly the same way, even though they share a similar viewpoint.

v) Maths as Enjoyable and Relevant

In terms of finding the split page useful or not, this group of participants seem to have found the split page strategy the least beneficial; they gave it a mean rating of 4 out of 10 with a range of 1 to 6 for usefulness. The 37% of participants rated it over 1; 6.9% reported that they did not find it useful while the rest did not offer any rating.

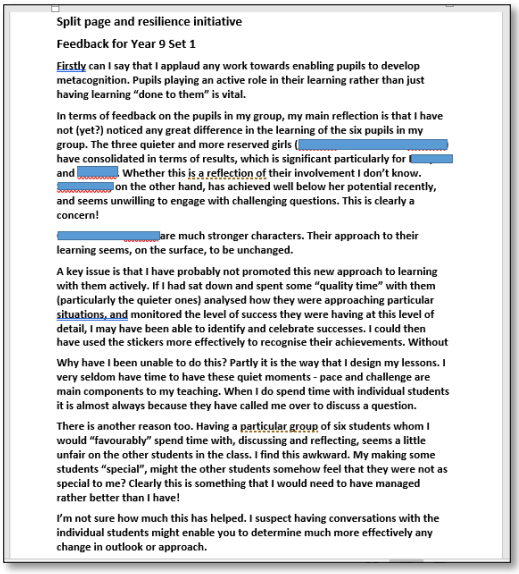
On an individual level, the comment '[j]ust read the question properly' indicates that this participant can identify their 'stumbling block', which is not reading the questions properly. This comment seems to imply that if they read the question properly, they could successfully work at their maths. Aspects of the question are not usually their stumbling block. To a certain degree, this reasoning could be a justification for not successfully tackling challenging tasks while avoiding delving into the task more. Another student reported that the SP 'helped me to understand why I can't answer the question'. This seems to imply some inroad into identifying stumbling blocks in a question. Another participant in this group commented that they only used the 'resilience developing' stickers when they felt they 'deserved' them. Again, an informal conversation with this participant confirmed that she understood the concept and the 'resilience developing' stickers were serving their purpose, encouraging her to work resiliently. She was very positive that she could 'reward' herself each time she felt she had worked 'resiliently'. She said she found this type of 'incentive' was good because it made her work 'hard' for it and that her effort was not 'overlooked' as sometimes she felt she would work really hard and the teacher did not acknowledge or notice it.

vi) Voluntary Participants

Based on the statistical measures in Table 4.14, the voluntary group found this strategy very useful. They all rated it seven or higher.

This intervention received mixed responses from the participants, with some aspects having the desired impact on some group members. It confirmed that the participants could understand and utilise their 'deeper thinking' skills safely while interacting with tasks in a more 'managed' manner. Figures 4.22a-d shows feedback from colleagues.

4.2.2.3.3 Feedback from teachers and Interpretation



Split page and resilience initiative

Feedback for Year 9 Set 1

Firstly can I say that I applaud any work towards enabling pupils to develop metacognition. Pupils playing an active role in their learning rather than just having learning "done to them" is vital.

In terms of feedback on the pupils in my group, my main reflection is that I have not (yet?) noticed any great difference in the learning of the six pupils in my group. The three quieter and more reserved girls (have consolidated in terms of results, which is significant particularly for and . Whether this is a reflection of their involvement I don't know. on the other hand, has achieved well below her potential recently, and seems unwilling to engage with challenging questions. This is clearly a concern!

are much stronger characters. Their approach to their learning seems, on the surface, to be unchanged.

A key issue is that I have probably not promoted this new approach to learning with them actively. If I had sat down and spent some "quality time" with them (particularly the quieter ones) analysed how they were approaching particular situations, and monitored the level of success they were having at this level of detail, I may have been able to identify and celebrate successes. I could then have used the stickers more effectively to recognise their achievements. Without

Why have I been unable to do this? Partly it is the way that I design my lessons. I very seldom have time to have these quiet moments - pace and challenge are main components to my teaching. When I do spend time with individual students it is almost always because they have called me over to discuss a question.

There is another reason too. Having a particular group of six students whom I would "favourably" spend time with, discussing and reflecting, seems a little unfair on the other students in the class. I find this awkward. My making some students "special", might the other students somehow feel that they were not as special to me? Clearly this is something that I would need to have managed rather better than I have!

I'm not sure how much this has helped. I suspect having conversations with the individual students might enable you to determine much more effectively any change in outlook or approach.

Hi Joyce,

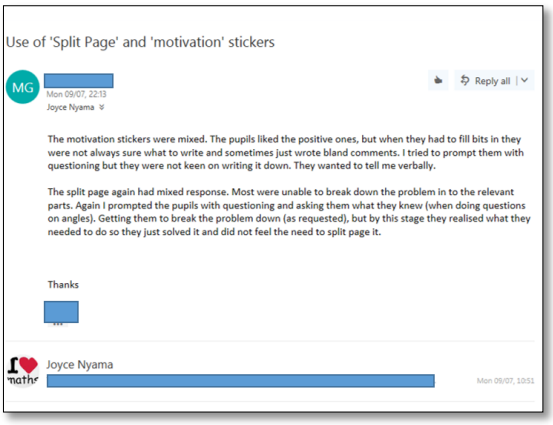
Sorry for the delay, I don't know why I keep forgetting!

Some students took very well to the stickers. Most students initially needed some ideas about what else they could do before asking me (Eg, looking in a textbook, asking other students, etc.), but about half the students took very well to them and it really focused them in terms of independence and resilience. Others needed more guidance and some just wrote 'I don't know' in the boxes for how to overcome the problems they had with a task. It was the least engaged students who used them least effectively. I had expected that the lowest attaining students would struggle most, but actually there seemed to be no connection. In some cases, there was some excellent use of the stickers, which allowed students to think through their options for how to tackle a problem without just giving up straight away. The follow up version, with the 6Bs, was particularly helpful to some who had been less independent with the stickers because they could look at methods to help them without any input from me. However, the least engaged member of the trial group still did not use it particularly well, which is unfortunate because I think she would have benefited greatly from it. I was surprised by how keen many of the students were to get a 'well done' type of sticker at the end of a lesson, which may have just been a trait of the bottom set, but it was a good incentive to use the split page method in lesson.

Joyce Nyama

When you get time please (and as soon as you can) could you, in writing, give me feedback on th... Tue 03/07, 14:41

Figure 4.22a: Feedback from a colleague *Figure 4.22b: Feedback from a colleague*



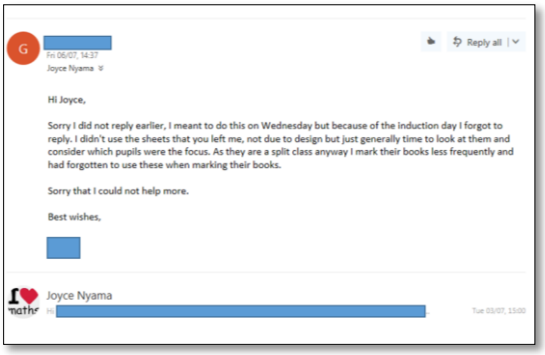


Figure 4.22c: Feedback from a colleague *Figure 4.22d: Feedback from a colleague*

	Feedback on 'Split-page' strategy	Other Comments.
T1 Firstly, can I say that I applaud any work towards enabling pupils to develop metacognition. Pupils playing an active role in their learning rather than just having learning "done to them" is vital.	My main reflection is that I have not (yet?) noticed any great difference in the learning of the six pupils in my group. The three quieter and more reserved have consolidated in terms of results, which is significant particularly for ……. on the other hand, …… has achieved well below her potential recently, and seems unwilling to engage with challenging questions. ….are much stronger characters. Their approach to their learning seems, on the surface, to be unchanged.	A key issue is that I have probably not promoted this new approach to learning with them actively. Partly it is the way that I design my lessons. I very seldom have time to have these quiet moments - pace and challenge are main components to my teaching. There is another reason too. Having a particular group of six students whom I would "favourably" spend time with, discussing and reflecting, seems a little unfair on the other students in the class. I find this awkward. My making some students "special", might the other students somehow feel that they were not as special to me? Clearly this is something that I would need to have managed rather better than I have!
T2	No Feedback	No Feedback
T3		I didn't use the sheets that you left me, not due to design but just generally time to look at them and consider which pupils were the focus. As they are a split class anyway I mark their books less frequently and had forgotten to use these when marking their books.
T4	The motivation stickers were mixed. The pupils liked the positive ones (*motivational stickers*)… ..but when they had to fill bits in they were not always sure what to write and sometimes just wrote bland comments. I tried to prompt them with questioning but they were not keen on writing it down. They wanted to tell me verbally.	
T5	Some students took very well to the strategy. Most students initially needed some ideas about what else they could do before asking me (e.g. looking in a textbook, asking other students, etc.), as most would write 'I don't know; in the boxes for how to overcome the problems that they had with a task. About half the students took very well to them and it really focused them in terms of independence and resilience.	It was the least engaged students who used them least effectively. I had expected that the lowest attaining students would struggle most, but actually there seemed to be no connection. In some cases, there was some excellent use of the stickers, which allowed students to think through their options for how to tackle a problem without just giving up straight away.

Table 4.14: Feedback from colleagues

Three of the five colleagues (T1, T2 and T3) did not 'actively' use or encourage this strategy with the participants. There are some interesting views expressed by T1. He applauded any initiatives that enable participants to take an active role in their own learning as opposed to having learning 'done to them'. However, T1 reported that they had not (yet?) witnessed any

changes in the participants in their teaching class but then admitted that he did not actively promote the strategy, which could account for the lack of change being witnessed. He went on to give several reasons for not actively promoting the strategy. This seems to resonate with what, for example, Chisholm (2017) reported on challenges faced when trying to change classroom culture. There is evidence in T1's report that he appeared to be 'set in his ways'. His reason that he did not want to appear to 'favourably' spend time with a particular number of students resonated with one participant in his group who reported that 'even though they used the resources no one looked at them'. This seemed to indicate that even though this particular participant was willing and finding benefit in using this strategy (this participant rated the strategy 9 out of 10 for usefulness), there was a lack of encouragement from the teacher. What was encouraging to perceive was the intended target group, the participants, found it useful. However, examples like this participant's experience could account for some of the negative subjective views students hold regarding their mathematics learning. Perhaps teachers have a bigger role to play in this.

T4 and T5 reported mixed reception of the strategy. The participants in their groups took well to some aspects of the strategy better than others. T5 reported that she witnessed some excellent use of the stickers 'which allowed students to think through their options for how to tackle a problem without just giving up straight away.' This report seems to indicate that the split page strategy effected some changes in the participants in their teaching groups, who were able to work more resiliently at their maths. They also reported that some participants struggled with coming up with things they could do to help themselves. This report resonated with some of the feedback given by participants during evaluation sessions. It was this feedback that confirmed the selection of the 6Bs to Mathematical Resilience strategy next.

Figures 4.24a-b show some examples of students' work, demonstrating how the stickers were used.

4.2.2.3.4 Examples of work

…with a teacher sticker

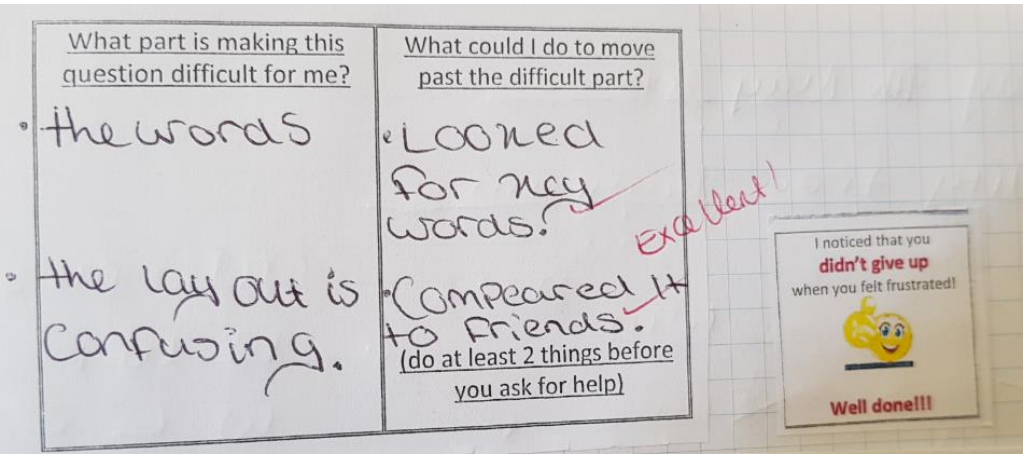


Figure 4.23a: Example one of the resources being used

...with student sticker

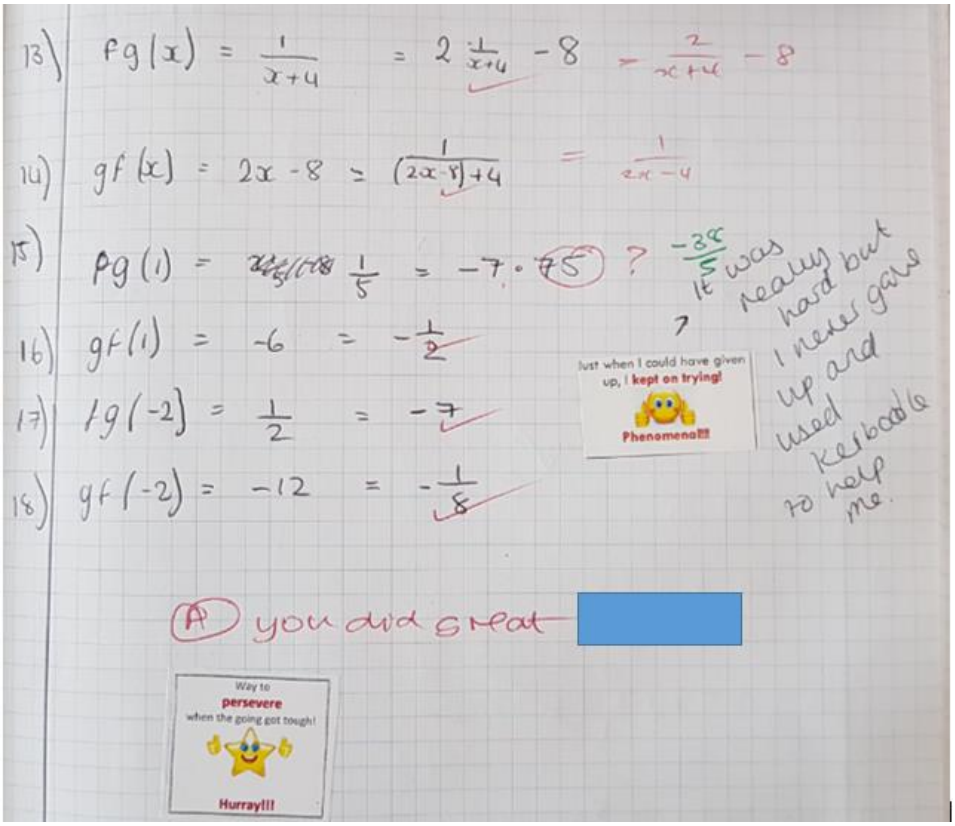


Figure 4.23b: Example two of the resources being used

These examples of use in the classroom showed some understanding and effective use of the strategy. These participants were able to identify sticking points, such as ‘the words’ and ‘the layout…’. They were also able to identify steps they could take to get past these hurdles, for example, ‘looked for key words’, ‘compare it to friends’ and ‘...used Kerboodle to help me’.

4.2.2.3.5 Reflection on feedback

Several issues stand out for me in this data:

i) There is evidence of working resiliently in the growth zone. Participants reacting to ‘how one is taught has an impact’ by saying ‘you can help yourself’ shows that this participant is taking some responsibility for their learning. They have made a transition from agreeing with the ‘it is not about the teacher’ to ‘it is about me.’

ii) One participant suggested that they would like more ‘mixed ability’ activities. They enjoyed the setup of this research, where participants were from different classes. Perhaps this could be explored further as an option for developing mathematical resilience.

iii) Engagement with the strategies varied greatly and could be a manifestation of working in, for example, the red zone. Some of the behaviours the participants displayed to show a ‘not fun’ lesson were such as I get ‘frustrated body language’ and the I ‘kind of understand it’, comments have been shown that, if not managed well, could be protective stances synonymous with the red zone.

iv) If students and teachers are going to experience the benefit from intervention fully, there is a need to actively implement it. One teacher reported that they had not seen any changes ‘yet’ while at the same time, they report that they had not actively encouraged the use of the strategy during lessons.

There are a lot of positives to build on and some negatives that can be readily addressed. In the future, I will be exploring these.

4.2.2.3.6 Evaluation

The data presented in this cycle provides evidence of the effectiveness of this strategy. While some participants reported that they did not benefit from this strategy, most participants reported that they found the strategy useful, with varying degrees of usefulness. Feedback from teachers seemed to crystalize what the participants reported, that some participants benefitted from this strategy while others did not. Mean ratings as a whole group, and subjective factors indicate that at this point, seemed to evidence of resilient working in some

participants immediately following the intervention, which is consistent with this strategy having some effect.

However, both participants and teachers' common recurring feedback was that participants struggled with thinking of **practical steps** they could take to help themselves. In the next section, I report on my third action research cycle, ARC3. In this strategy, I offered participants some practical steps they could take and further enable students to 'bounce back' from setbacks.

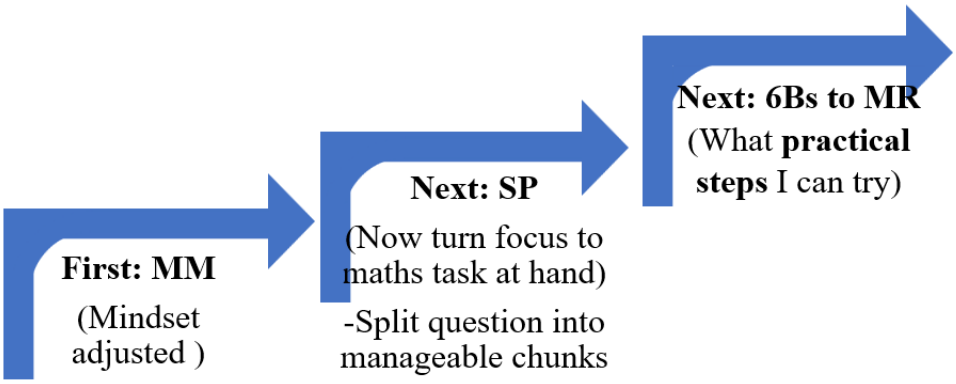


Figure 4.24: Order of ARCs

Students who reported not to have benefitted from the SP strategy:

MaER2
MaU1
MaU4
MaST6
MaTS1

4.2.2.4: Observation: Data collected and interpretations ARC3: 6Bs to Mathematical Resilience (6Bs)

While reviewing evaluation data collected from ARC2, it became clear that the issue of 'not knowing how to bounce back' was more widespread than initially anticipated. An example of this was a student who said, "Maybe giving ways to resolve the confusion *would be more helpful*" in response to 'suggest how the split-page strategy could be improved'. In the ARC2 evaluation feedback, a common and recurring comment in the feedback from students and teachers was that even though the participants found the divided-page somewhat beneficial and they could identify their mental blocks, most of the time they struggled with thinking of a systematic strategy that would help them move themselves forward, beyond these mental blocks, safely.

4.2.2.4.1: Implementing ARC3

At the start of the workshop, I led a quick recap discussion of the 'Zones of Learning' model and the Hand Model of the Brain, their implication to learning both in and outside of school and how they link in with the new strategy, the '6Bs to Mathematical Resilience Pit' strategy. The students were then presented with the '6Bs to Mathematical Resilience Pit' strategy stickers and prompt sheets, accompanied by an explanation and a demonstration of how the participants would use the strategy in their lessons. We discussed what emotions they might go through in the different sections of the 'pit', the red section, the orange section and the green (grassy part of the diagram) section, to tie this strategy to the 'Zones of Learning' model. We also discussed what the brain would be doing in each section of the 'pit', and I reinforced that these feelings and brain actions were normal and were part of learning mathematics. I also reminded participants that every single feeling they felt was valid.

Like the 'split page' workshop, I used higher and foundation course GCSE questions to demonstrate how participants used '6Bs' strategy. Participants were guided by using this strategy to make sure they could use it when they went back to their classes.

During the introduction session, a comment was made by one of the participants that stood out for me, something that I had not explicitly planned for. One of the participants commented that "This sticker (*strategy)* will help me organise my thinking, miss." This comment seemed to indicate that, as learning should, this participant had previously faced struggle in their learning journey and had struggled with methodically organising their thinking. For teachers, equipping students with strategies for improving their thinking skills should be just as important as teaching them subject content. Also, this participant's comment linked in with Burnett's (2002) findings, who suggested that staff may wish to offer other kinds of stimulus to address other learning acumens in planning for effective learning. He suggests that, for example, the learning objective "To learn how to feel confident taking risks and stepping outside of one's comfort zone to make positive change." (p. xvii) could be added as a subsidiary objective in a lesson. This subsidiary objective addresses aspects of learning that are not subject content. Chisholm (2017) referred to this as split-screen objectives. Chisholm (2017) asserts that planning for struggle would cultivate positive and optimistic attitudes toward taking risks and confronting fear. The 6Bs strategy would encourage teachers to plan lessons that include challenges that facilitate risk-taking in lessons. It is worth mentioning here that confronting fear safely should not be overlooked; fear also needs to be addressed. Addressing fear will enable participants to manage any intrusive thoughts and strong emotions and develop agency (cf. Bandura, 1997). Although I had not explicitly planned for this to 'develop thinking skills', it was through this discussion that I realised this use of this strategy. This was shared with the participants.

At the end of the workshop, the participants were then supplied with a ‘pack’ that included the A4 size ‘Mathematical Resilience Pit’ sticker sheet and the A5 copy of the ‘prompt sheets’ (see Appendix 12). The prompt sheets were not stickers; the participants kept them in their books as a close-at-hand reference tool. The participants were reminded that they could use these stickers as and when they felt they needed them.

Students took the strategy ‘packs’ to their classes to use as frequently as they needed to for the next couple of weeks. Their class teachers were encouraged to encourage students to use these stickers to support the 6Bs strategy. Because this strategy had more in-built scaffolding within it, I planned to have minimal influence on the participants’ learning; my presence in the other classrooms during lessons was minimal.

For the participants in my teaching group, I would remind them to refer to their strategy pack for the first couple of lessons before I could help them. I would remind and encourage them, for any task/question they were stuck on, stick the ‘6Bs’ sticker, and go through the suggested ‘steps’ out of being stuck. As time went on, I noticed that participants did not need my reminders to use these resources for this intervention strategy participant. On several occasions,’ participants were able to come to a solution using the stickers, without any help from me or any adult in the room.

The final of the three cycles, 6Bs, was also concluded by an evaluation session, Evaluation 3. During this session, as well as the standard rating of the strategy being utilised, I requested students to rank the three strategies against each other in terms of how useful or helpful they found them, with ‘first’ as the most useful to them and ‘third’ as the least useful. I was interested in observing how reflective Evaluations 1, 2 and 3 were of these final rankings.

This reflection would give some ‘triangulation’ opportunity to the evaluation findings and address the recency effect.

In this section, therefore, I discuss the rating of the 6Bs strategy, both quantitatively and qualitatively, then I present the ‘by sub-group’ and individual observations before reporting on which of the three interventions most students report they found to be the most impactful. Finally, I trace all the students who reported to have not benefitted from each strategy so far to determine if there are any repeat appearances.

4.2.2.4.2 Data Collected at Evaluation 3 and Interpretation

In terms of rating the 6Bs strategy, the whole group gave it a mean rating of 6.08, the highest of the three strategies used in this study. This result indicates that students found this strategy the most useful and helpful. The high mean score (Table 4.15) strongly suggests that most students rated this strategy high.

Variable	Obs	Mean	Std. Dev.	Min	Max
bs	25	6.08	2.675818	1	10

Table 4.15: Mean and SD of 6Bs to MR quantitative data

By presenting the data in a histogram over a normal distribution, it is clear that most students rated the strategy about five or more (Figure 4.25).

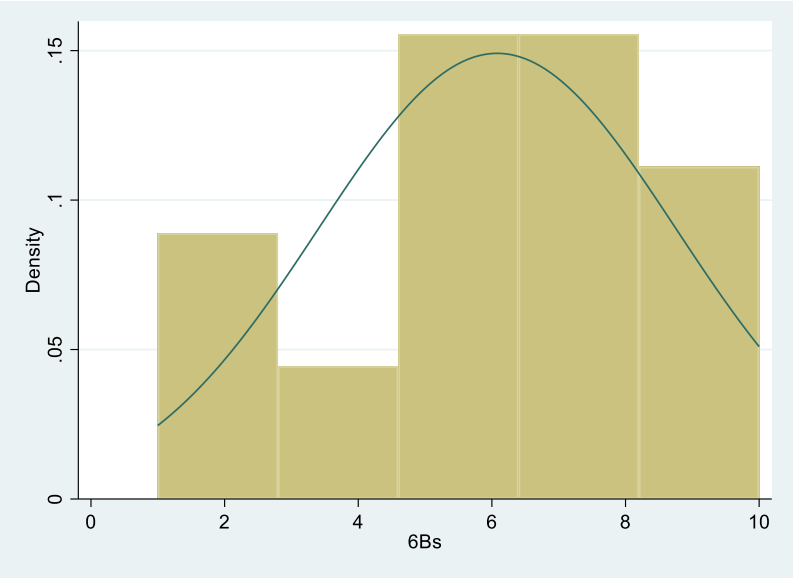


Figure 4.25: Graphic distribution of 6Bs to MR quantitative data

Two students did not find this strategy useful at all (Table 4.16).

6Bs	Freq.	Percent	Cum.
1	2	8.00	8.00
2	2	8.00	16.00
4	2	8.00	24.00
5	4	16.00	40.00
6	3	12.00	52.00
7	3	12.00	64.00
8	4	16.00	80.00
9	3	12.00	92.00
10	2	8.00	100.00
Total	25	100.00	

Table 4.16: Numerical distribution of 6Bs to MR quantitative data

In terms of skewness (small, negative) and kurtosis (less than 3), as shown in Table 4.17, these two measures confirm the closeness of this data to a normal distribution hence the mean score being a good representation of the students' feelings.

6Bs				
	Percentiles	Smallest		
1%	1	1		
5%	1	1		
10%	2	2	Obs	25
25%	5	2	Sum of Wgt.	25
50%	6		Mean	6.08
		Largest	Std. Dev.	2.675818
75%	8	9		
90%	9	9	Variance	7.16
95%	10	10	Skewness	-.4333955
99%	10	10	Kurtosis	2.26547

Table 4.17: Skewness and Kurtosis of 6Bs to MR quantitative data

All but 2 of the students reported that they did find the 6Bs strategy very useful and helpful. In the next section, I perform a 'by sub-group' and individual analysis.

The data collected involved participants completing the end-of-strategy evaluation form. The following sub-sessions present the feedback collected from participants. These were collected during the evaluation session at the end of the cycle.

Understanding the 6Bs to Mathematical Resilience and how you can use them to improve your learning.	Scale 1 – found it most unhelpful [not useful at all] 10 – found it most helpful [very useful] **(Mean Score and range of scores)**			
MaU	Mean Score:	**5**	Range:	**1 - 9**
MaA	Mean Score:	**8**	Range:	**8 - 8**
MaEE	Mean Score:	**6.1**	Range:	**4 - 8**
MaTS	Mean Score:	**6.4**	Range:	**2 - 9**
MaER	Mean Score:	**5.9**	Range:	**1 - 9**
Vol	Mean Score:	**6.5**	Range:	**5 - 8**

Table 4.18: Table showing the Spread and Mean rating by sub-group.

i. Maths as Utility

Some participants in this group expressed that they benefitted from this strategy; they collectively gave the strategy a mean rating of 5, with a range of 1 to 9. 33% reported that

they found some benefit in using the strategy. In comparison, 17% did not find the strategy useful, and the rest did not offer any rating. Considering that this was the group at the forefront of my mind when I selected and redesigned this strategy, what I found very encouraging was that more participants reported benefit than those who did not. These participants could now say they were aware of different strategies they could use to get out of being stuck.

In terms of their perception of being stuck, one participant (MaU3) reported that they now understood that 'being stuck is normal', and this perception would be their first step to managing the rest of the learning. This participant reported that they could now approach their learning more calmly, enabling them to take themselves from 'out-of-depth' zone to the growth zone. Another participant (MaU1) reported that 'It just made me feel slightly more stuck'. Upon following this up with the participant what 'it' was, they pointed out that 'it' was the idea of a pit; they had never looked at being stuck that way and that they are not usually good with closed spaces. I will be more careful next time in case there are such students in the group, considering that the '6Bs' Pit sticker presented participants with a visual representation of a usually abstract concept. It is bound to elicit such a strong reaction in a few students. This reaction was directed at the 'representation' more than at the concept because the participant reported that there are things they can do before asking the teacher. However, I would suggest that this reaction is to be considered by teachers who wish to try this strategy. With a mean rating of 5 (out of 10) and 33% reporting some level of benefit, I deemed this strategy to have promoted some resilience for some of these participants.

ii. Maths as Application

The feedback from this sub-group gave evidence for the potential of this strategy's usefulness in helping participants manage their learning. A mean rating of 8 and no participant reporting that they did not find it useful indicates that the strategy achieved the desired outcome. One participant (MaA1) reported that 'I could use it for more questions I did not understand', implying that they could also see the potential of using this strategy in other situations.

iii. Maths as Enjoyable and Explained

Looking at the rating scores awarded by this group, this strategy seems to be perhaps the first step in moving this group of participants towards creating a positive stance towards their mathematics learning and being more resilient in their mathematics learning. They collectively gave it a mean rating of 6.1 with a range of 4 to 9. All participants reported that they found this strategy quite useful.

When invited to comment on this strategy, one participant stated that it helped her 'understand what can be done to bring [her] out of the pit'. Another said it 'made me think harder and keep trying - not to give up' and it 'helped me understand what I need to do to not feel stuck'. These comments seem to imply that these participants could see the value this strategy added to their learning and articulate a way of thinking that was indicative of being more resilient.

iv. Maths as Thinking Skills

When it came to this group of participants, there seems to be evidence, from their mean rating of 6.4 out of 10 and no one reporting that they did not find the strategy useful, that the strategy had the desired effect on participants. Considering that this group of participants had

previously reported that even though they acknowledge that mathematics is hard, they disagreed that it gets easier with help, this strategy seems to have shown these participants that some forms of 'help' can make them more successful at maths. One of the participants' statements that 'I do understand my work a lot more now' suggests that they have found the strategy useful. What I am led to believe, however, was that this group of participants might have a different notion of what constitutes 'help'. They seem to have the view that being given 'suggestions' of how they can continue to work safely and successfully at mathematics was not 'help'. This notion demonstrates that 'help' to these participants involved direct input from another individual, particularly the teacher. When discussing whether the suggestions on the 'sticker' were not 'help', one participant reported that their teacher kept telling them things they could try and not how to do the question; help is deemed to be when the teacher tells you how to work out the question. This comment was indicative of a learned culture of 'tell me exactly how to do this question', do not tell me what I could try to answer the question.

v. Maths as Enjoyable and Relevant

This group of participants seem to have found this strategy useful; they gave it a mean rating of 5.9 with a range of 1 to 9. One participant reported that they did not find the strategy useful. 67% experienced varying degrees of benefit, while the rest did not offer any ratings.

For this strategy, this group of participants seem to have found some merit in the strategy. Comments like I no longer 'freak out' as much as I used to because 'I can find ways that can help a lot' (MaU6) and I now know of 'Many helpings [steps] to get out of the pit' (MaU6), demonstrate that these participants would be able to work more resiliently. These comments indicate that these participants were starting to establish routines and strategies for dealing

with challenges. Some reported that they did not use it that much. One participant reported that ‘I mostly understand everything being taught during the lesson, so I didn’t need help mostly’, this is not an unexpected reaction during the feedback because participants were required to use it as and when they needed it. If they did not encounter challenges in their lessons, then this would be an understandable response. Another participant reported that ‘I forgot about the workshop, so I have been improving in maths by myself - homework.’, this participant seemed to find working on challenging tasks at home helpful. However, the participant does not explicitly refer to ‘how’ they were working at home; there is evidence that they can manage their learning in the classroom.

A participant who said, ‘I wasn’t really thinking about the stickers and the 6Bs when I needed help’ seems to indicate that she was in the ‘red zone’ or ‘flipped state of mind’. This view is a reality to a lot of students in their day-to-day learning. In a brief follow-up discussion with this participant she pointed out that sometimes she just wanted someone to come and tell her what to do, she did not want to have ‘things to try’ as she felt this sometimes-wasted learning time. She was not in a ‘thinking’ state of mind. This is an expected reaction because the ‘red zone’ elicits mental/cognitive paralysis for some participants. Recognising and then supporting students in managing such episodes should be of paramount importance for teachers.

On reflection, some aspects of the feedback ‘prompts’ were not clearly communicated to the participants. For example, a participant commented ‘I don’t understand what you mean by ‘aspect’ *of resilience*’. This lack of clarity would be an area of improvement on my part, to make sure that every single aspect of instruction given to participants is clearly communicated.

Table 4.18 includes feedback I collected from a group of participants who had initially not been flagged up from the Q-Sorting activity as holding views that left them susceptible to being non-resilient. They opted to join the project of their own volition during ARC2.

vi) Voluntary

These participants seem to have found this strategy very useful. Even though they were not part of the identified target group, they still found this useful. This group gave the strategy a mean rating of 6.5 out of with none of the participants reporting that they did not find it useful. Some of the comments they gave were that it helped in ‘understanding what could get [them] out of the stuck stage in the pit’ while another said I could keep ‘trying not to stay stuck and understanding the work’. This occurrence indicates that educators should always allow ‘non-target’ groups to participate in or experience other ways of managing their learning.

4.2.2.4.3 Sample of Participants’ Work

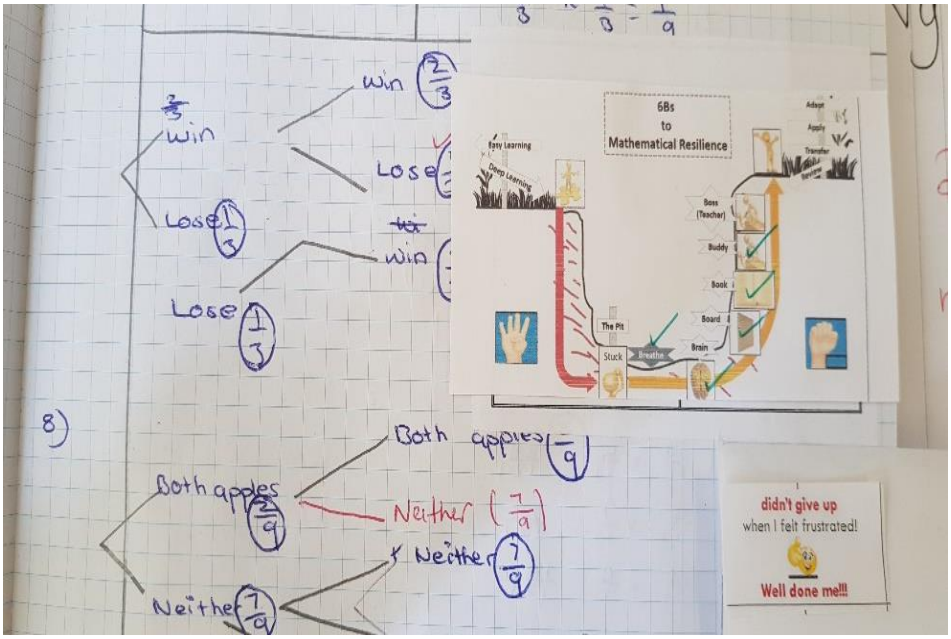


Figure 4.26: Sample of student work

The work shown in Figure 4.26 suggests that the participant effectively used the strategy in their lessons. In the course of a discussion during one of my class visits, one participant commented that she found herself repeating some of the stages for some questions. Upon further probing she reported that she would try maybe two or three things, 'get the answer' but then when she checked at the back of the book she found that the answer she got was wrong and so she went back and checked her working out.

4.2.2.4.4 Feedback from teachers

Feedback from a colleague (see Figure 4.22b) indicates that she deemed the 6Bs strategy impactful because she commented that '…the 6Bs was particularly helpful to some who had been less independent with the [previous] stickers because they could look at methods to help them without any input from me.' This observation shows that the strategy had some desired effect on the students' learning; it is possible that these students could now manage their learning better.

4.2.2.4.5 Reflections

In this section, I give a synthesis of the findings from the student feedback on this strategy.

What I found from this strategy is:

1. On the usefulness of this strategy, the mean ranking from each of the groups ranged from 5 to 8**.** In 4 out of the 6 sub-groups, every participant reported some level of benefit, and none reported that they did not benefit.
2. On comments about this strategy, how useful they found the strategy to be, feedback elicited mixed reactions. 76% were positive while 24% were negative.

4.2.2.4.6 Evaluation

I drew a lot of ‘lessons’ from this data. In the 6Bs strategy, participants were explicitly introduced to the term ‘stuck’. Canter (2016) describes being stuck or ‘stuckness’ as implying “that there is no obvious way to approach a challenge or difficulty and that the individual is struggling to move on.” (p.76). This view is echoed by Williams (2014)’s perseverance strand of resilience and the context I used this term in and therefore I refer to this context when describing ‘being stuck’. In the other ARCs, the most prevalent terms I used with the participants were ‘struggle’ and ‘challenge’. The introduction of the term ‘stuck’ in this context was in recognition that for some students their mathematics learning could feel exactly like how Canter (2016) described it, that there is no apparent way out.

In terms of usefulness, observations from this feedback seem to indicate that the students had relatively embraced and found usefulness in this strategy. Even though research evidence suggests that students can become encultured into practices, when stuck, of relying heavily on teachers’ immediate help (Al-Saadi, 2011) and therefore resisting change to this mode of operation (Chisholm, 2017), participants in my research generally seemed to have embraced this strategy.

Perhaps one of the reasons for this was that, at the outset, it was made clear that being stuck is part of learning and that the feelings associated with it are normal, and it was ok to feel that way. Chisholm (2017) reported that he found that the biggest barrier to overcome was the group’s view that being stuck was a negative thing in his initial analysis of the group he worked with. The initial discussion, right at the start of this cycle, with my group, allowed students not to get caught up in that ‘negative view’ and focus more on how to move on from

being stuck-which was the main focus of this strategy by exploring suggested ways the students could use to move on.

As mentioned at the beginning of this section, this strategy was primarily targeted at participants who strongly disagreed with the statements:

> ‘I know how to bounce back when I get discouraged in maths.’ and
>
> ‘When I have done poorly on something related to maths, I know how to adapt.’,

This group (MaU) rated the strategy at 5.67, which even though it was not the highest rating, was high enough to consider it a success. I deemed it a success because these participants had gone from ‘I do not know how to bounce back or adapt’ to ‘I am over halfway to knowing how to bounce back and adapt (that is how I read this rating). They were not professing complete confidence in their ability/capability to bounce back and adapt. They said, ‘I am no longer at that debilitating stage, I can now see possibilities (in the amber arrow in Figure 3.11b) in terms of managing my learning better’.

The majority of participants within the group reported that they found the ‘pit’ useful in allowing them to at least take some forward steps to proceed when stuck. When students were stuck and unsure what to do, initially they relied on being reminded to make use of the ‘pit’ sticker and prompt sheet before they could get any help. I observed this from the participants in the classes that I taught, and a few of my colleagues reported similar observations to me. Throughout the study, I saw the participants becoming more independent in their learning, asking me for help less frequently and, instead, supporting themselves through difficulties. Over time, they became more confident to work in the Growth Zone, which indicates some mathematical resilience development. Utilising different sources of support indicated participants developing their perseverance, persistence and confidence in their own abilities.

The frequent reference to and use of the ‘pit’ stickers were indicative of the participants experiencing the stuck moments and successfully working their way out of the ‘pit’. This observation also showed that the participants were not immediately seeking teacher help as soon as they got stuck and were not giving up easily, either when learning was challenging. I observed that they were more willing to ‘have a go’ by themselves. My observations also indicated that using the prompt sheet jogged their minds and allowed them to focus their thinking. I believe its success was because it was visual; it was visible ‘at all times’ and I regularly referred to it.

When it came to commenting on the different aspects of the strategy, some of the participants’ responses were negative. They seemed to indicate that although they had rated it well, they either did not quite understand what was required of them or could not think of what could be done to make this strategy more useful to them. This observation does not take away from the ‘usefulness’ scores they awarded the strategy. A discussion I had with some of these students revealed that even though they did not score some aspects of the strategy a 10, they had no suggestions about making it better. This could indicate that they probably did not want to entertain any new ideas or were content at the ‘level’ of support this strategy offered them. In effect, some participants pointed out that even though they did not score the strategy a 10 (or close to a 10) they were learning, so did not feel it needed improving. The less-than-10 scores did not reflect a lack of usefulness or ‘learning’ (growth zone learning).

Students who reported not to have benefitted from the 6Bs strategy:

MaER6
MaU1

4.2.3 Observation: comparing the impact of all three strategies

The participants were invited to rank the strategies first, second and third, depending on how useful they found them. The majority of participants ranked the Mathematical Resilience Pit strategy as the one they found the most useful. This 'personal perspective' of the participants could have been affected by the order in which the interventions were introduced.

Figure 4.27 presents the results recorded from data gathered to compare the three strategies.

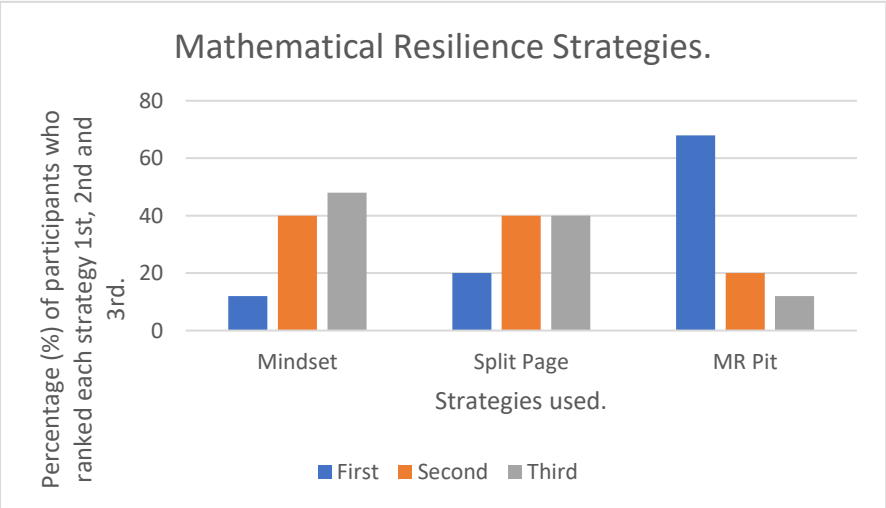


Figure 4.27: Comparative bar chart of the three strategies

These results and the data in Table 4.17 suggest that the '6Bs' was found to be the most useful. Several reasons could be forwarded for this. One of these could be concerning the timescale between using the strategy and completing the final ranking. The Mathematical Resilience Pit was used last (just before the project's conclusion) and would probably be the 'freshest' in their minds. The strategy also allowed students to 'see' a way out of their difficult or challenging learning situation, allowing them possible few quick early successes. Another reason could be that the '6Bs' offered more scaffolded support; it offered more 'direction'.

One thing that unites these interventions is that they sought to elicit some form of adaptable responses and, therefore, positive outcomes from the learner. What differentiates the three interventions is the level of participant-perceived challenge/or lack of support and direction with each intervention. Challenge is in respect of participants reporting on i) how easy they found using this strategy and ii) how impactful they found each strategy and direction in terms of telling them what to do or getting them to think and do for themselves. This interpretation can be summarised and represented as:

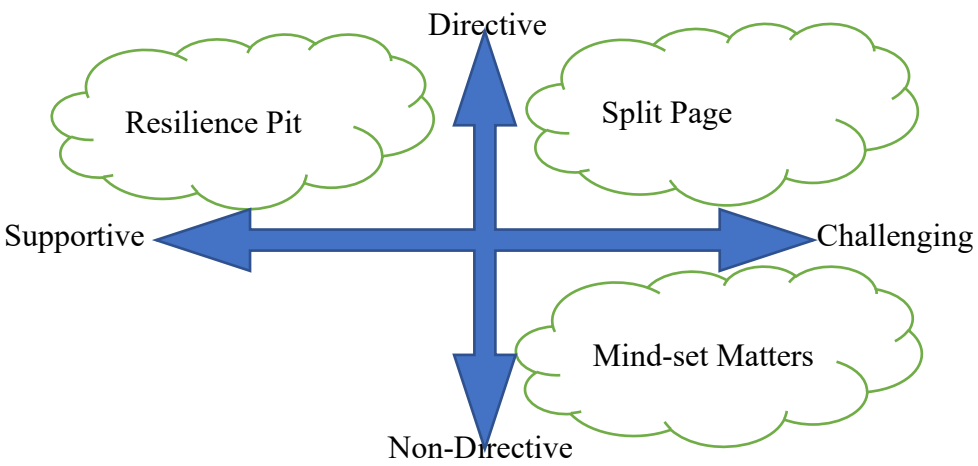


Figure 4.28: Interpretation of students' views on the three strategies

Performing a t-test (Table 4.19) on the Mindset Matters!!! data collected in this study revealed that at a 95% confidence interval, the range of $4.40<\mu<7.32$ contains the study group's true mean. This result means that if this study was repeated, there is a good chance, similar results could be achieved. The same conclusion can be drawn for the Split Page, at $3.30<\mu<5.99$, where the mean is also contained within this range. The calculated 95% confidence interval for the '6Bs' data, at $4.97<\mu<7.18$, indicates that this range includes the study group's mean.

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
mm	22	5.863636	.7034099	3.299285	4.400815	7.326457
sp	25	4.8	.5773503	2.886751	3.608408	5.991592
bs	25	6.08	.5351635	2.675818	4.975477	7.184523

Table 4.19: T-Test of the three strategies

As previously mentioned, (Section 3.5.2.1), I used the Zones of Learning model and Hand Model of the Brain as underpinning models for these strategies. At the end of all strategies, I also invited participants to rate how useful they now found these two models.

This exercise's results seem to indicate that an increased number of participants found the models useful throughout the research project. This finding appears to suggest that longer-term appreciation of these model grew. In turn, this observation sends the message that, with time, for some participants, it is possible to eventually find benefit from otherwise what might seemingly have been initially viewed as not useful.

In terms of reported impact by individual participants, every participant in the whole intervention group reported some benefit from at least one intervention. MaTS4, MaER5, MaU1 and MaU4 reported the least benefit across the strategies, with ratings ranging between 1 and 2. Although the rating of 2 means they did find marginal benefit, this might not have long-term effects for these participants. For such participants, a more in-depth discussion might shed some light on exploring other resilience-building strategies that could work for them. The goal was to try and enable every student to work resiliently.

4.3 Reviewing initial views as indicated by the Q-Sorting Activity

The data discussed in section 4.2 points to students reporting benefit from one or more of the study's strategies. As much as that data is a good indicator of evidence of possible development of resilient traits, the key to sustained working within the 'growth/resilient zone' would be a shift in subjective judgements of self. Another Q-Sorting would have been ideal, but the second Q-Sorting could not be performed because of unexpected timetabling issues. The next best thing was to request students to review their current stance at regular intervals compared to the programme's beginning. In place of an 'after treatment' Q-Sort, I requested the students to rate the very statements that led to their being identified as holding views that could leave them susceptible to being non-resilient. The data reported in this section attempted to gauge how these views had changed throughout the study.

This section's discussion focuses on how the students positioned themselves regarding the statements that flagged them up as holding views that would make them susceptible to being non-resilient. This data was collected over three reviews sessions; R1, R2 and R3. The students were asked to consider their feelings at the onset of the project at 1, then rate how they feel now from a 1 (I still feel the same) to a 10 (I now feel the complete opposite). All the data collected was treated to different statistical measures for analysis. Because the MA (Most Agreed) and the MD (Most Disagreed) were different for each sub-group, I did not carry out a whole group analysis.

i) Mathematics as Utility

From the Q-Sorting, these statements emerged as the most emotive for this subgroup.

Most Agreed: Having a solid knowledge of maths helps in my other work.

Most Disagreed: i) I know how to bounce back when I get discouraged in maths.

ii) When I have done poorly on something related to maths, I know how to adapt.

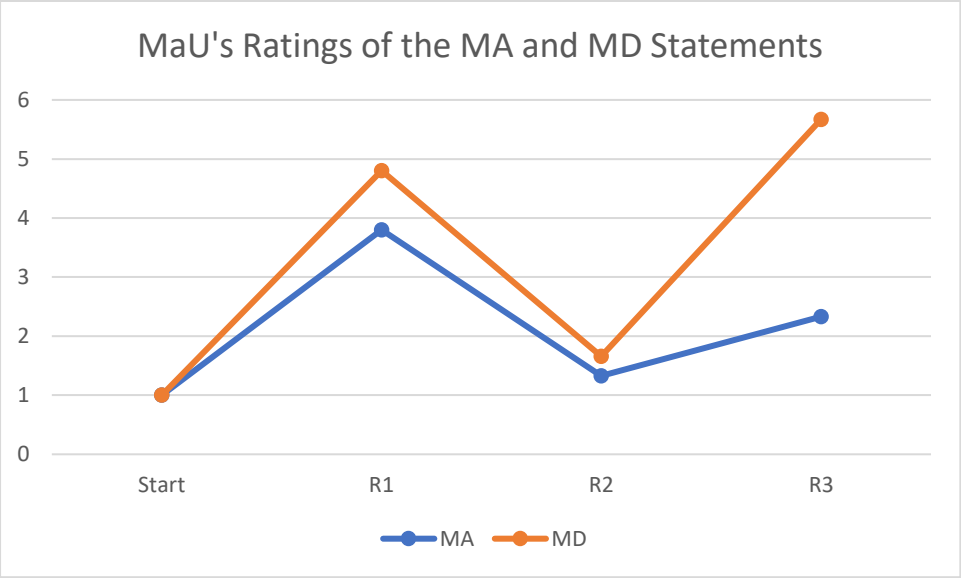


Figure 4.29: Graphic representation of MA and MD quantitative data

In terms of how students in this subgroup felt about the defining statements, Figure 4.29 shows some shift in students' feelings about them. There is evidence of the beginning of an upward trend in the ratings. It would be well-grounded to assume that a moving average calculation would further reveal and confirm this assertion if this project had continued. Table 4.20 shows that students experienced a substantial change in opinion on their most disagreed statement (5.67 at R3) and 4.5 across the study period (Table 4.20). The shift in perspective suggests that these participants manifested some increased resilience in their learning.

Variable	Obs	Mean	Std. Dev.	Min	Max
ma	11	2.545455	2.583162	1	10
md	11	4.5	3.694591	1	10

Table 4.20: Mean and SD of MA and MD quantitative data

The participants' mean rating indicates that they had made some advance from their initial standpoint. Further exploration of the data shows that in 4 instances, students rated the statements 1 (Table 4.21), meaning that they still feel the same as they did at the start of the project. Three students reported these 1s. One student reported a 1 at R1 and R2 on the graph while the other two students reported a 1 at either R1 or R2. By R3, all students in this group had made significant progress.

MA	Freq.	Percent	Cum.
1	4	36.36	36.36
2	4	36.36	72.73
3	2	18.18	90.91
10	1	9.09	100.00
Total	11	100.00	

MD	Freq.	Percent	Cum.
1	4	36.36	36.36
3	2	18.18	54.55
4	1	9.09	63.64
7	1	9.09	72.73
8.5	1	9.09	81.82
10	2	18.18	100.00
Total	11	100.00	

Table 4.21a and Table 4.21b: Numerical distribution of MA and MD quantitative data

Key: ma = Most Agreed; md = Most Disagreed

However, there is still evidence of helplessness (for example the participant who said 'Because it's always like that and it doesn't change of hardness') which could mean reliance on the teacher as the only source of help or a fixed mindset.

Regarding their position regarding the statement they most agreed and most disagreed with, participants in this group found the 'Spilt-Page' strategy (R2) not that impactful. Their responses indicate that they felt the same as their perspective at the beginning of the programme. It might be said that these participants seem to believe the split page had little impact on their initial viewpoint. For example, one of the participants reported that they still feel the same about their mathematics learning as they did at the start of the programme,

while another said maths is still the hardest subject. Interestingly, at R1, this group, when asked to rate how they felt about the most disagreed statements, the mean rating they gave was 3.8 (compared to 1.3 reported in R2). This change suggests that the split page was insufficient to provide them with the 'bounce back' or 'adapting' skills for this group of participants. This result is not unexpected for two possible reasons: i) this might not be the type of 'bounce back or adapting' they were expecting; ii) prevailing circumstances will influence the 'subjectivity' of this judgement.

Regarding their shift in perception from before the interventions, this group of participants reported a moderate shift in their belief that having sound knowledge in maths helps in their other schoolwork. One participant pointed out that not all subjects need maths knowledge and they put forward French as one of those subjects. However, they reported that they had made a noteworthy change in their perception of their ability to bounce back or adapt. One participant pointed out that she just needed more confidence and to work harder. This comment seems to imply that 'I now know what I can do, I just need to have more confidence in myself.' This confidence could then affect how hard they apply themselves to their work - work harder. I deem this a success.

ii) Mathematics as Application

From the Q-Sorting, these statements emerged as the most emotive for this subgroup.

Most Agreed: Personally, I struggle a lot in maths

Most Disagreed: Maths is all about the effort you put in from the start. What you put in is what you get out.

Variable	Obs	Mean	Std. Dev.	Min	Max
ma	1	1	.	1	1
md	1	3	.	3	3

Table 4.22: Mean and SD of MA and MD quantitative data

This group consisted of one student because only one student loaded on this factor. The student was out of school for a considerable period and therefore missed some of the data collection points. Concerning her view on the statement she 'most agreed' and 'most disagreed' with, the student reported a marginal shift in terms of the most disagreed statement. This participant gave the reason that the MM strategy does not explain the actual work, which seems to imply that she wanted to be told how to do the particular tasks rather than be equipped with skills that could help in any other situation. This perspective suggests that her view of 'support' was 'tell me, exactly, what to do' rather than suggest things I could do, in other words, 'spoon-feed me'.

As described by educational philosophers as far back as 384BC, Aristotle (384-322 BC), in Bates (2019), points out that this attitude advocated for not 'spoon-feeding' students with information but for allowing them to look for the solutions themselves. Also, this participant still felt that the effort she was putting into her work was not reflected in her learning outcome or her desired outcome (Pinxten et al., 2014); she felt her best effort was not good enough to achieve her desired outcome. The comment 'I put in *the effort,* but I need more help.' seems to be implying that there is a perceived limit to an individual effort's ability. It seems to be acknowledging that success is more than just effort, which is in line with, for example, Dweck (2015)'s Revisiting the Growth Mindset work. Perhaps more help or more scaffolding, especially if the steps are perceived too big, would benefit this group. On reflection, next time, I might introduce a model that has more scaffolding.

iii) Mathematics as Enjoyable and Explained

From the Q-Sorting, these statements emerged as the most emotive for this subgroup.

Most Agreed: I think maths lessons should be fun to help us remember

Most Disagreed: I want to study maths at A' Level, so I need a good grade at GCSE

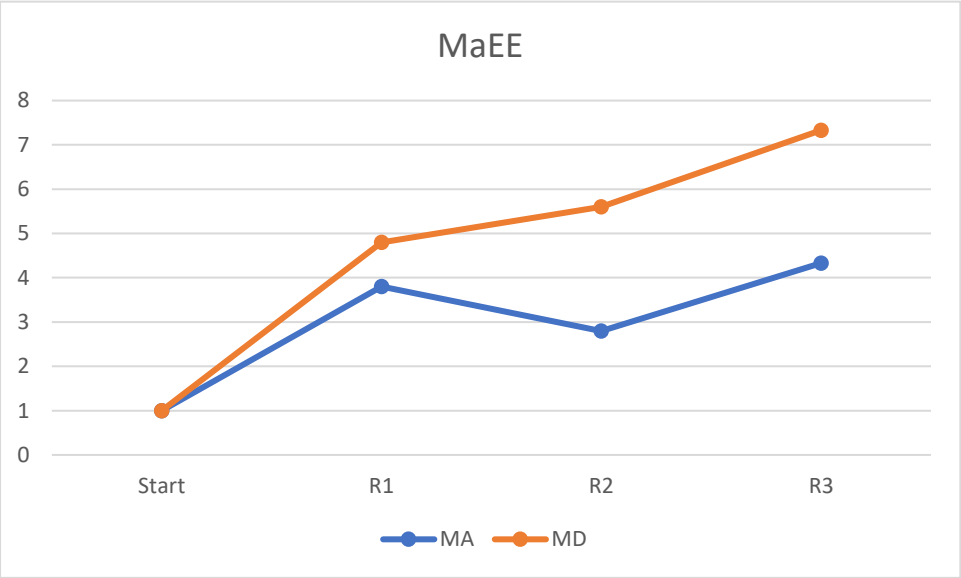


Figure 4.30: Graphic representation of MA and MD quantitative data.

Table 4.23 shows a steady increase in rating the statements that identified this group as holding views that would make them susceptible to being non-resilient, indicating a strong upward trend. For this group, their views on both the MA and the MD would greatly impact their reactions to challenging work or tasks, so this is the desired outcome for this study. And again, it would be conceivable to conclude that had this project continued; the students would have been impacted even more by exposure to resilience-building strategies. A mean rating of 3.76 (MA) and 5.67 (MD) indicates a substantial shift in opinion.

Variable	Obs	Mean	Std. Dev.	Min	Max
ma	21	3.761905	2.718543	1	9
md	21	5.666667	3.953901	1	10

Table 4.23: Mean and SD of MA and MD quantitative data

As shown in Table 4.24a and b, at 7 and 6 instances, students recorded a rating of 1, meaning that their views had not changed. The majority of students reported a significant change in their view, which will, in turn, enable them to manage their learning better.

MA	Freq.	Percent	Cum.
1	7	33.33	33.33
2	1	4.76	38.10
3	3	14.29	52.38
4	2	9.52	61.90
5	4	19.05	80.95
7	1	4.76	85.71
8	1	4.76	90.48
9	2	9.52	100.00
Total	21	100.00	

MD	Freq.	Percent	Cum.
1	6	28.57	28.57
2	1	4.76	33.33
3	2	9.52	42.86
5	2	9.52	52.38
8	2	9.52	61.90
9	1	4.76	66.67
10	7	33.33	100.00
Total	21	100.00	

Table 4.24a and Table 4.24b: Numerical distribution of MA and MD quantitative data.

As pointed out in section 4.1, there was no clear evidence that participants loading on this factor were expressing discontentment or failure in and of themselves, but they conveyed the message that if they do not find learning enjoyable, they will disengage and subsequently lack the motivation to continue beyond GCSE. This is still true judging by one participant in this group who expressed that they still want mathematics to be made enjoyable and easier to remember.

The data presented in this feedback seems to confirm that the participants would engage with their work but would benefit from the lesson being more memorable and more fun. Some of the participants in this group reported that they still want maths to be made easier to remember. They will study maths because they acknowledge that it will help them in the

future, and even though they do not want to do maths at A' Level, they still want a good GCSE grade. However, some have not yet established a link between awareness of how the brain works with how they can use it to manage their learning.

Through the discussion that took place with the participants in this group, they seem to be stuck in the 'tell me how to get to the answer', not 'how the brain works', indicative of some resistance to learning culture change or need to follow the path that seems to be 'of least resistance'.

There is some shift, following the intervention, in this group's opinion about GCSE grades. One participant confirmed that they did need a good GCSE grade but still had no desire to pursue maths beyond GCSE. However, they report that in terms of fun, lessons are still lacking – for example 'it *(lessons)* need to be engaging'. A further argument supporting the lack of change in opinion was expressed by a participant who said, 'I generally don't like maths, and I don't feel as though my feelings towards maths will change'. One participant suggested that maths could be more 'fun' if whole year group activities were organised, and students had a chance to work with fellow students from other sets. Participants still felt that maths lessons were not 'fun'.

Concerning the 'most agreed' and 'most disagreed' statements, the participants in this group also reported a reasonable shift on the most agreed statement and a considerable shift in opinion on the most disagreed statement. The 6Bs strategy seems to have had the desired effect on this group of participants (R3). At the outset of this study, these participants reported that they were not planning on further study of mathematics and so consequently did not need a good GCSE grade. It is possible that these participants were using this view to mask their lack of belief in their ability to do well. But they seemed to be now acknowledging that a

good grade in GCSE mathematics is important. This opinion could be because their self-efficacy increased through this strategy; they have now realised that they have greater capabilities than they believed they were.

Regarding the 'most agreed' statement, this group of participants still feel maths lessons could be more fun. One participant suggested 'cross-class' activities. This is worth further exploration.

iv) Mathematics as Thinking Skills

From the Q-Sorting, these statements emerged as the most emotive for this subgroup.

Most Agreed: I think how people are taught maths when they are young makes a big impact later on

Most Disagreed: Maths gets easier when you get a lot of help.

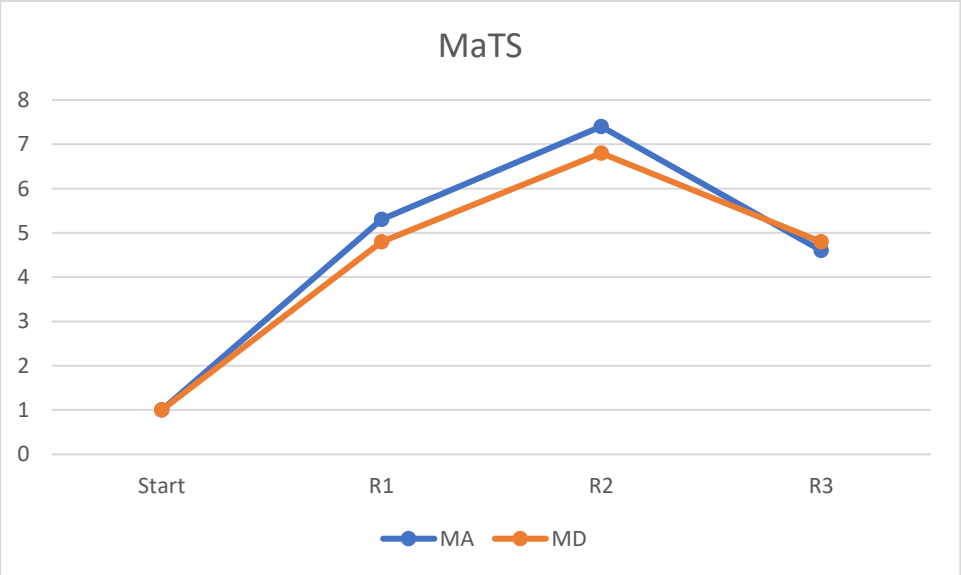


Figure 4.31: Graphic representation of MA and MD quantitative data

Figure 4.31 indicates that overall, students' view had shifted from what they felt at the outset of the programme. There was a steady increase across R1 and R2 with a dip at R3. However,

the drop would have minimal impact on this changed opinion's overall benefit compared to the starting position. The overall mean ratings of 5.78 and 6.71 confirm this assertion. For this subgroup, both the MA and MD statements would substantially impact their response to challenging work so a shift from their viewpoint at the outset is the desired outcome.

Variable	Obs	Mean	Std. Dev.	Min	Max
ma	14	5.785714	3.786181	1	10
md	14	6.714286	3.70921	1	10

Table 4.25: Mean and SD of MA and MD quantitative data

Further inspection of this data reveals that at 4 and 3 instances, students in this group reported a 1, meaning their view has not changed yet. This data was recorded from three students. One student recorded a 1 at 2 instances (R1 and R2) while the other two students recorded a 1 at R1 and R3. This result indicates that all participants in this subgroup felt different about the start of the programme opinion at some point during the study.

MA	Freq.	Percent	Cum.
1	4	28.57	28.57
2	1	7.14	35.71
6	2	14.29	50.00
7	1	7.14	57.14
8	1	7.14	64.29
9	2	14.29	78.57
10	3	21.43	100.00
Total	14	100.00	

MD	Freq.	Percent	Cum.
1	3	21.43	21.43
3	1	7.14	28.57
5	1	7.14	35.71
8	3	21.43	57.14
9	1	7.14	64.29
10	5	35.71	100.00
Total	14	100.00	

Table 4.26a and Table 4. 26b: Numerical distribution of MA and MD quantitative data

These are students who held the viewpoint that the kind of teacher one had in childhood has a significant impact (positively or negatively) on their current and future success. And similar to the other groups, they have reported a reasonable shift in the opinion spectrum. For the statement they most agreed with, that the teacher has a significant impact on their learning, these results seem to show that they are no longer placing as much significance on the role

the teacher plays and possibly realising that they (the students) and their mindsets have a substantial role to play. In terms of the most disagreed statement, the group has made inroads into acknowledging that appropriate support might impact their learning.

At an individual level, one of the participants (MaTS4) commented that they had learnt maths the same way since primary school and they did not have issues with how they were learning then and how they are learning now. This assertion seems to suggest that when this participant 'Most Agreed' with the statement 'I think how people are taught maths when they are young makes a big impact later on' she is affirming that the way she learnt maths from childhood up until now has had a positive impact on her learning (I don't struggle). Interesting to note is how she used the phrase '…I have been learning' instead of '….I have been taught' which seems to imply that she is placing more responsibility on herself. This would be advantageous in situations where students are achieving really well but could be detrimental if they do not experience success (Williams, 2014).

Another participant (MaTS3), when asked to comment on how they now feel about getting help in maths, seemed to point out that no amount of help will make maths easier, they seem to attribute how easy maths is to their intellect. They pointed out that 'Even if you get a lot of help sometimes it doesn't add up in your mind', which seems to indicate that while they appreciate the utility of help, sometimes their brain still struggles to process the information. MaTS1 reported that she had not changed her initial viewpoint by rating both statements 1 (at R1), meaning she still felt the same about these statements as she did at the beginning of the research project.

At R2, this group of the girls was the most positive about the impact of this strategy on their 'before intervention' perspective. They rated both statements 7.4 and 6.8 respectively,

implying their view had substantially changed. One participant changed from strongly agreeing with ‘I think how people are taught when they are young makes a big impact later on’ to yes, I still agree but ‘…sometimes you can help yourself’. This is indicative of the good probability of developing more resilience. Another reported change in view is from a participant who changed from initially strongly disagreeing with the statement ‘Maths gets easier with a lot of help’ to ‘I feel like I have improved ever since I have been getting help with my work in class.’ This participant seems to attribute some of their success to the support they were getting. This is indicative of the partial success of the strategy in transforming perspectives. When participants change their views of learning, they can improve their learning and ultimately their resilience and achievement.

At R3, this group reported a moderate shift in opinion. At the outset of this research, they held the opinion that the kind of teacher one had in childhood has a significant impact on their current and future success. This group seemed to have shifted the blame from ‘how someone is taught’ to the nature of the subject itself, which seems to imply that they could still have a successful future regardless of how they were taught maths. The comment …… seems to be saying that even though there is, to an extent, an element of how one is taught mathematics that impacts current success, this participant had concluded maths itself does not have any bearing on her future choices. It might affect current success but not their future choices.

v) Mathematics as Enjoyable and Relevant

From the Q-Sorting, these statements emerged as the most indicative for this subgroup.

Most Agreed: I think maths lessons should be fun to help us remember

Most Disagreed: Maths is essential for my future and very helpful no matter what I decide to study.

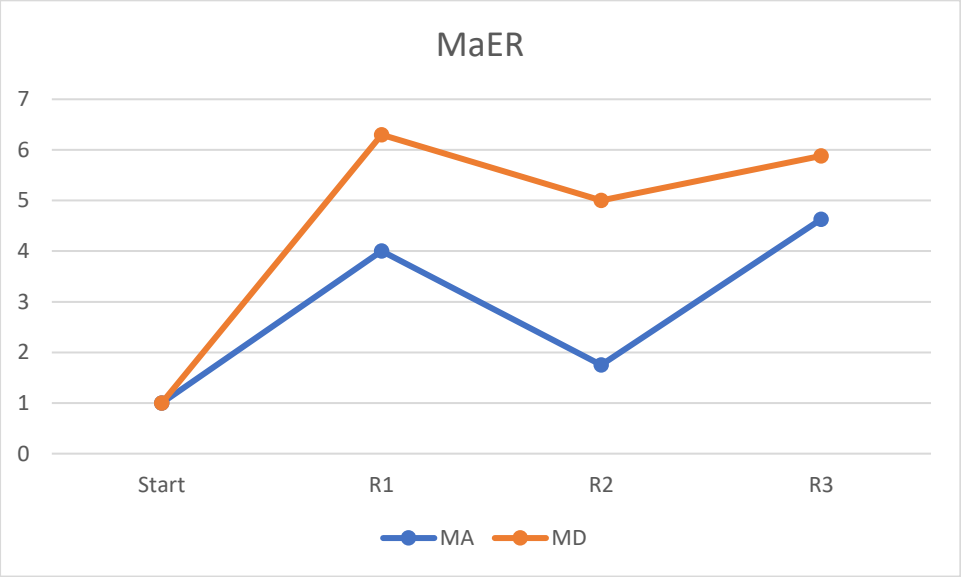


Figure 4.32: Graphic representation of MA and MD quantitative data

Figure 4.32 reflects changed viewpoints. The most disagreed view was that students' opinion changed the most (5.59 in Table 4.27), meaning they had come to believe maths are essential for their future and further studies.

Variable	Obs	Mean	Std. Dev.	Min	Max
ma	22	3.772727	3.053988	1	10
md	22	5.590909	2.575694	1	10

Table 4.27: Mean and SD of MA and MD quantitative data

As shown in Table 4.28a and b, nine 1s(MA) and two 1s(MD) instances were recorded. Only one student recorded a 1 across all stages (R1 to R3) while the rest of the students recorded a 1 at various stages of the study. This implies that apart from this one student, all the students in this subgroup at some point in the study felt different about how they felt at the programme's start.

MA	Freq.	Percent	Cum.
1	9	40.91	40.91
2	2	9.09	50.00
4	3	13.64	63.64
5	2	9.09	72.73
6	1	4.55	77.27
7	1	4.55	81.82
8	2	9.09	90.91
9	1	4.55	95.45
10	1	4.55	100.00
Total	22	100.00	

MD	Freq.	Percent	Cum.
1	2	9.09	9.09
2	1	4.55	13.64
3	1	4.55	18.18
5	9	40.91	59.09
6	3	13.64	72.73
7	2	9.09	81.82
9	1	4.55	86.36
10	3	13.64	100.00
Total	22	100.00	

Table 4.28a and Table 4.28b: Numerical distribution of MA and MD quantitative data

For a group that strongly disagreed that mathematics is relevant in their future, they made the most significant shift on this viewpoint. The majority of the participants in this group expressed their recognition of mathematics' relevance to their future (rated themselves to be at a 6.3 at R1). Some of the comments appear to reinforce this belief, such as 'I likely agree because it does help me with my future.' as well as 'It is true no matter what I study maths will always be essential for my study because it will give me knowledge.'. This statement is in line with what Nardi and Steward (2003) recommended. If students can see the relevance to their future, they are more likely to be motivated to overcome challenges. The participants in this group also seem to have made headway into realising that the 'maths must be fun' mindset might not be as important as they initially reported; there seems to be some success in transforming this viewpoint (rated 4 out of 10).

Looking at these mean scores at R2, the participants in this group seemed to be having a shift of opinion on the statement they initially most disagreed with. They all gave this statement a rating of 5. I was encouraged to see this shift in perception, which seemed to indicate that they were now finding some mathematics relevant to their future and further studies. A case in point is the participant who reported that 'I think maths is good in all future careers.' The participants who still reported some 'agreement with their initial position seemed to have

‘softened towards this statement. Their ‘Not really’ and ‘No, it really isn’t necessary’ indicate a less firmness than ‘No, it is not essential!’

The main observation of negativity in this group is they seem to convey that they find that maths lessons are still not fun. Participating in this study was aimed at transforming this viewpoint.

Regarding the ‘most agreeable’ and the ‘most disagreed’ statements at R3, these participants - quite similar to the other groups - made a noticeable shift from their early standing. Like the ‘Maths as Enjoyable and Explained’ group, they still felt maths lesson were not enjoyable, but some participants in this group became of the view that ‘enjoyment’ might not be as important as they had made it to be. For example, one participant reported that ‘The maths lessons should be fun but should also be serious.’, which seems to imply that they thought lesson content is just as important as the ‘fun’ element. In contrast, another participant raised the issue of having a good teacher as more important. These views resonate well with findings from Peterson et al. (2011), who reported that students in their study placed the responsibility of their failures on the teacher.

However, even though they have rated the ‘most disagreed’ just under 6 out of 10, one participant reported that she still felt almost the same as she did at the outset of the project. This participant reported that ‘I still mostly disagree *(with Maths is essential for my future and very useful no matter what I decide to study)* even if maths is one of the core subjects we need to study’. This participant seems to be suggesting that she would still engage with mathematics ‘because it is a core subject that I am required to study, even though I do not think it is essential for my future.’ This view was reiterated by another member of this group who said, ‘It depends on *the* job that you want to choose.’, implying they had not yet

established a clear link between the usefulness of maths and all future careers. Teachers are well placed to address this; if unaddressed, this could lead to disengagement for some students.

In addressing the overarching aim, 'How can understanding and amending the students' subjective judgements of self be utilized to support the development of mathematical resilience in students?', the data and discussion in this section has shown that:

1. Understanding how students view their learning journey has an impact and should be an integral part of any intervention programme. Such a programme will inform the strategies chosen and help students modify and adapt their reactions to challenging work, which results in better management of learning.
2. Over time, changed subjective views are achievable if students are given the platform and the exposure to different ways of looking at challenging learning situations.
3. There will always be students who are happy with the status quo and not open to change, but they will find some element of use in intervention programmes as long as they are given the opportunity
4. A variety of strategies allows for different elements of 'non-resiliency' to be addressed.

4.4 Impact of Study Summary

These results are a good indicator of the impact this study has had on the students, considering that

i) When requested to rate the learning models, students rated them 5.08 to 5.61 (ZoL) and 3.98 to 4.92 (HMoB).

ii) when asked to rate each strategy in terms of usefulness, students mean scored them between 4.8 and 6.08

iii) when requested to rate how they felt their thinking has changed over the course of the programme students allocated mean scores ranging from 2.54 to 5.78 (MA) and 4.5 to 6.71(MD)

iv) although individual scores across strategies' ratings ranged between 1 to 10, every one of the students reported at least a 2 or more in at least one or more aspects of this intervention programme. MaU1 did rate the learning models higher than 1.

All but one student reported gaining from at least one of the three strategies, so 97% benefitted. To further validate this assertion, I tracked the students who reported a 1 for any one of the aspects of this programme, the students who reported they did not benefit from each strategy are:

MM	SP	6Bs
MaER5	MaER2	MaER6
MaU1	MaU1	MaU1
MaTS4	MaU4	
	MaST6	
	MaTS1	

Table 4.29: Students who reported a one on the three strategies

MaU1 is the only student to report that she did not find any of the strategies useful. Several reasons could explain this. It could be that she genuinely did not find the strategies useful or could be, for example, that she was not open to exploring other ways of managing her learning. Only further discussion with this particular student could shed more light on that but

what was interesting to note is that she rated the HMoB and ZoL quite high. She reported that she found that these two learning models were a better fit for understanding her learning. MaU1 also reported that her views had changed throughout the programme. She was not among the students who recorded a 1 in any of her MA and MD statements. Based on this result, there is a good chance this student is also better able to manage her learning. All students reported a change of opinion at some points during the research. The longevity of the change in view is outside the purview of this study.

4.5 Gender-Related results

As discussed in Chapter 2, the research reviewed indicated that female students displayed more resilience than males in general. From the data I collected throughout the study, there was evidence the girls' resilience was improving. Figures 4.29 to 4.30 all show an upward trend regarding how the students' subjective views are changing. Research (Dweck, Bandura etc) has shown that individuals' belief of self is critical in how much they exert themselves to any undertaking. Every subgroup's viewpoint had substantially changed by the end of the study.

When considering the strategies used in the study, again there was marked acceptance of their usefulness for managing learning. Mean ratings scored were significant (between 3.4 and 8), indicative of reported success support better management of learning. The same could be said about the underpinning learning models. Students rated their usefulness to be between 3.9 and 5.6.

4.6 Chapter Summary

In this chapter, I discussed the results, the interpretation of the impact of the underlying learning models, the resilience-building strategies and how participants' opinions had evolved

throughout the study and the positive effect recorded for all aspects. In the next chapter, I address RQ4: 'What are the implications of these findings for practice and policy?'

The results from this study have indicated that there is great scope in addressing unhelpful subjective views students hold that could impact their learning. 100% reported benefit across the study indicating that there is traction in:

i) taking students' subjective views as the key consideration in any intervention endeavour,
ii) utilizing a series of intervention strategies for the benefit of providing a wider range of platforms for students to find their preferred coping mechanism,
iii) involving students at each stage of the intervention programme, using their feedback to improve 'treatment' and
iv) as educators, it is important to be sensitive to the students' 'needs' as expressed by their own voice (as opposed to needs as imposed by adult perception).

Chapter 5 focuses on spotlighting indications of 'improved personal management of reactions' to challenges. In greater detail, I also address implications for my practice, as the results of this study have resulted in some changes in the way I view my pedagogy. I also present an audit of my findings and how they addressed all the sub research questions but more importantly, how these findings addressed the overarching question:

'How can understanding and amending the students' subjective judgements of self be utilised to support the development of mathematical resilience in students?'

In Chapter 5, I also consider how the evidence collected relates to the construct of mathematical resilience in terms of what is already known, what I found out and how my findings add to or consolidate what already existed.

Chapter 5 – Findings and Discussion

Introduction

In this chapter, I present an integration of the different findings from my study and provide a commentary regarding consistency, contrast and complementarity. I discuss these findings structured by the research questions. I compare my study's findings with different perspectives that have been proposed in established research related to mathematical resilience. I highlight where this research has concurred with the established research and what I consider my research to have added/contributed to the field. First, Figures 5.1 and 5.2 offer a recap of how I carried out my action research project.

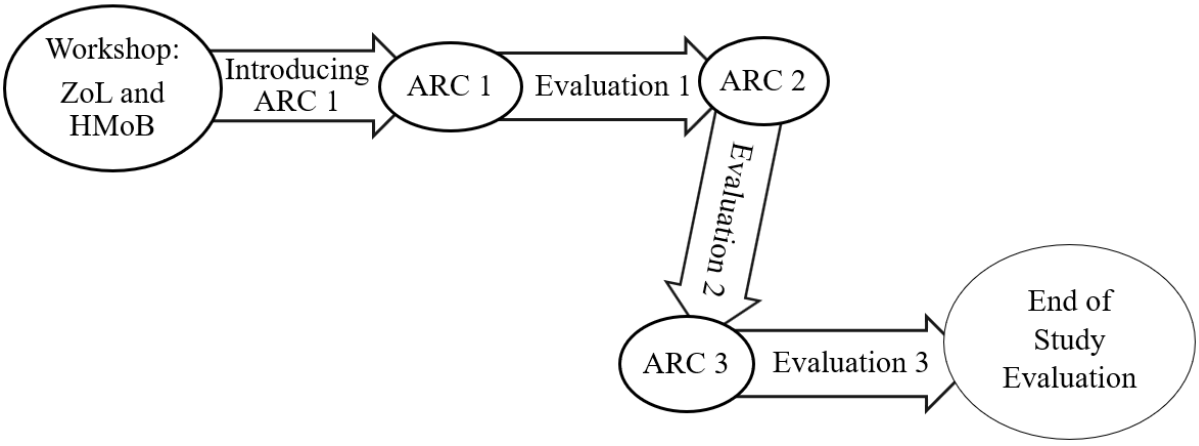


Figure 5.1: Order of ARCs

Figure 5.2 illustrates how the ZoL and HMoB models ran through the course of the study.

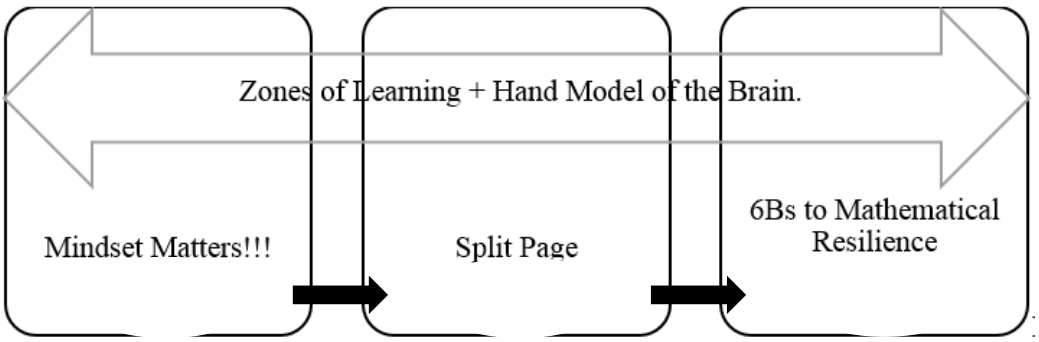


Figure 5.2: Link between underpinning Learning theories and chosen strategies

The rest of the chapter is presented as follows; in sections 5.1 to 5.3, I discuss the findings pertaining to RQs 1 to 3. In section 5.4, I address RQ4, and I conclude the chapter, in section 5.5, by summarising the findings.

5.1 Addressing RQ1

'What are the girls' subjective experiences of their mathematics learning journey to date and in what ways does Q-Methodology illuminate these affective dimensions?'

As discussed in Chapters 3 and 4, the participants' subjective views were vital in my research, and Q-Methodology was the vehicle I chose to elicit these views. I used the extracted subjective views to select my intervention candidates. In this sub-section, I discuss the first sub-research question in two parts: i) findings regarding the girls' subjective experiences of their mathematics learning journey and ii) in what ways Q-Methodology illuminates these affective dimensions.

5.2.1 What are the girls' subjective experiences of their mathematical learning journey to date.

A critical task in a social sciences study design is to identify appropriate participants. Historically, social sciences researchers in general and mathematical resilience researchers, in particular, have used a wide range of selection methods for choosing their participants. This section commences with discussing key findings from using Q-Methodology to elicit the girls' subjective views of their mathematics learning journey to select intervention students. 5 distinct viewpoints emerged from the Q-Methodology's Q-Sorting activity, and 36 participants out of a cohort of 98, that is 37% of the students, were identified as potentially holding non-resilient views. The students were across all different attainment backgrounds, Set 1 (high attainers) to Set 5 (low attainers).

I called the five subjective views that emerged from the Q-Sorting activities ‘Maths as Application’, ‘Maths as Enjoyable and Explained’, ‘Maths as Enjoyable and Relevant’, ‘Maths as Thinking Skills’ and ‘Maths as Utility’. Justification for these names is offered in Section 4.1, including defining Q-Sorts for each subgroup. These subjective views were possible to be elicited and distinguished in this way because of the use of Q-Methodology. The arrangements of the statements in the Q-Sorting frames and subsequent analysis enabled the distinguishing of distinct viewpoints. Students choosing one statement over another revealed the ‘inner’ convictions and perceptions of the students of self. This is in line with the idea that people think about ideas in relation to others rather than in isolation.

What I found from this undertaking was that Q-Analysis reduced the many individual viewpoints to a few factors, which illustrate shares ways of thinking. These shared ‘ways of thinking’ enabled me to select what I considered the most suitable students for this study. This selection method varied from previous research. At the time of writing, intervention for mathematical resilience studies did not utilise students’ voices to select candidates. In the next paragraphs, I discuss these studies and how my finding sits alongside them.

So, in terms of criteria for selecting intervention students for this study, contrary to established literature (Johnston-Wilder & Lee, 2010; Johnston-Wilder, Lee, Brindley & Garton, 2015), I found that students came from all performance backgrounds. Poor performance or repeated failure might not always precede non-resiliency. In other words, non-resilience can be found among students who also regularly experience success. I came to this conclusion because the students in this intervention group comprise high attainers and low attainers. Some of the students in this group were not experiencing repeated failure, but these participants still communicated characteristics and language associated with non-resiliency. This finding has not, at the time of writing, been shown to apply to all similar

research contexts but is a good indication that poor performance or repeated failure do not always account for the presence of non-resiliency.

However, this finding does not necessarily preclude poor performance or repeated failure as leading to non-resiliency. It adds to this body of research on the study of mathematical resilience, highlighting that there is more to causing depressed mathematical resilience than just poor performance or repeated failure. I hypothesize that this finding could be repeated in similar research contexts and confirm that non-resiliency is more widespread than in just repeated failure circumstances.

There is no doubt that the poor performance or repeated failure premise is a well-founded and logical reason for suspecting the possible existence of non-resilience. In my research, I had students in my participant groups who appeared to report that they had experienced repeated failure (e.g. 'Personally, I struggle a lot in Maths' as reported in Section 4.3) and had found it quite discouraging. Research has shown that being 'discouraged' can lead to non-resilient tendencies such as disengagement (Nardi & Steward, 2003). Equally, of the remaining 63% of students in the research cohort, despite some students having experienced repeated failure, they did not report characteristics or language associated with non-resilience. This result is a strong indication that repeated failure could not be wholly explanatory of non-resiliency. The study that used the 'repeated failure' method of participant selection (Johnston-Wilder & Lee, 2010) does not intentionally claim that this is generalisable but indicates how repeated failure affects self-belief/efficacy - a facet or strand of non-resilience. In terms of whether my research finding adds to or challenges this selection method, it does neither; it confirms that repeated failure could explain non-resilience but should not be the only reason to suspect non-resilience.

In other studies, the researchers used ‘lack of access to ICT’ as grounds for intervention for mathematical resilience (Mota et al., 2016; Lugalia et al., 2013), where ‘predominantly textbook teaching’ was used in the study school. In my study, I showed that ‘predominantly textbook’ teaching and lack of ICT access do not necessarily precede non-resiliency. I came to this conclusion because my research context was a well-resourced school with 8 ICT dedicated rooms housing over 250 computers and over 50 portable computer trolleys (Section 1.3). Students had access to these computers both for lessons and at their own private study time, yet some (37%) reported non-resilience tendencies.

‘Predominant use of traditional textbook approach’ can be a valid criterion for selecting resilience intervention students because established research has shown that ICT can support students’ resilience development (Lugalia et al., 2013; Johnston-Wilder & Lee, 2008; 2009). Johnston-Wilder and Lee (2008; 2009)’s studies asserted that the use of ICT could be part of a suite of tools that could be used to increase mathematical resilience.

However, using ‘lack of ICT access’ as a sole criterion for selecting resilience intervention students could be problematic. Students in schools that regularly use ICT in lessons can also be non-resilient. My research was conducted in a school where ICT use is significantly encouraged and expected. In addition to this, the school’s record from the Home-School agreement indicated that the majority of students had ICT and internet access at home. My selection method flagged up students with non-resilient belief tendencies who had access to ICT facilities. In terms of whether my research finding adds or challenges this selection method, my research shows that a lack of ICT experience does not seem to indicate non-resilience necessarily. I am not claiming that this selection criterion has no merit, but its use as a sole selection method could be challenged in light of my findings.

Another research I referred to in Chapter 2 considered a ‘target grade’ group as a selection criterion (Chisholm, 2017). There is a lot of merit in targeting a particular homogenous group of students (in Chisholm’s case ‘predicted just missing on a Grade C’). In this project, Chisholm’s assumption that all students predicted to just miss out on their GCSE ‘pass’ need support with developing resilience seems to be at odds with the results. One of the cohorts I used in one of my pilot studies was students working towards their GCSE examinations.

The potential intervention group indicated by the Q-Sort included students from set 1 (high attainers and passing target grades) to set 5 (predicted to not passing). Only set 3 was made up of students who would have made it into Chisholm’s target group - targeted as just missing on a pass. Using this argument, the expectation would have been that most identified students would come from this group but that was not the case. The majority of students in this group came from set 2 (25% of the whole group), out of a cohort of 5 sets. This means that not only were some students predicted a ‘miss’ on their pass grade exhibiting non-resilient characteristics and language, but some students from set 3 did not. In terms of whether my research finding adds or challenges the ‘just missing a pass’ selection method, my research shows that there definitely is merit in this selection method. Selecting students at ‘risk’ of just missing out on a pass is a plausible enough reason for making a selection but there is also a possibility that some of these students are resilient; there could be other reasons for this prediction. Conversely, there is a chance that students who do need support in developing their resilience are missed out.

This discussion is by no means an exhaustive coverage of research on mathematical resilience, but it gives a snapshot of existing thinking around this construct.

Reflections

Resilience has had a long history of academic and applied interest, initiated by early realist studies into 'vulnerable' populations which explored the finding that not all children deemed to be in 'difficult circumstances' succumbed to poor outcomes (e.g. Rutter et al., 1979). This was confirmed in my research in that my participant groups, who did not typically fit into any one of the particular groups I have cited, would have been 'missed out'.

A common theme that I noticed running through these sampled selection methods was the lack of the participants' subjective self-selection - my research aimed at adding the self-reference aspect to selecting participants for intervention. Having reviewed the literature on self-reference, I employed Q-Methodology to choose my participants. This finding provides some useful insights, particularly into how educators might be more sensitive to learners' needs across all backgrounds by taking the subjectivity approach. Pre-conceived 'classification' of students might result in students who need the support being missed or falling through the 'cracks'. As shown in the above discussion, there is some argument that can be levelled against various selection methods, but there can be no arguing with an individual's 'this is who I am'.

5.2.2 In what ways does Q-Methodology illuminate these affective dimensions?

This sub-section discusses findings relating to Q-Methodology as a more suitable subjective view eliciting method over other methods. I discuss three key discoveries.

Firstly, Q-Methodology enabled students to make focussed personal discriminations on aspects of resilience by placing more value on one statement over another within a prescribed frame. This allowed for deeper introspection.

Secondly, these discriminations revealed the innermost ‘like me or unlike me’ of the students’ view of self, hence exposing their ‘needs’ that led to identifying areas for developing mathematical resilience - which may not be achievable in a questionnaire.

Thirdly, by making students aware that they were in the programme because of how they described themselves and not what someone else thinks about them, students were more receptive to the programme. None of the participants withdrew from the programme even though they were made aware it was voluntary and were free to leave the programme at any time.

Based on these observations, I argue that Q-Methodology allowed me to gain an in-depth understanding of the participant’s subjective views more than I would have had if I had, for example, used questionnaires. I base this assertion on the argument that students were required to choose one statement over another, although they may initially deem some describe them equally accurately, to fit within a given ‘normal distribution type’ frame (Section 4.1). This choice uncovers that extra ‘depth’ to describe themselves. In a Likert-style questionnaire, students could have strongly agreed or strongly disagreed with any number of statements. In the provided frame they had to choose the two that <u>most described their view/stance</u> and the two that <u>least described their view/stance</u>, enabling them to make a judicious and considered choice of statements that most describe them. This would not be possible to achieve from a Likert style data collection tool. This is in line with assertions by Q-Methodologists (e.g. Brown, 1980; Coogan & Herrington, 2011) who stated that, in Q-Sorting, respondents sort statements on a topic into the order of how best the statements describe them, thereby uncovering the pertinence, to them, of one statement over the other and hence the subjective view of each participant.

It could be argued that I could have gained an equally in-depth understanding of the participants' subjective views through interviews. Still, one drawback of interviews I wanted to avoid was any inadvertent influence I might have by my close proximity, where students would feel the need to tell me what they think I need or want to hear. Q-Sorting's advantage is that there is little proximity between researcher and participants that is more prominent in interviews. One student pointed out that they felt free to 'express themselves' (Appendix 6), implying she was not subconsciously worrying about my immediate reaction to her responses, which is highly likely in interviews. This is in line with findings in studies such as Phellas et al. (2011) who state that interviews can introduce bias, from the respondents' wish to give 'socially desirable' responses. Therefore, I suggest that for the benefits I found to be gained from Q-Methodology, intervention researchers could utilise this method for eliciting students' viewpoints.

I argue that Q-Methodology and subjectivity offer a unique dimension in selecting intervention students and increasing their investedness in the intervention because they would feel they were part of the selection process. In using Q-Methodology, I allowed students to 'choose' themselves into the programme due to the responses they gave to the stimuli (they are saying 'this is who I am') and not because of someone else's pre-determined perception of them. Research has shown that people are more likely to participate or invest in an undertaking if they believe they had a say, a 'voice', in the decision process. This finding concurs with Christidou (2011), who asserts that students' voices seemed to be interrelated to and affected their success in school and career aspirations.

There is potential significance in my findings to the field of action or 'intervention' research. One of the biggest such significant contributions, I propose, is using Q-Methodology and subjectivity as a selection method. It offers a robust possible procedure or technique for

selecting intervention participants and would sit well within this field. In my research, the participants ‘chose’ themselves by making personal discriminations on aspects of resilience, resulting in a sample that I believe is as close as possible to the ‘ideal’ sample because students had the greatest and only ‘say’ in classifying themselves and therefore being part of the project. Furthermore, allowing the ‘student voice’ in the selection process adds an element of ownership as far as the participants are concerned. Established research (e.g. Christidou, 2011) has shown the perception of ‘ownership’ as a strong predictor for engagement and subsequently building resilience.

Another value I found in Q-Methodology was that in practice some participants in my study would often have been labelled as non-resilient or vulnerable, where such labels seemed to owe more to circumstances and adult perceptions than to young people’s own perceptions. My reason for using the Q-Methodology and its subjectivity feature as a selection method was the importance I placed on students’ views of their own mathematical learning and how these views impact their resilience. These views would even have more impact on their commitment to the programme, and on developing their mathematical resilience. I chose to use Q-Methodology because of the extra dimension it brought to participants’ selection, letting young people make personal discriminations on aspects of mathematics learning resilience. These personal discriminations made for more practicable and suitable selection. Heffernan (2017) deemed Q-Methodology as suitable for participants self-selection. In using this method, I was able to incorporate as many aspects of mathematics learning and resilience as possible while retaining an overall view of the construct of resilience. There is no escaping the fact that the process of inputting Q-Sort arrangements into the PQMethod software makes this selection method ‘labour-intensive’ maybe even more so than analysing interviews. For the sake of targeting the students best placed to benefit from intervention, it makes it

worthwhile. Based on the results from the subjective views revealed from Q-Sorting, I chose intervention strategies I deemed, as a 'suite of strategies' that would benefit all participants in one way or another.

The evidence of Q-Methodology's functionality as a subjective view eliciting tool and a tool to elicit extra levels of understanding students' views of self that emerged from this study indicates that non-resiliency is prevalent in students from all backgrounds and educators need to be sensitive to this.

Reflections

The significance of the inclusion of the student's voice in any educational endeavour is well established (see section 2.2.5.3). Q-Methodology is the instrument deemed one of the most unique procedures for eliciting students' voices (see sections 2.3.1, 3.5.1 and 4.1). As labour intensive as it is administratively, the benefits that educators can gain from utilising it are undeniable. To allow students to reflect on themselves and share with their significant adult to this depth can only benefit all concerned. This has been reflected throughout my research, in that with my participant group, I was able to discern what mattered the most to these students, in terms of their beliefs and their learning. Established research (e.g. Mkimbili & Ødegaard, 2019)) has reported that teaching and learning in the classroom should involve the learner's voice, suggesting that feeling heard was a strong predictor for engagement with intervention programmes and subsequently building resilience.

However, this does not make this procedure criticism-proof. There will always be room for improvement or alternate ways to look at any procedure, but the Q-Methodology procedure fits my study. Again, established research (Denscombe, 2010) has shown choosing a suitable method is a strong indicator for a study's validity.

5.2 Addressing RQ2

‘What educational intervention activities, as indicated by the subjective views and literature, might I devise to address negative subjective views and how might I implement the devised activities?’

In this section, I discuss my findings based on the students’ interaction with the different strategies I devised to address the students’ unhelpful views and how I implemented them, to facilitate mathematical resilience development. I initiated the intervention project by introducing the Zones of Learning model and the Hand Model of the Brain. I planned for these models to be the underpinning learning frameworks to the strategies I selected and devised. I discuss findings in terms of students’ interactions with these underpinning models before addressing the findings regarding RQ3.

Interaction with the strategies.

In this section, I discuss findings related to the interventions strategies I utilised in this study. Regarding the underpinning learning theories, I found that most of the students interacted positively with them.

Regarding the Zones of Learning model, for example, a participant reported that ‘I can improve my learning in the right zone’, and another said ‘It was more captivating and memorable’ about the model. Furthermore, another said, ‘If I’m in the red zone, I know to try and *work* harder to get out of there’. Another said I could ‘try harder and work my way to the amber zone’. These examples show that the students are now better placed to manage their reactions to challenges, to work more resiliently. When asked to rate how useful the model was, the resulting group mean was 5.08. Established research (e.g. Johnston-Wilder & Lee,

2010) has shown understanding the learning 'process' as a strong predictor for better management of the learning process and building resilience.

Regarding the Hand Model of Brain, I found that, similar to the ZoL model, a significant number of students responded positively to the model. For example, one student reported that it helped them in 'Managing how to do that piece of work', while another said I kept 'go*ing* back to the hand model', and 'I could use it to manage to improve my learning'. This is evidence of a good connection being established between managing reactions to challenges and the HMoB. When asked to rate how useful the model was, the group mean was 4.92. Established research (e.g. Siegel, 2010) has shown comprehension of the brain's workings as a strong predictor for building resilience.

Of the three intervention strategies I utilised, the MM, SP, and 6Bs to MR, I found that students interacted more positively when the strategy in use offered more scaffolding in terms of how they can move forward. The recurring comment on the MM and SP was that they did not offer ideas or ways to resolve the confusion. They had more positive interactions with the 6Bs and ranked it highest at the end of the study.

Secondly, interactions could have been improved if the link between the strategy and learning were made more explicit, and more regular reminders and reinforcement. A recurring comment, especially with the MM strategy was that participants did not see how this helped them with their learning, while others needed more reminding and reinforcement.

This study, therefore, provided some useful insights, particularly into how different learners interacted differently with some of the interventions. While some students interacted positively with the interventions and found some interventions useful, some did not interact well with some of the interventions selected. One student found all interventions to be of no

use to her but found the learning models useful. Some reported that they did not see how the interventions related to their learning. These reports provided some useful insights, particularly into how different learners seemed to find it difficult to notice the relationship between the interventions and mathematics to support them in becoming more resilient. Established research (e.g. Di Benedetto, 2015) has shown establishing links between an endeavour (innovation) and desired outcome was a strong predictor for engagement and subsequently building resilience. Establishing this link could be further improved in my practice.

The need for intervention that supports the students to become more resilient in any educational endeavour is well established (see Section 2.2). This study highlighted that not all students will react the same to a stimulus; incorporating a varied selection of stimuli benefitted every student in my study at some point or another. Across the study, every student reported that they found at least one of the selected interventions and models useful. Established research (e.g. Graham,1995) has shown appropriate intervention explicitly designed to address self-reported subjective views is a strong predictor for perceived benefit and subsequently building resilience. What has been lacking in intervention studies was a combination of intervention activities that would potentially address different subjective views.

5.3 Addressing RQ3

'What is the impact of these activities on students' personal management of reactions to challenges towards developing mathematical resilience?'

This section discusses the impact these interventions and models had on students' managing reactions to challenging work and their mathematical resilience. The evidence of this study's

impact that emerged from the ARCs and feedback data indicated that increased awareness of models and resilience-building strategies increased students' awareness of their ability to manage challenging learning situations.

5.3.1 Zones of Learning

When it came to the learning models, at the end of the study more participants communicated the 'usefulness of knowledge about the ZoL' than at the beginning. Secondly, some participants could identify what zone they were working in (Figure. 5.15b), i.e. whether they were in the 'growth zone', 'comfort zone' or 'out-of-depth zone'; a position that enabled them to adjust their reaction to challenging learning accordingly. For example, in the online platform feedback, MaU3 reported that she was coping well with her classwork, acknowledging that she does get some questions wrong (i.e. encountered challenges) but knows she is in the growth zone. This report demonstrated an ability to regulate their reactions to learning challenges, which would create a learning environment that facilitated productive learning. Thirdly, some participants reported that they now understand why they feel the way they do and can attribute it to the zone they were in instead of being 'dumb'. For example, MaEE3 remarked 'finally, I know I am not dumb, when I cannot do the work in class it means I am in the red zone. This participant reported that she has always thought she was dumb, but now she knows it has more to do with the zone she was in, to a lot of head nodding and 'that's what I was going to say' from the other participants. They explained that they could now realise that they were not dumb for not getting it the first time but were probably just in the 'red zone'. I was quite intrigued by one participant's use of 'my red zone'. When I asked her what she meant by 'my red zone', she explained that she felt frustrated when she did not 'get it' when other students did. This was a good indication to me

that this participant understood two things: i) that different people have different ‘red zones’, ii) not getting it the first time is not ‘being dumb’.

Previous to this, especially when I first started teaching in the UK, a common comment that students made when they did not ‘get it’ was ‘Oh, I am so dumb’. This observation indicated a significant personal ‘turning point’ in my experience as a practitioner that I can support students’ in managing their learning journey more successfully by exposing them to learning strategies that were not specifically ‘subject content’. Research (e.g. Chisholm, 2017) showed that addressing other aspects of learning, for example, a learning skill, was a strong predictor for engagement and subsequently building resilience.

I also found out that some participants pointed out that they had become able to control their anxiety and stress by referring to suggestions on the resource (Figure 3.11), anytime and anywhere. One participant (MaU1) reported that initially, they found the ‘breathe’ suggestion weird and they even thought it was pointless. Still, once they tried it they found it quite helpful in reducing their stress and anxiety levels. A body of studies has shown that breathing techniques are widely used to manage and reduce stress and anxiety (Benson, 2000; Wilkinson, Buboltz Jr. & Seemann 2001; Jerath 2015; Garden 2018); this was a good blend of a resource and a technique for my study. These studies advocate mindfulness for dealing with stress. I argue that if maths teachers can incorporate such techniques into their everyday lesson more students would be better equipped to deal with challenges in their learning journey.

In addition to that, some participants reported that they were better able to concentrate on their maths. The majority of participants reported that they found the ZoL model quite useful (they rated it 5.61 out of 10). They described that they found it helpful to have this tool at

hand and that knowing that they could quickly refer to it as and when they needed the 'support' was comforting. It was quite gratifying to see regular use of the model in lessons. They explained that understanding that there was something they can do when they get 'all frustrated and stressed' helped them concentrate more on working at their maths. Established research (Johnston-Wilder & Lee, 2010) has shown that students' awareness of GZM was a strong predictor for building resilience.

Besides participants reporting that they were better able to concentrate on their maths, they also reported that they benefitted from 'knowing' steps they could take to help them come out of a challenging situation. The most likely paths individuals take are the ones where individuals can see the steps out of the situation they are in. Sometimes the individual's problems are not that they are not trying hard enough, but it might be that they are seeing the challenge in an 'unhelpful' way. Bandura (1997) and Dweck (2006 & 2008) have shown self-beliefs (or subjective views of self) were strong predictors for building resilience.

These findings are indicative of participants taking steps towards developing coping mechanisms. Research (Johnston-Wilder & Lee, 2008; 2010, Nottingham, 2014; O'Connell, 2017) has highlighted the importance of students' awareness of support systems because they help students develop a learning 'management mechanism' in their mathematics learning journey. Therefore, the first step to students' awareness of and acknowledging the different feelings and experiences associated with their learning journey will be equipping them with strategies to manage these feelings and experiences. I argue this will make their learning journey an experience in which they will thrive more.

The workshops generated interest and planted the idea of 'not giving up' or 'keep trying'. These are phrases I heard being exchanged in the informal discussions students engaged in.

Students were encouraged to see that ‘avoiding’ or giving up does not produce new learning, but persistence and perseverance do. The theory of coping mechanisms is steeped in research (Vygotsky, 1896; Senninger, 2000; Johnston-Wilder & Lee, 2013; Lugalia, 2013; Seth, 2016; Chisholm, 2017). The ZoL model has allowed my participants to exhibit attributes of persistence and perseverance in learning and thrive, despite the difficulties and barriers. Comments such as ‘If I am in the red zone, I know to try ……to get out of there’ in Appendix 6 suggest that this participant could manage to move out of the red zone.

These findings concur with, for example, Senninger (2000)’s need for ‘creating a positive learning environment’. I argue this ‘positive learning environment’ has to include equipping students with coping mechanisms to avoid ‘avoiding’ challenging situations. Students need to be enabled to ‘successfully manage’ those feelings and experiences of challenge. I ensured that students were not encouraged to avoid any challenging work or situation but to manage the work or situation by persisting and persevering with the aid of strategies. In line with established research (Yeager & Dweck. 2014), my data shows evidence of frustration. In some participants, with the ZoL resource, participants were not expected to respond to these resources in exactly the same way. Indeed, while some reported that they found it useful, others did not.

The data I collected, therefore, indicated that by the end of the research project, more participants were significantly positively impacted by the strategy. I base this assertion on several findings. Firstly, when requested to rate, on a scale of 1 (not useful at all) to 10 (most useful), how useful the participants found the ZoL strategy, 82% of the participants rated it a 2 or more, which I deemed to be a significant reported impact. At the end of ARC3, 88% of the participants rated it a 2 or more.

Secondly, during the feedback session, participants reported that they could now recognise what zone they were at any particular point in the lesson. Some students (e.g. MaER subgroup in Section 4.2.2.4.2) reported that they did not 'freak out' as much as before when they started experiencing negative emotions invoked by encountering a question that they find difficult. They reported that they understood that it was normal to feel how they did. Other students also reported that they could recognise when they were not in the 'growth zone' (e.g. 'If I am in the red zone…' in Section 4.2.1.1.1). Johnston-Wilder and Lee (2010) have shown that students' awareness of the GZM was a strong predictor for building resilience.

In addition to that, during class visits, I observed the majority of participants using and referring to the ZoL model. There was more frequent use during the first couple of weeks of this strategy than the later part. This could be explained by the assumption that participants became quite familiar with the thinking process with more exposure to the tool and experience with the tool. Another assumption could be that the participants now had well established and embedded the ZoL model as a 'guiding' tool for dealing with challenges. This assumption is in line with Johnston-Wilder, and Lee (2010)'s finding that the right support helps foster resilient learning characteristics. Furthermore, on the online platform, a participant reported, 'I was in the growth zone' during my lesson. When we explored this comment further during the feedback sessions, this sentiment was echoed by about 75% of the group, a clear indication of the established link between learning and the ZoL model.

Along with feedback from the online platform, colleagues reported some improvement in participants' reactions when faced with challenges. Established research, (Williams & Portman, 2014), has shown that educators can observe behaviours assigned to any one of the affective factors.

Based on these reports, I can argue that future students would benefit from being made aware of the Zones of Learning model and being aware of each zone's feelings and thoughts. Acknowledging that such feelings and thoughts are part of learning and equipping themselves with strategies to manage their reactions to these emotions and thoughts is crucial. This will help with how long students persist and persevere with their learning. Established research (Johnston-Wilder & Lee, 2010) has shown awareness of the ZoL model as a strong predictor for engagement and building resilience.

These findings do not challenge what was already known; there is a lot of confirmatory evidence (for example, Senninger, 2000; Seth, 2016) of these findings. What this study does offer is a possible design of how this concept could be presented and implemented. It gives other teacher-researchers suggestions on how to use the ZoL concept. It is not a 'blueprint' of how to use it but offers ideas. Also, the idea of allowing participants to manage, indicate and communicate their feelings, thoughts and learning non-verbally is easily achievable and gives participants another alternative communication channel. Those students who are not great conversationalist can still have a 'voice', and the ZoL model (Figure 3.8) would be a good conversation starter.

What this research has added is another way of facilitating access to the participant's voice. The ZoL model is beginning to be used in schools where anxiety is prevalent and in coaching (for example, Garton & Johnston-Wilder, 2013) but not so widely used in secondary school intervention programmes or research on resilience. This study is adding to the evidence base.

The evidence of this concept's impact that emerged from the monitoring data indicated greater access to mathematical concepts, increased engagement, participation and interest in the learning of mathematics, and changes in attitude, motivation and confidence in some

participants (Appendix 6). Each of these aspects is a component of mathematical resilience. Established research (Kavanagh & Bower, 1985; Bandura, 1997; Amirali, 2010; Williams, 2014) has shown each of these components as strong predictors for building resilience.

Reflections

Most of the studies I sampled did not describe how the ZoL concept was introduced or even used with students, so I could not make a like for like comparison on that aspect. What I could compare was what impact each study claimed the construct had on students. My findings concur with a considerable number of aspects of the sampled studies. This leads me to conclude that introducing the 'Zones of Learning' model to both students and teachers is not only needed but essential if the next generation can help manage their learning better, ultimately positively impacting performance and success. Zones have also been used successfully for children with special needs, usually with more obviously emotionally unstable children (Greenberg et al., 1995).

I acknowledge that I could not guarantee a positive learning environment for all participants, as they were in different classes and had different teachers. This workshop and resource aimed to provide students with a 'safety net', their own individual 'positive' environment, where they could safely navigate the challenges they were bound to face in their learning. What I found was that it provided for a positive learning environment and participants could monitor their learning using this tool. Established research, Greenberg et al., (1995) has shown awareness of zones was a strong predictor for managing reactions to challenging situations. Here I have applied it to learning mathematics.

5.3.2 Hand Model of the Brain

Interest in how the brain works is increasingly having an impact on numerous research projects about, among other things, education and counselling (Burton, 2004; Day, 2008; Codrington, 2010; Schrag, 2013; Lorelle & Michel, 2017). Similar to the Zones of Learning model, my judgement on the impact of this model on students was based on empirical data collected through two main monitoring points. The data collection monitoring points included my researcher field notes and students' feedback.

I found that participants benefitted from knowing about the HMoB and throughout the research project, more participants realised its usefulness. The rating participants gave to the HMoB suggested that some of them derived use out of it throughout the project. They rated it 3.97 out of 10 for usefulness at the beginning and 4.91 out of 10 at the end. Also, 6% more participants found the model useful by the time the study concluded (77% at the start and 83% at the end). Based on this rating, and published literature, I suggest that the participants were likely to work more resiliently than they used to if they found a question difficult. The rating and the comments made by some of the participants during feedback sessions seemed to indicate the participants' understanding that sometimes their brain just needed help to 'not be flipped' or to unflip (e.g. I could '[g]o back to hand model' in Section 4.2.1.1.2). They reported that when they could recognise that their brain is flipped and that they were not learning during such episodes, returning the mind to 'closed fist' mode enabled them to return to and stay in the 'growth zone'.

Secondly, I found a participant displaying the 'I am frustrated' dejected body language (she was sitting slumped over, sighing), which is usually a reflection of the state of mind that could potentially result in negative outcomes for the participant. I had a brief discussion

about managing what she was thinking and how she was feeling by recapping on the Hand Model of the Brain and the Zones of Learning. At the end of the conversation, she appeared calmer and came up with suggestions for courses of action that resulted in finding the solution (Section 4.2.2.2.6). This was a clear indication of how impactful this discussion could be, but I had to contemplate how much time a teacher could have to give students this level of support.

This brief intervention brought to light, without helping students manage their reactions and emotions during learning, how much time could be wasted teaching students who are not learning. Established research (Ashcraft, 2002; Hembree, 1990) has shown that inability to manage reactions and emotions disrupts cognitive processes by compromising ongoing activity in the working memory.

The Hand Model of the Brain, a short but impactful visual illustration of how our brain is structured, has also been shown to explain how the integration between different parts of the *brain* works (Siegel, 2011). It can also be used to explain why a student is unable to do maths in the red zone. At the heart of this model is the student's metacognition; students need to understand their metacognition mechanics. As explained in Chapter 2, the key message Dr. Siegel conveyed when sharing this construct is that when students understand (through the hand model metaphor) what is going on in their brains when they are learning, they can modify their brains or what they are thinking. This is practising mindfulness and self-regulation. To some extent, my research seems to concur with this assertion; at the end of the project, 83% of my participant found it useful; they rated it 2 or more for usefulness.

So, I argue that teachers that embrace the insight of teaching the hand model to enable students to understand what could be going on in their brains gives their students a greater

chance of managing their learning and making progress. When teachers teach this reflection in the midst of already trusting teacher-student relationships, the potential to support resilience is enhanced. Based on this argument, I recommend that teachers introduce the Hand Model of the Brain to students at the earliest chance possible. Codrington (2010), in her research into interpersonal neurobiology and the adolescent brain, concluded that "A most interesting element is that through the interest families show in these concepts and the focal attention it brings to their interactions with each other, they begin to alter their brain structure and move towards integration through the science of mindfulness." (p. 299). This is more evidence of the benefits that can be gained from this construct.

In terms of subjectivity, I argue that the Hand Model of the Brain has a significant impact on students' personal views of themselves and hence their reactions to challenges. The model explains what the brain is doing during learning encounters, whether the brain is in the 'coping state' with the new information or not. If students do not understand that their lack of success is a state of the brain and not a description of themselves, and are not equipped with mind-calming mechanisms, they are highly likely to believe that 'not good enough' is who they are. They describe themselves by their negative reactions to new information when describing themselves by their achievements.

In terms of adding or challenging existing research, there is not a great deal of research that report the impact of this strategy on students. My research seemed to confirm, in the secondary maths context, what Dr Siegel declared, that learner awareness of brain function supports better management of own learning.

Regarding how awareness of the HMoB impacts students' mathematical resilience and based on the argument that participants can modify what is happening in their brain, I believe that

some of my participants are now more aware of what they can do to stay longer and safely in the growth zone. This, in turn, is indicative of the development of mathematical resilience. Based on at least 78% of the participants rating the HMoB more than 1 for usefulness, I conclude that a substantial number of my participants could now manage their learning better and that they were better placed to engage with challenging work more effectively; resulting in not giving up as easily as they used to. The other 22% might still be dealing with unhelpful thinking. Established research (Codrington, 2010; Siegel, 2011) has shown that young people would benefit from being introduced to the science of neurology and subsequently building resilience. I have shown the application to mathematics learning and teaching.

Reflections

On reflection, many positives can be drawn from the participants' feedback. Some of their feedback was indicative of moves towards developing some aspects of thinking that could support the development of mathematical resilience. Informal conversations during and after the implementation of interventions confirmed that some participants found it very useful to know how the brain works. For example, they rated it a mean score of 4.91 out of 10. Established research (Codrington, 2010; Siegel, 2011) has shown that young people would benefit from being introduced to the science of neurology and subsequently building resilience. I have extended this to mathematics.

As expected, some other participants were not so positive in their feedback. They commented that they did not see the point in thinking about the model. Festinger (1962)'s Cognitive Dissonance theory, based on three fundamental assumptions, purports that students like consistency (the familiar). Any inconsistencies (outside of their normal) observed will lead to

dissonance. He also points out that educators would have to accept that there will be cases where some students will be unwilling to change their way of doing things, at least initially.

5.3.3 Mindset Matters!!!

There is a growing body of studies showing that students' mindsets play a crucial role in their achievement (Dweck 2006). According to proponents of the mindset theory, holding a growth mindset is beneficial while holding a fixed mindset is detrimental to learning. Based on this argument, students' mindsets are, therefore, a potential for intervention.

Data collected from the participants showed some indication that some of these participants acknowledge the importance of maintaining a growth mindset (a mean rate of 5.7 was reported across the groups). I found that participants benefitted from utilizing this strategy, based on the mean ratings and the percentage of participants (6 out of 10 and 82% respectively) who reported that they found the strategy useful. In statistical terms, an 82 % 'uptake' is a good result. One study participant reported that this strategy '…makes me think I can do it if I try hard.'. This participant's report shows evidence of her persuasion of the brain's elasticity - 'I can do it.'. Another student reported that 'I find myself often giving up when things get too hard. I try to maintain a growth mindset but find with certain things I have a fixed mindset.', evidence that they can recognise the mindset they are in, a first step to 'naming it to tame it', as described by Siegel (2011).

Secondly, some participants considered this as another approach to their learning which could result in improved achievement. A Year 9 participant reported that the mindset strategy 'shows us ways we can improve and still do our learning.'. This seems to indicate that this participant found the strategy's utilization as expected, similar to Yeager et al. (2012) when they pointed out that parents and educators' salient task is to prepare students to respond

resiliently when they face adversity. I believe that some participants, like this Year 9 student, are now better equipped to handle challenges.

Furthermore, as a stand-alone strategy, it might not be sufficient to teach students about brain plasticity and mindsets; teachers need to delve a little deeper into this terrain by exploring practical steps for supporting resilient learning in the students. I do not doubt that mindsets play a crucial role in shaping the type of students that participants become, whether they will be resilient students or not, but I argue that students needed a 'next level' of support. My succeeding theme, the 'Split Page', was designed with that in mind. The subjective views expressed in the evaluation session alluded to this fact.

In terms of the mindset strategy and its impact on managing learning, this research crystallised many of what previous researchers found - students benefit from any new strategies they could employ to manage their emotions, reactions and subsequently their learning, better. Embracing the growth mindset can help. What I argue is that there is a need to go further with the support offered to students. This is important because transforming mindsets in and of itself is a good first step. In the maths context, participants need further guidance with practical steps for achieving success when they encounter challenging work. Established research (Tobias, 1994; Dweck, 2006 & 2008; Nottingham, 2015) has shown that transforming mindsets and providing clear guidance for tackling hurdles was a strong predictor for engagement and subsequently building resilience.

Regarding the impact on participants' mathematical resilience, as pointed out in Section 4.2, a substantial number of participants reported that they found this strategy useful. Based on the previous researchers' (Yeager & Dweck, 2014; Seligman, 2006) findings and my findings, I

can conclude that the participants who found it useful will work more resiliently in their mathematics learning. So, I deem this strategy, to some extent, as successful.

Reflections

Based on these findings, and in line with the literature, I recommend that schools place the students' mindset at the centre of all their improvement initiatives. Claro et al. (2016)'s research on the relationship between students' mindsets about their intelligence and their academic performance showed that, at every socioeconomic level, students who hold more of a growth mindset consistently outperformed those who did not. In other words, what they found is that for any two students with equal characteristics, the student endorsing a growth mindset is more likely to enjoy higher academic achievement, suggesting that the benefit of having a growth mindset holds widely.

I argue the same can be said about developing mathematical resilience, as I discovered in my research. Participants who reported to 'question' their mindset and adjusted it accordingly started working resiliently on their work (e.g. 'I can understand my mindset and I can improve when learning things that are difficult' in Appendix 6). Participants need mindsets that view challenges as something that they can take on and overcome over time with effort, new strategies, help from others, and patience. When teachers emphasize students' potential to change, I argue, they prepare their students to face life's challenges resiliently.

5.3.4 Split Page

Several researchers reported on studies that investigated the use of the split page method in various learning situations. As described in Chapter 3, the divided page version I chose to use was modelled after Sheila Tobias' version. What I found was that this method was effective for several reasons. Its primary value lay in its inherent structure that required students to

make active decisions about pinpointing the part of the question that they were struggling with (‘I was able to communicate specific areas of difficulty’, ‘Helped me to understand why I can’t answer the question’) and to think of ways to get past these sticking points (‘When the whole class contributes’ - peer support). This indicated that this strategy’s intended effect was achieved; participants could now identify sticking points in any challenging question and become more aware of their ‘support network’. Established research (Tobias, 1994) has shown scaffolded support using the split page to be a strong predictor for engagement and building resilience.

Secondly, feedback from participants seemed to indicate that, at a mean rating of 4.93, there is evidence that participants were more aware of the benefit of pinpointing the sticky issue. This was echoed by teacher feedback, where one of my colleagues reported that ‘Some students took very well to the strategy.’. This seemed to indicate that some of these participants were eager to try new ways of learning. Most participants competently identified the parts of the question they were struggling with but struggled with coming up with the ‘two’ things they could do before asking the teacher for help. Another colleague reported that ‘…they were not always sure what *do*…. I tried to prompt them with questioning…’, while another still said, ‘Most students initially needed some ideas about what else they could do before asking me…’. This same colleague went on to say, ‘About half of the students took very well to them *(stickers),* and it really focused them in terms of independence and resilience.’. Established research (Tobias, 1994) has shown the right support as a strong predictor for engagement and building resilience.

Furthermore, the feedback is evidence of some effectiveness of this strategy. I argue that it enabled some (80%) participants (Table 4.12) to be more sensitive to their level of involvement with the task at hand during the learning episode. Some students could ask

themselves questions and think about solutions to these questions before asking for help. This presented students with a way to prolong engagement, interest and motivation and establish a specific purpose for engaging with their earning. During the feedback process, some of the participants reported that their level and length of active involvement improved by asking themselves these questions. It helped them continue to focus on the learning process and content. Established research (Tobias, 1994) has shown directed guidance as a strong predictor for engagement and subsequently building resilience.

Similar conclusions could be drawn from the feedback that was reported by colleagues, especially the part that required them to identify the sticking points of any question they are struggling with. My preliminary data revealed that teachers considered this a useful strategy simply because of its practice-oriented approach, which enabled students to think deeper about their learning process. But what also emerged from discussions with colleagues was they picked on the opportunity this strategy afforded students to 'put their language to use', as one of the teachers put it. Another colleague reported that '[t]hey wanted to tell me verbally'. This feedback is evidence that the teachers found it useful for articulating and promoting a discussion of higher-order thinking skills. This finding was an unintended but important one. Drawing on wider research, Lewis and Smith (1993) point out that 'higher-order thinking occurs when an individual takes new information as well as information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations.'. This interpretation of higher-order thinking sits well with, in part, the aims of developing mathematical resilience. This strategy presented participants with a platform and environment to exercise every aspect of this definition (Lewis & Smith, 1993).

In terms of reception by the participants, the initial version (drawing a line down the page as used in the pilot study) yielded more positive feedback than negative. The majority of the positive feedback was on the usefulness of the strategy itself (for example, 'sp'), while most of the negative feedback was because participants felt their time was not effectively used (for example, 'It takes too long I could do extra maths questions in the time it takes to respond'). The students also reported that their pages were wasted (for example, 'It wastes pages…') or not their learning style (for example, 'I don't like it because it doesn't fit with my learning style.'). Considering that the objective for choosing this strategy was to support resilient learning, the positive feedback (Appendix 6) seems to evidence that resilient learning is developing in some students. Established research (Johnston-Wilder & Lee, 2008) has shown that increasing the articulation that pupils must undertake in mathematics is a strong predictor for engagement and subsequently building resilience.

However, when it came to the right-hand side of the 'split page', both the teachers and students reported that they found that part challenging for students because students could not always come up with ways to get out of the sticking part. They struggled to come up with what they could do to get over the part they were stuck on before asking for help. I drew from this that the participants could probably not yet get themselves out of the historical 'immediate help from the teacher' mode, even though they had participated in the workshop. Consequently, teachers reported that they needed to regularly give students suggestions about what they could do, which meant students still got some form of 'almost immediate' help from the teacher. 'Cutting the apron strings' seemed a lot harder than had been anticipated, but teachers must keep striving towards achieving it. Research (e.g. Chisholm, 2017) has shown expectations of immediate help from the teacher is a mechanism for resisting change.

Furthermore, teachers reported that the motivation for this strategy was not ‘sustainable’ long term. One of the reasons forwarded was that, with time, students felt writing sentences down was a waste of time when they could quickly ‘get help from the teacher’. This ‘waste of time’ was especially directed at the ‘what can I do’ part. They were happy to identify what they found challenging but preferred to go straight to asking the teacher for help rather than think of and try two (or any number of) things before asking the teacher. Research (e.g. Chisholm, 2017) has shown expectations of immediate help from the teacher as a mechanism for resisting change.

The teachers also remarked that students lost interest in writing sentences down, whatever the topic. Some even suggested that if there was a way for students to have some ready-in-hand suggestions, they might find the SP more useful. The teachers felt the ready-at-hand suggestions would mean that there would be no need for students to ask the teacher what they could try first, thereby lengthening student independent time. Although this was a valid observation and suggestion, it appears that the teachers missed one of the crucial elements of this strategy, that of using the right-hand side for students to communicate to themselves as well as to teachers what they had tried. This would then enable the teachers to respond more closely to what is needed. The issues raised here were addressed in the intervention that followed.

Regarding how my findings add or challenge what was already known, my study may not have added to or challenged most of what was already known about using the split page, but what it did was to crystallise what previous researchers had found. What my research did highlight was how this strategy had the added benefit of providing a platform for a discussion between teachers and students in terms of enabling teachers to encourage more independent

thinking and allowing students to ‘verbalise’ their struggles, for example, the teacher who reported that their students wanted to tell them ‘verbally’ (T4 feedback in Table 4.14a).

In terms of mathematical resilience, one statement from participant MaEE1 summed up my findings: when asked what they had learnt about how they could work resiliently in maths, she replied, ‘That you can still succeed because you can try multiple things/strategies.’. Another participant fed back that ‘I learnt to take time and think through what I know and don’t know and how to overcome it.’. Established research (Williams, 2014) has shown ‘thinking through’ as a strong predictor for engagement and building resilience.

The split page questions in this strategy facilitated an interactive heuristic approach to learning for students. It enabled students to begin developing a framework for prolonging their independent involvement with the learning process. The directed thinking process was one way to encourage learner independence and control in the learning process and provide a more successful experience engaging with their learning longer and safely. This concurred with Tobias (1993) when she said the divided-page strategy enabled the students to continue working on a problem even after they could have ‘given up’, meaning students develop resilience. I deem this to be good evidence that this strategy did promote some resilient learning among the participants.

As discussed in Chapter 4, students’ failure to come up with what to do to get past the sticking point inspired my next strategy, the 6Bs. Furthermore, high levels of teacher dependency emerged as a crucial stumbling block to the development of mathematical resilience. It became apparent that more guidance was required to produce readily available, student-friendly materials that helped support the development of mathematical resilience.

Established research (Nottingham, 2014) has scaffolded guidance as a strong predictor for engagement and subsequently building resilience.

Reflections

On reflection and taking all the data collected into consideration, I conclude and argue that the Split Page strategy yielded some success and can be deemed to have promoted some participants' resilient learning. Ratings in end-of-strategy feedback, comments and informal conversations during the observation period confirmed that the participants found the strategy useful. There is no escaping that some of the participants were not so positive about the experience when giving end-of-strategy feedback. One participant commented that they did not see the point in doing this as it wasted time; they wasted time thinking about what to do before asking the teacher when they could have just asked for help and completed more work that way. This could be indicative of resistance to new learning strategies (Chisholm, 2017).

5.3.5 6Bs to Mathematical Resilience

I introduced the 6Bs strategy in response to feedback from both colleagues and students' who expressed a need for more 'support' in terms of suggestions as to how to move beyond the obstacle - the 'stuck' point. Having observed that students struggled to think of what to do to get past the 'sticking point' and teachers having to suggest action points regularly, the 6Bs was a suitable solution. What I found was that this strategy was deemed quite useful by the participants. At Evaluation 3, the participants gave this strategy ratings of 6.08 to 10, with 92% giving it a rating of more than 1. Established research (Nottingham, 2014) has shown comprehensive support using the pit model as a strong predictor for prolonged engagement and building resilience.

Another finding from this strategy's use was that whilst the sticker seemed to suggest that the 6Bs stages were sequential in some instances, they were, in other instances, cyclic. For instance, during informal discussions during class visits, some participants reported that, on some occasions, they entered a cycle of stages within the 'pit' as they tried different approaches to the problem. While this would probably happen in any learning situation, the tangible reference to the 6Bs model made this experience more manageable (e.g. 'I knew that there were ways to get out *of the pit'* as reported in Appendix 6). This seems to imply that the participants would feel and think they had figured the question out only to realise they had not (when they do not get to the correct solution), so they had to go back and try again. These episodes indicate that the participants may have experienced some intermittent moments of 'perceived success' before another slump into being stuck.

An example of this is that a learner could go through breathe-brain-board-book, feel they had been successful but then when they checked the answers realise theirs was not the correct one, maybe go back to breathe-brain-board-book, either to check where they went wrong or try something different. Success at any point during this experience will generate resilience. This is in line with established theories, for example, Bandura (1977)'s self-efficacy theory.

What is key to note is that some of these participants were doing all this within a safe and supportive environment and were operating in the 'growth' zone safely. For example, one participant [MaA1] reported that 'I could use it for more questions I did not understand'. While these participants seemed to embrace the possible 'cyclic' nature of being in the pit, some still felt that it was a waste of time, they would rather just ask the teacher. Research (e.g. Chisholm, 2017) has shown expectations of immediate help from the teacher as a mechanism for resisting change.

Furthermore, another observation I made was that while this strategy provided ‘support’ in suggesting different approaches to succeeding, it also helped some participants organise their thinking and stay calm in the face of challenges. One participant (MaEE4) reported that the strategy helped them with ‘Understanding what could get me out of the stuck stage in the pit.’, suggesting that this participant may be able to avoid slipping into the ‘out-of-depth’ or ‘panic’ zone in future; the ‘being stuck in panic’ zone would have a negative impact on her learning. The implications are in line with the literature (Nottingham, 2004; O’Connell, 2017); this participant will engage with their learning for longer, possibly increasing her confidence/self-efficacy and ultimately resilience. Teachers (for example T5 in Figure 4.22b) also reported that they found this strategy the most useful. Established research (Nottingham, 2014; O’Connell, 2017) has shown that built-in support was a strong predictor for prolonged engagement with tasks at hand and subsequently building resilience.

In terms of adding or challenging what was already known, my study’s findings crystallised a lot of the previous findings.

Regarding the impact on mathematical resilience, which in this study refers to working in the ‘growth zone for as long and as safely as possible with the appropriate support and coping strategies’ (as proposed by Johnston-Wilder & Lee, 2010), the 6Bs strategy is a strategy that could enable students to work more resiliently in the growth zone. Participants reported that they did not ‘freak out’ as quickly and frequently as they used to. They could calm themselves down (by taking long breaths) before they had another attempt at the task, by trying other techniques.

Reflections

Based on these findings, I deemed the resilience pit as the most impactful of the three strategies. When asked to rank all three strategies, the resilience pit was ranked first by the highest percentage of participants (68%). This could be explained by the level of support in terms of 'clear steps to take' when faced with a challenging maths task (e.g., this sticker (strategy) will help me organise my thinking, miss) or the cumulative nature of the strategies. Established research (Nottingham, 2014) has shown that clear support strategies were a strong predictor for prolonged engagement and building resilience.

5.4 Gender-related findings

From the data discussed in section 4.5, I can infer that my research demonstrated a substantial propensity for girls to cope well with challenges when presented with the right support. Because I did not have male participants in my study, I cannot make a comparison between male and female students regarding their coping mechanisms and management of reactions to challenges.

Literature has suggested that single-sex education did not improve outcomes for narrowing the gap between boys and girls. Doris, O'Neil and Sweetman (2013) report that the gender differential is larger in children educated in single-sex schools than coeducational schools. That being the case, more input is crucial in single-sex schools, like my study school. While this might be the case, some of the grounds given for these disparities (Stereotype - Eccles, 1994; gender-based learning styles - Boaler, 1997; personal viewpoint - Oswald & Harvey, 2003) can be addressed within the single-sex education environment. When it comes to stereotyping, I can assume that my study group being, the effect of stereotype would have been minimal. I make this assumption because there were no males in the school that could

have ‘presented’ the pressure Eccles reported on. Modifying perceptions of self and others seems to be a logical first step. Psychological factors have been shown to have impact on regulating one’s learning. Furthermore, designing interventions that are particularly suitable to individual needs becomes imperative.

This study made some inroads into addressing personal viewpoints and utilised interventions that were designed to address students’ specific needs. When these interventions are incorporated within the learning process, pedagogical factors could be mitigated.

5.5 Chapter Summary

Of all the strategies I used in my research, based on the evaluative data collected at several monitoring points, the 6Bs strategy seemed to have had the most impact on students. At the end of each cycle, we had evaluation sessions where participants rated each strategy’s usefulness. At the end of cycle evaluation sessions, the participants gave the Mindset Matters!!! strategy a mean score of 5.86, the Spilt page a mean score of 4.8 and 6Bs was rated at a mean score of 6.08. During the end of the project evaluation session and 68% of the participants ranked the 6Bs strategy the highest when asked to rank all strategies against each other in terms of how useful they found it (see Figure 4.27).

These results might be accounted for by the timescale between using the strategy and collecting this data. The 6Bs strategy was the last strategy the participants used and would probably be the freshest in their minds. However, to check if that was the case, I also compared the data collected at the same point for each strategy. This data confirmed that the participants did find this strategy more useful and, therefore, more impactful. Therefore, based on this comparison, I deemed the 6Bs to have been the most impactful at promoting resilience among participants. These results and conclusion do not negate the reality that my

data showed that different strategies had different effects on different subgroups. It highlights that students find more benefit when there are clear steps on explaining what to do when they encounter a challenge (Tobias, 1987; Nottingham, 2014).

The issues of resilience are germane to the whole educational debate and are not confined to mathematics. Hence there is a need to discuss these issues with fellow professionals and others with an interest. More specifically, and despite changes over the years, I agree that researchers and educators are still 'far from achieving a consensus about approaches to teaching within the mathematics education community itself' (Wigley, 1992). When feeding back on one of the strategies, a colleague at my school wrote 'Firstly, can I say I applaud any work towards enabling pupils to develop metacognition. Pupils playing an active role in their learning rather than just having learning "done to them" is vital.', indicating that the need for a shift in both learning and teaching pedagogies is recognised. However, any pedagogical innovations need to be underpinned by an implementation. This implementation is not always going to be easy. With a constant focus on 'target grade' progression and time limitations, it is easy to see how different teaching models have developed. A student reported that there was a lack of reinforcement from their teacher. She reported that she sometimes felt she would work really hard, and the teacher did not acknowledge or notice it. Perhaps teachers have a more prominent role to play in reinforcing new strategies.

I also acknowledge that the ideas I have presented in this study are challenging to implement in the classroom, but on the basis that they have been shown (through literature and through my study) to enable students to manage better their reactions to learning challenges, they have a place in the pedagogy 'toolbox'. Using a 'suite' of strategies was insightful. Every participant reported that they benefitted from at least one of the strategies. Established research (Williams, 2014) has shown using different strategies as a strong predictor for

building resilience. Using different strategies in my study highlighted that addressing any form of unhelpful self-belief is usually underpinned by qualities of self-doubt and apprehension and quite often reactions out of proportion to the perceived 'threat' (Hembree, 1990) is important. One participant reported that they now know being stuck is normal and another said she no longer 'freak out' as much as she used to because she could find ways that can help a lot and now knew of many helpings [steps] to get out of the pit.

Although this was not an expected result, one participant suggested that learning would be 'fun' if whole year group activities were organised and students had a chance to work with fellow students from other sets. Some of the participants still felt that maths lessons were not 'fun', which affirms Boaler's work. What was worth noting was that some students tapped into the mindset needed for their lesson, and one participant reported that she probably would 'have given up', but instead she reminded herself that she needed to 'keep trying' because if she gave up, she would not learn anything, indicative of the emergent of resilient learning tendencies.

In this chapter, I have presented the findings of my research in terms of using students' subjective views as an intervention selection tool, and the impact of the intervention tools used by the whole group as well as by participant in light of established literature. In greater detail, I also addressed RQ4, ''What are the implications of these findings for practice and policy? In the next chapter, I conclude my research by reviewing my research plans, explaining how I addressed the research questions and what I learnt during this study.

Chapter 6 – Conclusion

Introduction

In Chapter 5, I presented the findings of my research and discussed them regarding the existing literature. In Chapter 6, I conclude the thesis as described below.

In Section 6.1, I summarise the thesis, while in Section 6.2, I discuss how my research addressed the overarching research question. In Section 6.3, I discuss how this study addressed the research questions as defined in Chapter 1. In Section 6.4, I discuss the study's strengths and in Section 6.5, I discuss my contribution to literature. In Section 6.6, I report on the limitations of the study. In Section 6.7, I address challenges I faced and what I could have done differently. Section 6.8 discusses the credibility and transferability of this study, and Section 6.9 presents recommendations for different stakeholders. Finally, in Section 6.10, I report on the personal significance of the study.

6.1 Summary of the thesis

In Chapter 1, I outlined what I was going to cover in my research. This section of Chapter 6 narrates what I did.

This study's focus was to explore novel systems of enhancing students' resilience that educators can utilise to address the well-established concern of students' inability to regulate themselves when studying mathematics. The inability to regulate themselves has been shown to indicate non-resilience and therefore ineffective learning. Established research has highlighted that this inability to self-regulate stems, among other affective factors, from how students perceive their abilities. To address the entrenched unhelpful views that students had of self, my study sought to find out what these subjective views were and then propose,

devise, and use intervention strategies I deemed suitable for addressing these unhelpful views, based on my reading of literature.

To elicit these views, I researched studies that reported different methods of drawing out subjective views. This is discussed in greater detail in Chapter 2. I determined that Q-Methodology met the requirements of what I wanted to achieve; it suited my study's aims.

Finding: A key finding from this endeavour was that Q-Methodology enabled a deeper understanding of what mattered most to students regarding their learning. It gave students the profound 'voice' that could be missed by, for example, a questionnaire or an interview.

Summary: The more in-depth understanding of what mattered most to students regarding their learning and reading the literature enabled me to earmark intervention strategies I deemed suitable for my research. In undertaking this endeavour, I was also able to deepen my understanding of which strategy would potentially benefit students that ended up in my study.

Through a literature review, I also determined that the Action Research Framework was the most suitable for achieving my research aims, primarily because, as a teacher:

i) improving the self-regulation and resilience outcomes of students that self-identified as needing support was critical,
ii) being more effective in my teaching would support my students' development.

Once I had established my research design, I administered the Q-Sorting activity. This enabled me to gain significant insight into the students' perception of self, which has been well established as a pivotal self-regulation factor. Perception of self determines the level of engagement with learning and, ultimately, resilience. The subjective views that emerged from this exercise highlighted that:

i) non-resilient beliefs and tendencies exist in students from ALL attainment backgrounds and therefore,

ii) educators should be more sensitive and responsive to the subjective views of ALL students when planning educational interventions programmes;

iii) although there are many methods available for eliciting students' subjective views, each method's suitability and illumination should be carefully considered.

Based on the Q-Sorting activity findings, further literature research gave me strong indications on the strategies I could use to address my research questions. These are detailed in Chapter 3. I planned for a series of workshops, and review/evaluation sessions to run throughout the study within a framework of action research cycles. In the first workshop, I introduced the project to the students as well as the learning models that I utilised. I concluded the workshop by introducing ARC1 and discussing the role that mindset (Mindset Matters!!!) plays in successfully managing learning. I used the feedback from Evaluation 1 of this cycle to modify the second proposed intervention (Split Page). Feedback from Evaluation 2 on the Split Page was used to refine my third intervention strategy, 6Bs.

Finding: A key finding in this process was that students interacted positively (to varying degrees) with the strategies used in this study. They were more positive with a strategy if given more scaffolding/support. They appeared reluctant to 'think for themselves' and ranked the 6Bs (for example) as the most useful. Although there were more positive than negative reactions to the strategies, there was an undertone of students who did not seem to have established a link between the learning strategies and how the strategies would help them 'learn my maths' in class. These particular students seemed to be expecting to be 'told' how to work out the answer rather than understanding the process of learning.

As discussed in Chapter 5, every student reported that they found at least one of the strategies or models useful despite these misgivings. I would argue that some success was experienced, albeit to varying degrees, and that there are areas of this study that could be improved. These are discussed later in the chapter.

At the end of the third action research cycle, I carried out an 'end of the research' evaluation session (Evaluation 3) to collect data for evaluating the whole project.

6.2 Summary of Findings (addressing overarching question)

This section reports the summary of main key findings from each intervention tool towards addressing the overarching question:

'How can understanding and amending the students' subjective judgements of self be utilised to support the development of mathematical resilience in students?'

Understanding: To understand the subjective views of the students I used a selection method that had not been previously used in intervention studies (contribution). Using this selection method enabled me to show that there is no single homogeneous population that is susceptible to non-resilience. Criteria such as repeated failure, target grades, lack of access to a manipulable etc., do not always imply that an individual will be non-resilient.

Although these affective factors could explain non-resilience, my findings showed that more thought needs to be put into selecting intervention participants, especially for a construct based on or influenced by personal feelings, tastes, or opinions; such as mathematical resilience. This is, I argue, because mathematical resilience is heavily steeped in the subjective perceptions held by participants. Each participant's voice is crucial, and educators need to be sensitive to these subjective judgements as they play a bigger role than credited in

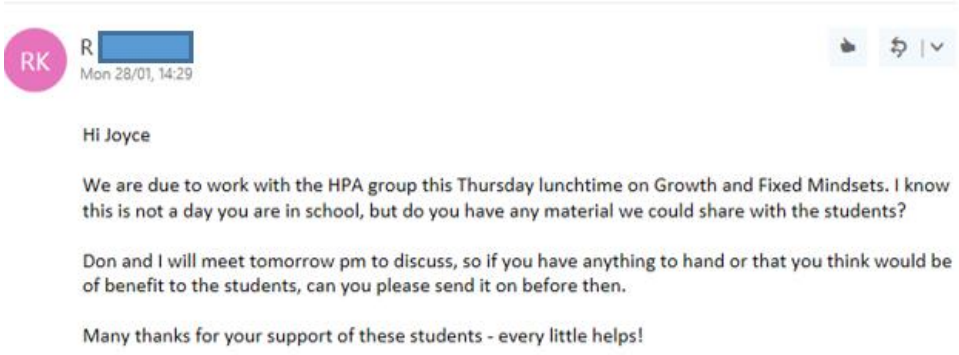
identifying and overcoming personal learning barriers (e.g. Lincoln, 1995; Graham, 1995; Mitra, 2001; Silva, 2001; Yonezawa & Jones, 2007; Christidou, 2011; Mkimbili & Ødegaard, 2019). I, therefore, demonstrated that understanding students' subjective views were vital.

Amending: Understanding the students' subjective judgements of self also enabled the selection of potentially suitable interventions. For students who reported that, for example, 'Personally, I am not good at maths', a strategy that would enable them to amend this thinking was what I researched for. It was during this research that the learning model emerged as good starting points.

The two underpinning learning models running through all three research cycles were the Zones of Learning model and the Hand Model of the Brain. Although these learning models were incidental to students' subjective views, I deemed they played a crucial role in 'managing reactions' to learning. Therefore, as indicated by the ratings of these models' usefulness in managing learning, I judged that these two underpinning learning models helped the students better manage their response behaviour to learning challenges. An example is that of one participant who posted the 'I was in the growth zone' comment on the online communication platform (Figure 4.16).

Furthermore, as demonstrated in Chapter 4, when participants were asked to rate how useful they found the knowledge of Zones of Learning and Hand Model of the Brain, they rated them high mean scores of 5.61 and 4.91 respectively on a scale from 1 to 10. Additionally, the Head of Department at my school acknowledged the importance and impact of students' awareness of the Zones of Learning model and the Hand Model of the Brain - especially the mindsets associated with these models. She requested that I hold workshops with a target group of students she had identified for an intervention programme group in 2019 (Figure

6.1). Her selection method for this group of intervention students and the account of impact is outside of this study's remit.


RK
R [redacted]
Mon 28/01, 14:29

Hi Joyce

We are due to work with the HPA group this Thursday lunchtime on Growth and Fixed Mindsets. I know this is not a day you are in school, but do you have any material we could share with the students?

Don and I will meet tomorrow pm to discuss, so if you have anything to hand or that you think would be of benefit to the students, can you please send it on before then.

Many thanks for your support of these students - every little helps!

Figure 6.1: Invitation from HOD

In terms of supporting mathematical resilience, and based on students' reported impact of the strategies on their day-to-day learning, I argue that when students had been made aware of tools to manage their reactions and responses to challenging learning situations, they work more resiliently than when they have no coping mechanisms in place. This is in line with established research such as Yeager and Dweck (2014). I demonstrated that subjective views could be amended if students and teachers are made aware of available tools.

As well as identifying the learning models, my better understanding of the students' subjective views enabled me to select and design potential strategies students could use to cope with and manage challenging learning situations. In the next paragraphs, I describe how I used my understanding of these subjective to select strategies that I deemed would address the unhelpful views.

The 'Mindset Matters!!!' strategy was the first of such strategies. This intervention strategy was introduced in the final section of the introductory workshop. Students were encouraged to use the 'Mindset Matters!!!' strategy in their lessons and record their interactions with this strategy.

In terms of usefulness in managing learning, I found that, for some of these students, just being reminded to consider their mindset, what zone of learning and what was happening in their brain, had an almost immediate calming effect. This reminder opened the way to exploring different thoughts associated with a growth mindset that enabled moving forward, including taking a few long deep breaths and then having a refocus on positive thinking to approaching the challenge. I regularly reminded students that if they think they have no strategy to re-approach the work, they may never find one, but if they can think and talk themselves into feeling comfortable and secure, they may let in a good idea. The typical response of 'Oh yeah!' and the 'I should have known that is what it was' smile often followed, and sometimes the comment 'I thought that too' were voiced.

Furthermore, in terms of mathematical resilience, as the use of this strategy progressed, I noticed that students could adjust their thinking without a lot of input from me. This seemed to be indicative that they could spend longer periods trying to figure out the challenging task and not stopping without trying or asking for help immediately after encountering a challenging task. Interestingly, some students appeared to be talking to themselves, indicating that they were willing to keep trying before asking for help.

Perhaps the most significant focus of this mindset matters strategy was helping the students dispel the notion of being 'dumb', something I witnessed since my early years of teaching in the UK. This was a common phrase that students threw about without any shame or loss of face. Coming from a country where being viewed as or admitting to being dumb at maths was dishonourable. It was encouraging to see evidence that seemed to suggest progress in transforming such mindsets held by participants.

In my intervention group, I had students who reported that they did not know how to bounce back when stuck; the second strategy, the Split Page strategy was introduced to support such students. Students were aware that it was not helpful to say ‘this question is hard’ or ‘I am confused’ but that it would be quite useful to say ‘what exactly is making this question hard’ or ‘what is confusing me about this question …’.

In terms of thinking about a specific aspect of the question causing them problems, Figure 4.23a and Figure 4.23b show an example. It is indicative of developing constructive self-talk and positive refocusing of thoughts. This student, for example, was beginning to understand how and why she struggles with a particular question instead of jumping to negative conclusions about her ability. She was learning to sort out the factual stumbling blocks she encounters from her aptitude. This discernment would enable her to recognize the thoughts, behaviours and mistakes she makes *only* because she is failing to deal with frustration and anxiety.

It is worth noting that the students were being encouraged to transfer the ‘blame’ from themselves, i.e. their ability, to the question, i.e. identifying the part of the question that makes answering the question difficult. But the significant breakthrough that I observed was at that point of realisation, when it became clear to the students that they seemed not to have really understood what was being asked in the question, that the students changed their view. This could have been the result of them giving themselves the chance to understand the question or give ‘due diligence’ during their interaction with the question. It was only after they started an exploration into the different aspects of the question to identify what it was that was making the question difficult that they realised that they did not understand the question in the first place. This is another example of the impact of my intervention. Furthermore, this finding demonstrated that when students allowed themselves to shift focus

from themselves to the question, they calmly processed information. Understanding of maths was gained especially when they realised that they knew more than they gave credit to themselves (e.g. ‘I know what I am stuck on most of the time and use a buddy or think better’, Appendix 6).

In addition, understanding and addressing the students’ subjective views enabled the development of mathematical resilience tendencies because that particular moment in time or stage in the process of identifying the ‘stumbling block’ in the question enabled the students to interact with the question a lot longer than they would have otherwise. Any ‘small’ successes experienced in this process would support the development of some resilience.

The final of the three strategies, the 6Bs, aimed at supporting students further increase their levels and lengths of resilient engagement and to experience some independent and successful working at mathematics.

Before being part of this research project, I observed that some of the students would have typically stopped at the ‘stuck’ stage at the bottom of the pit. The 6Bs strategy enabled some students to persevere and persist more with more confidence in the safe knowledge that there are other things they could try. They reported that they did not experience the ‘panic’ or anxiety that usually accompanied being ‘stuck’, as evidenced by comments like ‘it helps organise my thinking’ made by one of the participants (Ma… in section 4.2). During class visits, this participant echoed this feeling, reporting that she does not stress about being stuck any more. Panic can, for some students, be quite crippling. An example of a participants’ work using the 6Bs can be found in Figure 4.26. I have demonstrated that clear and visible ‘steps’ to solving a problem enable elongated interaction with tasks at hand and therefore more resilient learning.

Development of MR: Associations between resilience and the inclination to explore unfamiliar challenging problems in maths have long been established (e.g. Yeager et al., 2014). What is still developing in this field are programmes and strategies that can be used to support the development of resilient working in mathematics classrooms across the country (Maloney et al., 2010). I needed to answer how I could incorporate students' subjective views to support the devising of mathematical resilience-building conditions into my lessons to enhance students' better management of reactions to challenging learning situations and ultimately better mathematics performance. In this study, I explored different ways in which educational intervention tools can be devised based on students' subjective views and how they can be used to support mathematical resilience development.

To sum up: Through reflection on this action research study, I reached the following conclusions. Firstly, when selecting participants, great care has to be considered, especially when considering the selection criteria because what educators may think or see may not always be what the participants are experiencing. Secondly, my research crystallised that intervention researchers and teachers might need to become more sensitive to students' subjective judgement of self and allow students' voices to take precedence over any preconceived criteria that teachers might have. Thirdly, students seem to favour strategies that have clear guidance to allow them to work as independently as possible. Also, students vary as to which interventions are most helpful to them, depending on their subjective judgement of self.

Furthermore, the findings from this study point to several emerging patterns. One, in the context of developing mathematical resilience, there is insufficient 'student voice' in the selection of intervention candidates and insufficient understanding of what drives or discourages students (at a personal level) to learn. Two, in the context of developing self-

regulation mechanisms in students, students need to be exposed to activities that enable awareness, acknowledgement and ownership of feelings and thoughts associated with learning and be equipped with how to manage them. Three, in some cases, although there is a conflict between embracing change and sticking with the status quo among students, exposure will have some degree of impact. When educators desire to adopt and utilise strategies that facilitate students' resilience, the students concerned may display reluctance in adopting these new strategies. This can be partially disguised by 'I don't understand how to use this strategy' and a preference to resorting to getting help from teachers immediately: students wanting to be 'spoon-fed' versus teacher wanting resiliently working and largely independent students. Four, there are important aspects of material development in resource selection that need to be considered, e.g. making the resources as user friendly and as easily understandable as possible.

The stance of addressing unhelpful subjective views that I have taken in this study is corroborated by literature (e.g. Harackiewicz & Priniski, 2018) which says intervention strategies will be ineffective if they do not attempt to locate, understand and utilise the nature and strength of subjectivity. Very few researchers consult the students or listen to their concerns before effectively placing a label on them. But, through the Q-Method aspect of my research, indications were that using students' subjectivity as a selection criterion was, in every respect, appropriate.

6.3 How my research addressed the research questions

The overarching aim of this study was to explore the incorporation of students' subjective judgement of self into devising education intervention tools that support the development of mathematical resilience in students. To achieve the aim, I reviewed various tools used for

eliciting student subjective views and chose Q-Methodology's Q-Sorting to elicit these views (RQ1). As suggested by the subjective views that emerged from the Q-Sorting activity and literature reviewed during the research, I explored various intervention strategies. I selected three 'intervention strategies' (RQ2) that I deemed best addressed the participants' 'negative' subjective views. I evaluated their impact on managing reactions to challenging learning situations and developing mathematical resilience (RQ3) through participant feedback, colleague feedback and field notes. The findings of this study enabled me to modify my teaching and policy implications (RQ4).

6.3.1 RQ1: Girls' subjective views of their mathematics learning and how 'new' Q-Methodology illuminates these affective dimensions.

6.3.1.1 Views elicited

Using Q-Methodology I was able to elicit every student's views in the cohort about their mathematics learning journey (Table 4.1). Through the PQMethod analysis software, I selected students whose Q-Sort flagged them up as consistent with what a learner susceptible to non-resilient tendencies would think of their learning journey.

The results from analysing the students' Q-Sorts produced five distinct factors (views) as shown in Table 4.1. What the Q-Sorting analysis showed was: a) how diverse and varied views held by students about their learning journey can be while highlighting salient shared views, b) non-resilient views are prevalent across all ability backgrounds and c) interventions can be more specialised and individualised according to how students' subjective (subjectivity) views of themselves have been presented.

6.3.1.2 How 'new' Q-Methodology illuminates these affective dimensions.

Q-Methodology was invaluable in illuminating the diverse views while exposing the salient shared ones. The defining statements and defining sort highlighted the shared elements within a subgroup while the individual Q-Sorts revealed the diversity in standpoints. This enabled the uniqueness of the selection process for the reasons outlined in Chapter 3 and 4. Including participants' subjectivity in intervention candidate selection was crucial. The Q-Sorting arrangement offered some holism that questionnaires cannot offer in a time frame that interviews cannot offer. When interpreting the Q-Sort, I took the view that the distinguishing statements were intimately interconnected and explicable only by reference to the whole. The Q-Sort 'presentation' allowed me to gain a deeper understanding of the individuality of the participants. The distinguishing statements' positioning revealed in-depth salient views (when compared to the other statements around them). This in-depth inspection would not be possible with, say, a questionnaire or even an interview.

Although I used the same selection method in both my pilot and main study and did not do anything different between the cohorts, it was interesting to note that a larger proportion of Year 9s identified as potentially being non-resilient compared to Year 11 (section 3.8). A possible hypothesis I can offer here is that maybe the longer a student is within, in this case, the 'secondary education system', the more resilient they become. Year 9 were at the beginning of their KS4 course, while Year 11 were near the end of their KS4 course. This hypothesis raises the potential question of what impact an early introduction of resilience-building strategies could have on the number of students who still hold 'non-resilient' views by the time they get to Year 11. It appears that students may develop resilience as they progress in the school system, but I believe educators could help them along the way by accelerating the process. To substantiate this 'early introduction' hypothesis, a Q-Sorting

activity with Year 7s could shed some light on that, especially if the same cohort is tracked over the five years. This could be a direction for future research.

6.3.2 RQ2: Intervention Strategies used and how they were implemented

Inspiration for the intervention strategies was multi-fold. I selected the Zones of Learning model and Hand Model of the Brain as my underpinning frameworks for this intervention project primarily because of their inherent characteristics of allowing individual students to understand actions, feelings and emotions associated with learning. Literature (e.g. Johnston-Wilder & Lee, 2010) considers this understanding a crucial aspect of learning that is not part of the mathematics school curriculum but equally important. More importantly, being able to manage these feelings, emotions and actions effectively is critical. I used these models because I deemed them to make a good foundation for the other interventions. I argue that once students understand why they are feeling or reacting the way they are, they can better adjust their action for meaningful learning. If students understand what is going on in their brain, they will also be able to adjust their frame of mind and subsequently their actions or reactions and management of these.

Once I had decided, based on subjective views and literature, that these models were suitable for what I was hoping to achieve, I considered what the Q-Methodology activity described in Chapter 4 revealed about participants' subjective opinions about their learning. I selected the Mindset Matters!!!, Split Page and 6Bs to Mathematical Resilience to address the views that had emerged. I discussed these strategies at great length in Chapters 2 and 3, including the adaptations I made to the literature versions to address feedback from students and therefore make them suitable for my study. I explained how I used them during the research project in Chapters 3 and 4. The findings from the ARCs are summarised in the next section.

6.3.3 RQ3: Impact of intervention tools on MR

The data on the reported impact of the interventions on mathematical resilience was collected at different points during the study (Evaluation 1, 2 and 3). The data collected showed mixed results. Some participants reported that they found all the interventions really useful, while others reported that they did not find much use in some of the selected strategies. This disparity can be accounted for by either learning styles, learning preferences, previous experiences or subjective judgements of meeting the need at hand (as described in Chapters 4 and 5). The rating exercise revealed significant acknowledgement of the usefulness of the strategies in day-to-day learning. These results revealed the strategies impacted 100% of students, to varying degrees, indicating they could work more resiliently in lessons. More importantly, this study highlighted that when what students believe about themselves is given due importance, they could have a greater propensity to apply themselves to their work. Different strategies produced the desired effects on students according to their feedback.

6.3.4 RQ4: Implication of research findings on practice and policy

I drew several lessons from this study. Firstly, students' voices will play a major role in future intervention endeavours I design and administer including when selecting intervention students. I came to this conclusion because when students in my study came to understand that the interventions were individualised to their input, the intervention was better received. The intervention strategies were better placed to address their pressing concerns and ultimately gained greater traction. This was more apparent when the students' themselves were explicitly made aware that being selected was purely based on their input into the selection criteria, and the strategies were selected to address their opinions specifically.

Secondly, stereotyping lower attaining students might not be the 'fairest' way of selecting intervention candidates. The fact that the group I ended up working with was mixed attainment, for example, provided an opportunity to find inadequacies in stereotyping students. Students from the low achievement class at the time would not feel 'I am in this group because I am dumb'. After all, the intervention group included high attaining students.

Thirdly, I will make students aware of the learning theories used in this research at the earliest opportunity. I believe the awareness helped students to be more resilient.

6.4 The strengths of the study

The strategies used in this study gave all the participants a method of reviewing their learning in any given lesson; most participants did this enthusiastically (good ratings) and with significant thought. Comments such as, 'I was in the growth zone' and 'I am not dumb, I might be in the red zone ….' revealed that some of the students had engaged with the intervention and they could apply it to their day-to-day learning. The ZoL and HMoB were useful tools for reflection for students, but they enabled me, as a teacher, to obtain candid feedback from participants to better support them manage how they react to challenges.

The students and I benefitted from the discussions relating to the learning frameworks. Students showed a better understanding of the emotions they experienced in any lesson and could use this to engage appropriate support, including calming down techniques such as trying a different view/thinking approach. I was able to direct them to relevant support when needed. This study also revealed that acknowledgement of students' 'voices' was appreciated by students. One student commented that teachers did not look at their 'work' and therefore felt it was pointless to engage with the activities. Also, 'quieter' participants found it easier to

communicate with the teacher and other students; one reported that 'I compared [my work] with others.' rather than asking the teacher.

Some participants reported that their duration of engagement in collaborative work significantly increased, particularly the type encouraged through the 6Bs. They were, for example, prompted to ask a 'buddy' before asking the teacher. This was a marked improvement compared to what I had previously experienced with some students in this particular group.

Only one participant in the research claimed that they did not find any of the three strategies (MM, SP and 6Bs) useful. In line with Dweck's (2000) mindset theory, this student (according to her Q-Sort) held a view that was akin to a fixed mindset, implying there was an expectation of significant resistance to new ways of learning and ideas. What was quite fascinating was that this student claimed that she had 'completely changed her viewpoint' by rating the most agreed and most disagreed a 10 (I feel the complete opposite of how I initially felt) and rated the ZoL and HMoB quite highly. This rating suggests that while it might seem as if the strategy used has not 'worked', the learning models might perhaps have helped. This finding is similar to the 'Split Screen' teaching method used by Chisholm (2017). Consistent and constructive use of such strategies that support the transformation of subjective viewpoints has been strongly supported in earlier studies.

Furthermore, colleagues reported that participants were making more effort to be resilient in class since the intervention programme commenced. This was an encouraging outcome. Over time and with consistency, I believe that the effects of the intervention could be nurtured. In the longer term, these participants could work with resilience in any given maths lesson.

Indeed, while this study was primarily about encouraging reflection and promoting an active presence in the growth zone for these students; I am developing a 'suite' of effective strategies that I can employ to encourage resilience regularly. This research project has initiated that development.

Experience with the strategies I employed in this research project revealed how important it was to present the intervention strategies in a form that does not exacerbate the 'anxious' situation students find themselves in. One participant commented that she 'was not good with closed spaces' when referring to being in the 'pit' of the 6Bs to Mathematical Resilience Pit. In future, that would be something I would be mindful of.

Strategies used in my research allowed participants to grapple and struggle with concepts by and among themselves. When a teacher does not immediately step in to assist, students' resilience is required and developed. Allowing students to 'struggle' is more difficult with lower attaining groups (for example, T4 and T5 feedback); these teachers found themselves tempted to step in sooner, but this ultimately does not assist with resilience building. Spoon-feeding students has been shown to be counter-productive to building resilience.

I deemed Q-Methodology to be strong and appropriate for this study, particularly due to its capacity to elicit multiple subjective viewpoints within my chosen cohort. One of my principal motivators in undertaking this study was the belief that students' voices were crucial in the learning journey. As explained in Chapter 2, much research had used different elements of selecting intervention participants.

In addition, using Q-Methodology elicited varied views because participants, as expected, sorted statements differently. What was noteworthy was that through Q-Methodology, intervention participants from all attainment levels and backgrounds were identified. This

significantly differed in selection criteria from previous studies where participants were homogeneous groups. Participants in this study span across different 'abilities', thus demonstrating non-resilient views in the least expected young people. This finding contrasts with much of the previous research that has attempted to find commonalities amongst non-resilient students. In doing this, previous research has ignored the diversity of viewpoints amongst students. More needs to be done in terms of research that puts more emphasis on exploring what students feel and think about their learning experiences.

Resilience is a concept that has currency in all students' and practitioners' lives and does need to be embraced. Therefore, it is vital that research acknowledges and attempts to explore resilience in the eyes of the recipient so that resilience as a subjective construct is better understood within both research and practice. Also critical is the approach interested parties take in selecting target groups. Pre-conceived selection criterion has its place, but as action researchers, it is important to emphasise recipients' voices and let them have their say.

I hope that this study will challenge other action researchers who utilise homogeneous aspects as selection criteria or indicators of non-resilience. While the focus on participants in adverse circumstances has some merit, offering a certain level of 'recipient voice' in a structure that appropriately facilitates the recipients' views to be heard must be considered.

My selection method resulted in the engagement of a range of participants and avoided an unduly homogeneous participant group, as Watts and Stenner (2012) recommended. Throughout my action research cycles, I worked with thirteen-year-olds, and because I did not have any preconceived selection criterion, participants came from all backgrounds, the students that were classed as least able up to the ablest students. Also, because this research was primarily concerned about students' self-referring, I did not include teachers or parents in

the selection. The heavy reliance on students' voice is a strength because I observed that when students felt like their decisions resulted in them being chosen into this group, their motivation was better. They did not feel as if this program had been imposed on them.

As an action research project, the other primary intention in undertaking this study was to improve my practice. I discussed the implications of this study on my practice in Section 6.3.4.

6.5 Contribution to literature

There is a growing body of literature on educational interventions for mathematical resilience that utilise different participant selection methods. My study has shown that Q-Methodology, educational interventions and participant selection are a constructive partnership. Previous Q-Methodology research focused on gauging viewpoints (Wheeler & Montgomery, 2009; Oswald and Harvey, 2003) while studies on mathematical resilience have focused on utilising preconceived criteria for choosing intervention groups (Johnston-Wilder & Lee, 2010; Chisholm, 2017; Lugalia et al., 2015; etc.). Yet, some studies purport it is logical to make recipients' views a priority. In this study, I determined students' viewpoints and used these individuals' subjective viewpoint to select intervention candidates. I forward that selecting intervention candidates should be based primarily on the prospective candidate's beliefs, and Q-Methodology offered this option.

A 'combination' of strategies that encouraged the transformation of negative subjective views I showed to be imperative. Each of the strategies I used could support mathematical resilience development in itself, but my research has shown that no single strategy was impactful to all the participants. Some benefitted more from one than another.

Most importantly, the study provides some useful insights, particularly into how educators might be more sensitive to learners' needs across all backgrounds by taking the subjectivity approach as I described in this study. High achievers, as well as low achievers, benefitted from this sensitivity. This study also offers insight into how learners interacted with different selected interventions and how some found it challenging to establish the relationship between the strategies and learning mathematics to support them in becoming more resilient.

6.6 Limitations of the study

I recognise that one introductory session cannot be relied upon to enable the needed level of understanding of the introduced concept. If I were to redeliver the introduction session, I would spread it over at least two sessions and take more time to iron out any misconceptions or comprehension gaps earlier on in the cycles. I believe that my participants needed to develop a clearer understanding of each strategy; this could have increased the strategies' usefulness and impact.

Further attention could also be given to building a better range of independent strategies that students could use to remain active in the growth zones by inviting participants to add any strategies that 'work' for them if they are not included in the researcher's suggestions. Also, the building resilience that could happen out of the classroom could have been included during the conversations with participants.

Research has shown that some behaviour traits are ingrained and difficult to modify. Wigley (2008) claims that one of the stumbling blocks of the 'stand back and watch them grapple' approach is students' reluctance to embrace such a new strategy. It may well not meet their expectations of what a teacher should do and therefore not be easily digestible. In explicitly

teaching students about mathematical resilience strategies, teachers may help overcome such reluctance.

I recognise that the overall long-term impact may not be seen immediately, but the little daily successes could have a cumulative effect that could aid in supporting the development of mathematical resilience, especially with a continuous reflection by students on the ZoL and HMoB. The same applies to the reflective analysis of my practice to allow further adaptation of appropriate strategies. So, while I aim to build resilient students, my practice must epitomise resilience if I am to successfully support students in my care.

One of the limitations of the selection method I utilised is that the researcher is primarily responsible for choosing the sorting activity's final statements. Although the collaboration with participants at most stages did occur, participant involvement varied, and, in my study, it was not as extensive as I would have desired for practical reasons. Timetabling issues were a key player in this limitation.

Another major limitation to selecting participants from a whole cohort was that because the participants were in different classes and had different teachers, student support was not as consistent and extensive from one class to the other. Some students reported that their teachers did not actively support them. T1 reported that he did not actively support the students either. However, the regular group meetings and feedback sessions, the class observation visits, as well as students being made aware of my availability (anytime they and I are free) as a support system provided the necessary monitoring points to make the findings of this research credible.

Another limitation was that because all maths teachers taught their groups simultaneously, I conducted the class visits on a rotational basis, resulting in more extended periods between

the previous and next class visit. This became marginally better when I started working part-time.

6.7 Credibility and transferability

I addressed credibility in this study through the framework presented by Mills et al. (2012). Drawing on wider research, Mills et al. (2012) outline four key questions related to the credibility of research findings. These are addressed in the next paragraphs.

The first of these queries refers to whether the findings are 'true' for the participants and the context, i.e. the extent to which the researcher appropriately identifies the presence of the central construct under study. In section 4.1, I reported on the findings from eliciting the students' subjective views, which were key to this study. Discussions with students in the study during the course of the research confirmed I had appropriately identified the presence of the central construct.

The second question refers to judgements about applicability, i.e. whether the findings can be generalised or transferred to another setting. The exact findings of this study, however, will not be widely transferable because of the subjectivity aspect of this research project, but they offer useful 'guidance' for teachers of young people with similar negative subjective views of themselves and their learning. The actual results may not be transferable but the principle of taking subjective views as a priority in intervention programmes can be transferred to another setting.

The third question refers to whether the findings would be similar if the research were repeated with identical or similar participants in an identical or similar context. A study carried out in a similar context, and similar participants to my study could produce similar

findings. The researcher would be able to draw similar conclusions that are pertinent to their participants' views.

The fourth question refers to how the researcher's biases and perspectives influenced the findings. This is an elusive criterion to address completely but through discussions with the students, my supervisors and colleagues, I reduced researcher biases as much as possible.

Other ways of enhancing credibility involve data saturation, which Mills et al. (2012) refer to as triangulation across sources of data. In sections 3.5 and 3.6, I described the different data collection methods and data sources I used, enabling a claim of this study's credibility. Mills et al. (2012) also point out that extended time in the field is essential to building trust between the researcher and participants, thereby increasing the likelihood that the participants will be open and honest with the researcher and accept the researcher's interpretations. In my case, I had been in the research school for an extended period of time and I had established good relationships with the students. I was an active participant in the school community and thus gained the students' trust and understanding while providing an insider's view of the case.

6.8 Challenges and what I could have done differently

I encountered several obstacles during the course of the research. I did not anticipate the challenges of being given time to undertake the research. Verbal support was brilliant, but it proved quite problematic when it came to 'allowing time' in the timetable, even during my timetabled lessons. I can only assume that this was because i) the research project was viewed as a personal endeavour, and that overshadowed the benefits to students; ii) the school's teaching and learning focus was on 'already proven research'. In this respect, I do not think I could have done anything differently. There was a prevalent culture of preferring 'proven' strategies as opposed to 'research' strategies.

Teacher resistance was not quite expected either. Again, verbal promises did not equate to on the ground use of the strategies. Maybe a more in-depth 'workshop' for teachers so they understand better the potential benefits of the project to the students (outside of it being perceived as just a research study) would have been more constructive.

Furthermore, on reflection, I did not clearly communicate some aspects of the 'instructions' to the participants. For example, a participant commented, 'I don't understand what you mean by 'aspect' of resilience'. This would be an area of improvement on my part to make sure that every single aspect of instruction given to participants is clearly communicated.

On a personal level, I had UK visa procurement issues that affected my study resulting in temporary withdrawals and changing my student status. By being resilient, I have completed my study.

6.9 Recommendations for different stakeholders

For the reasons discussed in this study and because of the key Q-Methodology characteristics I presented, I strongly argue that more intervention researchers could benefit from incorporating Q-Methodology in their studies, especially in educational interventions, because of the more in-depth level of students' voice afforded by this method. I believe educators might more often consider incorporating the Q-Methodology way of choosing intervention students and designing intervention strategies. Q-Sorting and PQMethod analysis are a time-consuming undertaking but for the sake of targeting optimal intervention students, giving them 'a voice', makes this methodology worthwhile.

Secondly, I propose a combination of the Zones of Learning and the Hand Model of the Brain (or other models) be considered for all learners; they complement each other well. ZoL helps identify the emotions being experienced, while the HMoB explains how the brain reacts to

these emotions. This enables students to realise that it is not about being dumb at maths but about understanding these principles.

Thirdly, I recommend that a ‘set’ of intervention tools be considered in any intervention programme and should be thought through thoroughly. For my research on the transformation of subjective views, Dweck’s mindset theory made an appropriate first step. I concur that it is only when participants embrace the growth mindset that teachers and participants can have better prospects of reacting constructively to a challenging learning situation. They can then be supported into deeper thinking to identify sticking points in that learning episode and then consider different approaches to finding the solution. All three strategies I employed in my research work in and of themselves for some students (for example, Dweck, 2008; Tobias, 1995; Nottingham, 2014), but I believe a combination of the three in the sequential manner presented in this study can exponentially benefit more participants.

I have shared these research findings with colleagues (at an individual level) in my department. Now I am putting together ‘workshop style’ presentations to disseminate at a department ‘workshop’ with the department and students. Although this study started as an exploration of other approaches to interventions in the classrooms, under the ‘current’ circumstances, it also became a ‘navigation’ task in terms of disseminating the utility of these strategies to my colleagues.

Research that involves students and teachers produces a direct impact on learning and teaching practices. 100% of my research project participants reported that they found either the models or strategies utilised useful, to varying degrees. I recommend that teachers embrace, acknowledge, and encourage students to adopt new learning strategies too. One participant attributed the mindset’s ineffectiveness to their lack of utilising it, and other

students (MaTS1 and MaTS2) concurred that the teacher did not remind them, so they did not use it.

An unexpected observation, based on a comment made by one of the participants, was that I recommend regular mixing of class sets. A participant in my research project pointed out the need to '[m]ake maths fun like the whole year [group] joins for challenges …. and teamwork is gained with different sets' (Appendix 6) so that students work collaboratively. Such sessions could involve mixed groups of 'resilient' and 'non-resilient' students working on, for example, rich investigational tasks.

Regarding the education policy, I hope that my research will add to the researcher voices that advocate for policies that put students' voices at the forefront. Wider spread dissemination of the study and its findings will be through publication, seminars and workshops.

6.10 Personal significance of the study

This section explores my engagement with this process, reflecting criticality on the main personal lessons learnt in this research.

When I first started teaching in the UK, a common comment that students made when they did not 'get it' was 'Oh, I am so dumb'. Throughout the study, I made observations that indicated a significant personal 'turning point' in students' experiences and hence my experience as a practitioner. I can help support students in managing their learning journey more successfully by exposing them to learning content that is not specifically 'subject content'. I now strongly argue that such interventions can enhance learning and ultimately build long term resilience in students.

However, I am also aware that this can only be the case if I continue to incorporate the strategies into my everyday teaching while simultaneously developing new strategies to promote resilience and self-confidence. The experience of planning, delivering and reflecting upon the intervention lessons has led me to conclude that they have provided useful tools for both students and me in evaluating learning lesson-by-lesson.

My practice has changed significantly as a result of this study. The students found it very useful, and so did I. What I do differently now is that I regularly refer to the ZoL and HMoB models during my lessons. I also use different strategies in my lessons. I use the Q-Sorting activity to learn my students' subjective viewpoints and offer appropriate mathematical resilience intervention strategies to my teaching groups. Addressing the unhelpful views, students hold is critical. Student input will be paramount. I also encourage volunteers.

Completing a thesis was a long process during which ideas evolved and changed. I believe my values and beliefs shaped the decisions I took and paths I trod.

My research was motivated by challenging and improving my practice, so choosing an appropriate paradigm was crucial. I felt that social constructionism offered a coherent framework for resilience exploration within a practice context, which I argue is very important. The growing amount of research where teachers and lecturers research their own practices provides hope for qualitative and educational improvement. My research adds to this hope. Also, it is important that research involving students and teachers directly impacts learning and teaching practices. My research has impacted my teaching practices.

Even though I was in part motivated by developing resilience, generally, the fact that I worked in a girls' school offered me the opportunity to explore female resilience in particular. There recently has been a surge in research interest around differences between male and

female performance, especially in maths. Therefore, this research is well placed within the current research atmosphere.

Resilience will continue to be a dominant discourse in education. Future research should continue to question what resilience is and what it means for different individuals, without starting from the stereotypes that resilience (or non-resilience) is unique to a particular group of people. As opposed to purely qualitative methods such as interviews, the use of Q-Methodology also offers the complementary insight of quantitative analysis of qualitative data. Furthermore, I believe selection criteria for intervention should be heavily based on the recipient's voice.

I enjoyed the research process more than I expected, and ultimately, I am proud of my work. Now I want to challenge educational practices and how I approach all aspects of the support I give to my students. Mathematical Resilience is a term I will be using more often in my day-to-day work. Also, I have developed a strong appreciation of the subjectivity of action research; I became acutely aware that the decisions I made all contributed to producing one very particular piece of research….my own.

Post-note

At the time of submission, a new article came to light. In their article 'Stress and Learning in Pupils: Neuroscience Evidence and its Relevance for Teachers', Whiting et al., (2021) report on a review of evidence on i) how children differ in their attention and learning style and ii) intervention research on stress management techniques in children, concentrating on psychological techniques (for example mindfulness and stress reappraisal), physiological techniques (for example breathing exercises) and environmental factors (for example reducing noise). In this report, they advocate that teachers need to be aware of and

accommodate the differing needs of children in their classroom if they are to achieve their full potential. Their report has set up in theory what I have sought to achieve in practice. They report that “We have described potential classroom strategies for addressing this issue” and propose that “raising teachers’ awareness of the inter-individual differences in their pupils’ stress responses will be an important step in accommodating the differing needs of children in their classrooms. Developing personalized approaches and training programs may prove to be the ultimate goal, to not only prevent stress-induced impairments but also enable all children to achieve their full potential.” (p. 8). This presents a parallel case to what I have achieved in this thesis. While their study provides for theoretical argument for tailor-made approaches for enabling students to regulate responses to learning challenges, my study has demonstrated that what they are suggesting works.

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Appendices

A1 Original Q-Set

1 Maths is essential for my future. V	2 Maths will be useful to me in my life's work. V	3 Maths courses are very helpful no matter what I decide to study. V
4 Knowing maths contributes greatly to achieving my goals. V	5 Having a solid knowledge of maths helps me understand more complex topics in my field of study. V	6 People who are good at math have more opportunities than those who aren't good at maths. V
7 Thinking mathematically can help me with things that matter to me. V	8 It would be difficult to succeed in life without maths. V	9 Maths develops good thinking skills that are necessary to succeed in any career. V
10 Everyone struggles with maths at some point. S	11 Good mathematicians experience difficulties when solving problems. S	12 Successful people who work in maths related fields struggle when working on hard maths problems. S
13 Everyone makes mistakes at times when doing maths. S	14 Struggle is a normal part of working on maths. S	15 People in my peer group struggle sometimes with maths. S
16 People who are good at maths may fail a hard math test. S	17 Maths teachers are sometimes stumped by a math problem. S	18 When someone struggles in maths, it doesn't mean they have done something wrong. S

19 Making mistakes is necessary to get good at maths. S	20 Everyone can get better at maths if they try. G	21 Maths can be learned by anyone. G
22 If someone is not a maths person, they won't be able to learn much maths. G	23 If someone is not good at maths, there is nothing that can be done to change that. G	24 People are either good at maths or they aren't. G
25 I believe a person's maths ability is determined at birth. G	26 Some people cannot learn maths. G	27 Only smart people can do maths. G
28 I believe I can grow in my knowledge of maths. G	29 When I have done poorly on something related to maths, I know how to adapt. R	30 I sometimes get discouraged by difficulties in mathematics, but I bounce back. R
31 I have strategies to use when I get stuck trying to solve maths problems. R	32 When I fail or do poorly on a maths test, I know I have to work harder. R	33 When I struggle with maths, I return to it until I get it. R
34 When I experience a setback in something related to maths, I seek encouragement from others R	35 I sometimes find math confusing, but I stick with it. R	36 When I don't do as well as I hoped on a math task or test, I keep trying until I can do it R

A2 Final Q-Set (47 item)

1 Maths is essential for my future and very helpful no matter what I decide to study.	2 Knowing maths contributes greatly to achieving my goals.	3 It would be difficult to succeed in life without maths.
4 Good mathematicians experience difficulties when solving problems.	5 Having a solid knowledge of maths helps in my other school work.	6 People who are good at maths have more opportunities than those who aren't good at maths.
7 When I experience a setback in something related to maths, I seek encouragement from others.	8 Struggle is a normal part of working on maths.	9 Maths develops good thinking skills.
10 Making mistakes is necessary to get good at maths.	11 Everyone can get better at maths if they try.	12 If someone is not good at maths, there is nothing that can be done to change that.
13 People are either good at maths or they aren't.	14 I believe a person's maths ability is determined at birth.	15 I believe I can grow in my knowledge of maths.
16 When I have done poorly on something related to maths, I know how to adapt.	17 I sometimes get discouraged by difficulties in mathematics.	18 When I fail or do poorly on a maths test, I know I have to work harder.

19 When I struggle with maths, I return to it until I get it.	20 I think maths lesson should be fun to help us remember.	21 I want to study maths at A Level, so I need a good grade at GCSE.
22 I think some maths topics shouldn't be taught as they make maths harder such as algebra.	23 I think I should learn things that are going to help me in the future (paying the bills), I do not like algebra	24 I think maths is important for most *careers* but I don't believe it's essential for a successful or happy life.
25 Maths gets easier when you get a lot of help	26 Maths is a wonderful world of numbers.	27 Maths is about your attitude towards it. Whether you are positive or negative towards it, it has a great impact on your work.
28 Maths for me is all in the explaining. If it is explained in a way I understand the first time, I will grasp it for life.	29 Maths can be used as a tool for empowering communities.	30 I think how people are taught maths when they are young makes a big impact later on.
31 I am not a very mathematical person and prefer English to maths but I do believe that I can get better at maths if I tried harder.	32 Maths can be a very difficult subject and many people get discouraged by it.	33 Ability to do well in maths is based highly on confidence.
34 Personally, I struggle a lot in maths.	35 Maths is all about the effort you put in from the start. What you put in is what you get out.	36 I think if I enjoyed maths I would work hard to succeed.

37 Maths helps my brain to develop.	38 It's really hard to remember how to incorporate the rules we learn in class into exam and test questions.	39 More people need to understand that just because they may be bad at maths now, doesn't mean they'll always be bad at maths.
40 I think that the kind of teacher you have will be an influence in how well you'll do in maths.	41 Maths can be learned by anyone.	42 I have strategies to use when I get stuck on a maths question.
43 I know how to bounce back when I get discouraged in maths.	44 Maths is the reason why I come to school.	45 I am aware that I can improve in maths.
46 It feels like there is a limitation on my ability to understand it.	47 Maths keeps me thinking each time I do any maths related work.	

A3 Q-Sorting Instructions

QSort Instructions

*Read through the statements on the set of cards.

*Place them into roughly 3 equal groups, the 'agree' group, the 'disagree' group and the 'neutral'.

*For agree group, rank them from the 'most' describing me and place it in the **+5** box(es). Choose the next two or three and place in the **+4** column. Repeat until all the agree cards have been placed.

*For disagree group, rank them from the 'most' describing me and place it in the **-5** box(es). Choose the next two or three and place in the **-4** column. Repeat until all the disagree cards have been placed.

*Then place the neutral cards in the remaining columns. Some will be on the **(-)** side, some in the **(0)** column and the others in the **(+)** side.

*Write the card numbers in the appropriate section of the frame given.

This is all based on **your** opinion, there are **no right or wrong answers**.

Please sign below to give consent for the use of this information you supplied. Your information will be used anonymously. You do not need to write your name but should you require individual results feel free to supply your name.

Signature…… Date……

A4 Evaluation Sheet

Name……

In this part of the program you are invited to give feedback on the second strategy towards developing mathematical resilience – The '6Bs to Mathematical Resilience Pit' strategy.

This feedback is aimed at finding out how you feel about your learning so far. It involves rating items from we talked about in the last workshop. Consider that workshop where we looked at how you can use different coping and excelling tactics that can make your working at maths manageable. We also spoke about what you could do to get past the 'sticky' part of the question to support and manage your learning. Please rate these statements and suggest any improvements that can be made to make this more useful.

Item description	Scale 1 – found it most unhelpful; 10 – found it most helpful	If less than 10, what could take it closer to a 10?
Understanding that a key first step to managing my difficulties is deep breathing.		
Understanding different tactics that I can use to 'help' myself before asking for the teacher's help.		
Understanding there is always something I can do to make progress towards finally solving the question.		

In the card sorting activity, some of the things you most disagreed and most agreed with are in this table, please can you indicate how you feel about them now?

Item description	Scale 1 – still feel the same; 10 – feel the complete opposite	If less than 10, what could take it closer to a 10?
Most agreed: Having a solid knowledge of maths helps in my other school work.		
Most disagreed: I know how to bounce back when I get discouraged in maths. When I have done poorly on something related to maths, I know how to adapt.		

Use this space to say anything else you feel you need to say……

……

……

Consent signature……

A5 Prompt Sheet

Breath: Take a deep breath.

This will enable you to manage your anxiety/stress/panic and help you re-focus, in a calm manner, your attention to the task at hand.

Brain: Ask yourself…

Have I used these skills before (in another topic)?

When did I do this? What do I know about this?

Board: Look at the board.

Does the board have information that you need?
Is there a similar worked example there?

Book: Have you looked in your exercise book for relevant information/examples?

Have you used your textbook? Have you tried the Maths dictionary or even an English dictionary?

Buddy/Backup: Ask the person nearest to you.

If that person is unable to help, ask up to 2 more others.

If still stuck ask other adults in the room (if available) or use ICT (if possible).

Boss (Teacher):

If the first 5 steps are unsuccessful then ask the teacher. They will help you to find the information you need or explain to you the parts you are not quite getting.

A6 Table of qualitative data results

	Analysis Structure		
	Positive	Negative	Unexpected
MM	I now understand showing my working out in answers.	More frequent reminders in classrooms	Maths is always hard, but some topics are easier than others
	I can understand my mindset and I can improve when learning things that are difficult	I don't understand the use of this concept	I think I should move to set 2 and start building up from there
	You can use it to manage time in a way	Not very effective	I don't see how my brain works will help in maths
	Mindset must be helpful to people to stay on track	I found it hard to understand so it needed to be explained more	I'm still bad at maths
		I just don't see how this helps with classwork	Maths is something that should help everyone, and it may help in everyday life but I don't remember/see how to use my brain

		Show ways we can improve and still do our learning More explanation and help I think personally if I understood more of mindsets, it would help me out It doesn't help in class because I don't refer to it It does not help with school/homework	Thank you for all extra help :-)
SP	I put stickers with the emojis where I thought I did well. Helped me read the question properly	I didn't use them how I was supposed to. I think that the stickers are not that useful.	I think that maths is very easy. The lessons are still boring. I can see my teacher trying to make the lesson more exciting and fun to do but to

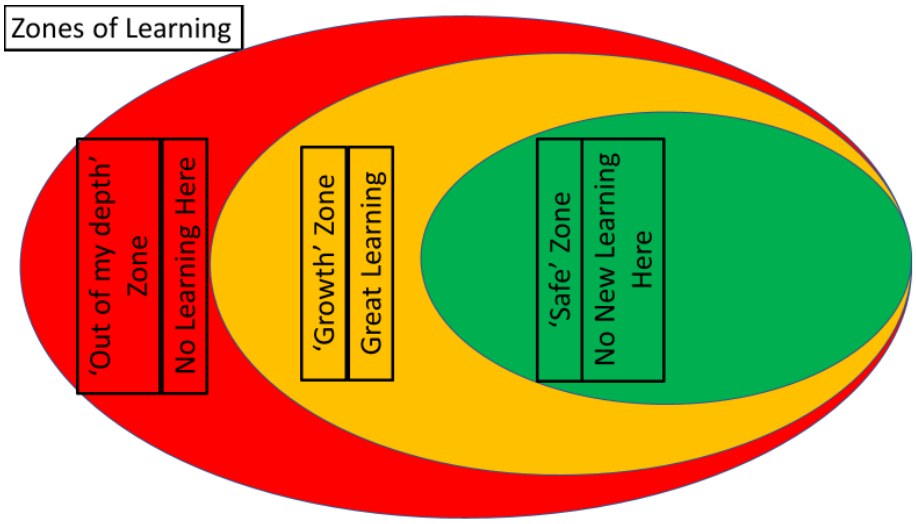
			me I guess I'll never find it engaging and entertaining.
	Know what I am stuck on most of the time and as a buddy or think better	I did not use the stickers	Maths is the hardest subject
	Yes, I understand	It was not useful to me	I don't think this session helps me at all
	It is useful; however, no one ever sees it	Most of the time I still needed help from the teacher	I generally do not like maths and I don't feel as though my feelings towards maths will change.
	Happiness when I understand and do well	Not sure about resilience	To make maths more fun the whole year joins for challenges to support each other and teamwork is gained with different sets
	Understanding what maths is needed and how to do the maths	Sometimes it's the whole question, not part of it.	I feel like I have improved ever since I have been getting help with my work in class

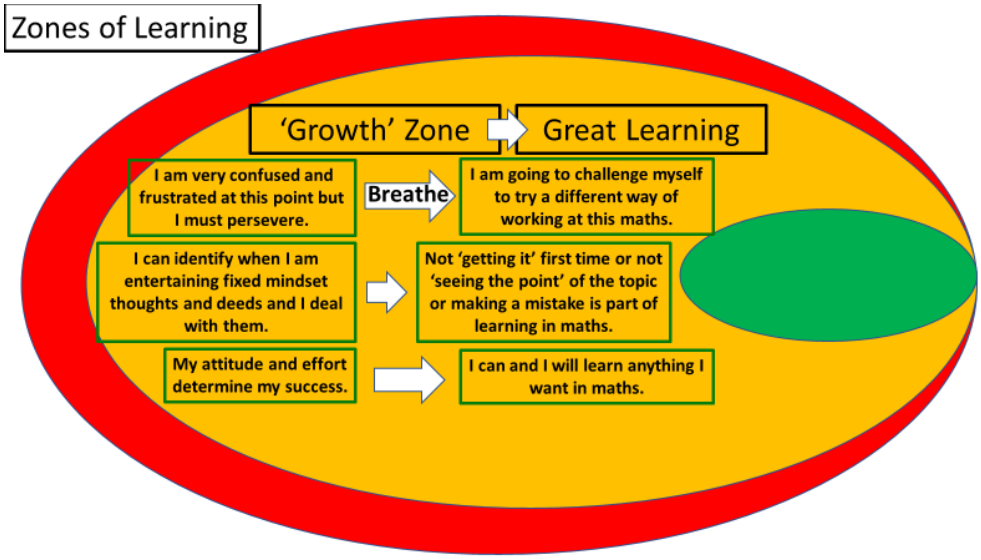
	I sometimes try and help myself before asking the teacher	I didn't need it	Sometimes I get angry with myself before answering
	I don't get stuck in class anymore, the sticker helped me a lot. Thanks for the sticker.	Maybe giving ways to resolve the confusion	I want to move down sets
	I found questions with really long words easy to answer	More options on what to do when stuck	I struggle with maths especially completing the classwork and understanding it
	I always rely on someone sitting next to me	I understand but it is not helpful	Need a lot of revision in class
	Asking my partner or person sitting next to me	Sometimes the help is not enough, and I need help from the teacher	
	I can do wordy questions better	I feel I need to learn and practice the maths more first.	
	Asking the teacher at the end	Sometimes I don't know what to do to help	

		myself, so a teacher is required	
6Bs to MR	Make myself believe I can do it and not give up Understanding what could get me out of the 'pit' I understand that I have to attempt my questions in other ways I know ways in which I can help myself I do understand my work a lot more now Actually, putting in resilience It is ok to not know	This programme doesn't really help me at all I was not really thinking about the 6Bs when I needed help Not sure about resilience It made me feel slightly more stuck I forgot about the workshop, so I have been improving maths by myself, especially homework	I have been able to improve on my own

	Made me think harder and keep trying - not to give up Helped me be proud of myself Helped me understand what I need to do to not feel stuck Helped me understand what can be done to get me out of the pit I knew that there were ways to get out I am able to understand that being stuck is normal This reminds me that I can actually do this Understanding more Being aware		

A7 PowerPoint Presentation





A8 Ethical Approval

Centre for Education Studies

Application for Ethical Approval for Research Degrees
(MA by research, MPHIL/PhD, EdD)

Name of student	MA By research	EdD	PhD
Joyce Nyama			

Project title: Mathematical Resilience: Developing a Mathematical Resilience Scale (MRS) and using Q-methodology to study mathematical resilience.

Supervisor: Sue Johnston-Wilder

Funding Body (if relevant)

N/A

Please ensure you have read the Guidance for the Ethical Conduct of Research available in the handbook.

Methodology
Please outline the methodology e.g. observation, individual interviews, focus groups, group testing etc.

i) MRS:
In developing this scale I will use questionnaires as my data collection method.

ii) Q-methodology

For this part of the research I will use a Q-set as a means of data collection.

In both cases individual interviews will only be employed if need for further explanation arises.

Participants
Please specify all participants in the research including ages of children and young people where appropriate. Also specify if any participants are vulnerable e.g. children; as a result of learning disability.

I currently work as a long term supply teacher at a girls' school. The participants will be made up of students from my school and those from the collegiate that my school belongs to. This is to enable me to have both male and female participants in my research as I will be interested in gender comparisons of my research.

Respect for participants' rights and dignity

How will the fundamental rights and dignity of participants be respected, e.g. confidentiality, respect of cultural and religious values?

The participants will be fully informed, verbally and in writing, of what the research is about, what the expectations from them are and that they are free to not participate or withdraw at any point in the research. They will also be informed that the data they provide will be treated with the appropriate confidentiality and any results published will be anonymous. The participants will be asked to sign to consent to the use of information they provide.

Privacy and confidentiality

How will confidentiality be assured? Please address all aspects of research including protection of data records, thesis, reports/papers that might arise from the study.

Data records will be appropriately coded and I will be the only person with these codes. When reporting in my thesis the data will be anonymous. The same applies to any reports I will produce or papers I will publish.

Consent - will prior informed consent be obtained?

- from participants? Yes/No from others? Yes/No

- explain how this will be obtained. If prior informed consent is not to be obtained, give reason:

The participants in the research will be secondary school age. Consent will be obtained in three stages. Initially it will be through the school's leadership regarding access to the potential participants as well as finding out whether there might third party (eg parents or carers) concerns/objections to the exercise. The second stage would be a verbal informing of the participants and written information to carers or parents if need be. The third stage will be a signature at the bottom of questionnaire and the Q-sort.

- will participants be explicitly informed of the student's status?

The participants will be explicitly informed of my status in writing.

Competence

How will you ensure that all methods used are undertaken with the necessary competence?

To ensure the procedures are undertaken with the necessary competence I will follow the guidelines for using each procedure. I will also pre-agree procedures with my supervisor. Furthermore, I will carry out small scale pilot studies first.

Protection of participants

How will participants' safety and well-being be safeguarded?

The research will be carried out in the familiar environment of the participants' schools under the strict safeguarding and well-being guidelines already in place within the schools.

Child protection

Will a DBS (Disclosure and Barring Service formerly CRB) check be needed?

Yes/No (If yes, please attach a copy.)

Addressing dilemmas

Even well planned research can produce ethical dilemmas. How will you address any ethical dilemmas that may arise in your research?

This research will be conducted within an ethic of respect for the participants first and foremost. Any part of the research that violates the participant will either be immediately stopped or withdrawn from the findings of the research. The research will also be conducted within an ethic respect for the community of educational researchers as per the guidelines stipulated by BERA.

Misuse of research

How will you seek to ensure that the research and the evidence resulting from it are not misused?

I will endeavour to communicate my findings, and the practical significance of my research, in a clear, straightforward fashion and in language judged appropriate to and understood by the intended audience. This will eliminate any misuse of the research and the evidence arising from it. I will also explicitly spell out conditions of use and permissions of use given. All this will be done under the direction and regular meetings in with my supervisor.

Support for research participants

What action is proposed if sensitive issues are raised or a participant becomes upset?

I do recognize that participants may experience distress or discomfort in the research process so I will take all necessary steps to reduce the sense of intrusion and to put them at their ease. For example, I will desist immediately from any actions, ensuing from the research process that, cause emotional or other harm. Also, if need be, relevant authorities will be notified.

Integrity

How will you ensure that your research and its reporting are honest, fair and respectful to others?

I will desist from any instances of misconduct as outlined in the BERA guidelines, namely,
-Falsifying research evidence or findings;
-'Sensationalizing' findings in a manner that sacrifices intellectual capital for maximum public exposure;
-Distorting findings by selectively publishing some aspects and not others;
-Criticizing other researchers in a defamatory or unprofessional manner;
-Exploiting the conditions of work and roles of contract research staff;
-Undertaking work for which they are perceived to have a conflict of interest or where self-interest or commercial gain might be perceived to compromise the objectivity of the research;
-Undertaking work for which they are not competent;
-Using work carried out with co-researchers as the basis of individual outputs without the agreement of the co-researchers concerned;
-Using research for fraudulent or illegal purposes.

What agreement has been made for the attribution of authorship by yourself and your supervisor(s) of any reports or publications?

Authorship will reflect the relative leadership and contributions made by the researchers concerned.

Other issues?

Please specify other issues not discussed above, if any, and how you will address them.

Signed

Research student	Date
Joyce Nyama (by email)	5th May 2015

Supervisor	Date
Sue Johnston-Wilder (by email)	5th May 2015

Action

Please submit to the Research Office

Action taken

- [x] Approved
- [ ] Approved with modification or conditions – see below
- [ ] Action deferred. Please supply additional information or clarification – see below

Name G Lindsay Date 18/5/15

Signature [redacted]

Stamped

Notes of Action

A9 Q-Set Development Timeline:

Phase 1

Month	Development Stage of the Q-Set.
February 2015	Research proposal and ethics request submitted.
March 2015	Ethics application approved.
April 2015 – July 2015	Reading literature on mathematical resilience + Developing initial concourse from the literature review.
September 2015	Seeking and getting permissions to work with Year 11 students. Producing the first set of Q-Set cards consisting of 36 statements generated from the literature review.
December 2015	Piloting administering the Q-Set to Year 10 students using statements generated from the literature review. Initial scrutinizing of Q-Sorts for missing or repeated statements.

Month	Development Stage of the Q-Set.
	Collecting ‘student voice’ statements.
January 2016 – March 2016	Piloting PQMethod software to analyze data collected in the Q Sorts and familiarizing myself with the analysis outputs + interpretation of these outputs.
April 2016	Reviewing ‘students’ voice’ statements for incorporation into Q-Set. I had +/-105 statements from students.
July 2016	Selected 24 statements from the ‘student voice’ statements that I felt said something significantly different to those from the literature review and added them. Increased Q-Set to 60.

Phase 2

Month	Development Stage of the Q-Set.
October 2016	Piloted this 60 item Q-Set with a few Year 11 students and carried out another PQMethod analysis run.

Month	Development Stage of the Q-Set.
March 2017	Presented 60 item Q-Set to conference delegates as part of my conference presentation.
May 2017	Reviewed Q-Set in light of feedback from delegates at the conference.
July 2017	Discussed draft of final Q-Set with my supervisor. Identified 'similar' sounding statements + some that could need splitting up.
September 2017	Decreased the 60-item Q-Set to 47.
October 2017	Final Q Year 9 Set established
October 2017	Final Q-Set pack produced.

A10 Strategy Resources: